N.T. WATERWATCH
EDUCATION KIT

Part 5
Monitoring Catchment Health

NT WATERWATCH EDUCATION KIT

PART 5:
MONITORING CATCHMENT HEALTH

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PART 5: Monitoring Catchment Health

Introduction

We rely on our healthy waterways and so do many plants and animals. The quality of the water is an important component of catchment health, as many creatures are sensitive to even small changes in water quality.

To ensure there is a common understanding regarding the quality of water there are guidelines produced, which are used by researchers, governments and *Waterwatch* groups (Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000). They assist in the monitoring of catchment health by these groups.

By reading this section on assessment and monitoring of catchment health, you will become familiar with what is involved in:

- water quality sampling including physical, chemical and biological parameters;
- habitat assessments; and
- catchment surveys

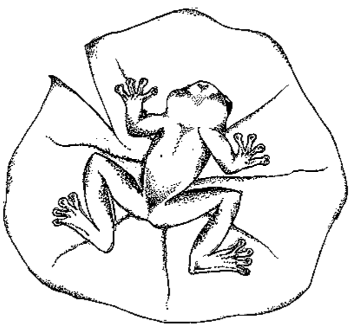
The main aims of PART 5 are to:

- introduce a selection of water quality parameters that are known to influence the health of a waterway.
- provide an understanding of how water quality is monitored and catchment health assessed.
- assist students and teachers to be become involved in water quality monitoring, habitat assessment and monitoring catchment health.

This section will provide an overview of the role Waterwatch plays in your community and allow you to determine the suitability of the exercise for your class, the resources required and give you a basic understanding of what a waterway assessment involves.

If your class is intending to undertake water quality monitoring or habitat assessment it is recommended that you contact your local *Waterwatch* coordinator for safety advice, additional technical information and materials to complete the tasks.

Rationale



"Involve Me and I Will Understand"

Involving students and the general community in monitoring water quality and catchment health enables them to feel that they can be a part of maintaining a healthy environment.

What is Meant by Water Quality?

Water quality is a term that describes a valued judgement, that people have made about how useable the water body is, based on what is in the water.

People create a 'scale' on which to judge water quality against. Most commonly used categories of water quality are: poor, fair, good, excellent.

Poor water quality has limited capacity to be used by people and poor biodiversity, while excellent water quality has many opportunities for use by people and comparatively higher biodiversity.

Just as we all use the same standard measures on our classroom rulers, water quality measures need to be standardised.

To standardise peoples' judgments, Water Quality Guidelines have been developed so that when one person talks about 'good' or 'poor' etc water quality everyone else has a similar vision of what that means.

It is difficult to discuss water quality without mentioning the term *pollution*. Pollution is defined in the Waterwatch Technical Manual as:

> "*any harmful or undesirable change in the physical, chemical or biological quality of air, water or soil as a result of the release of chemicals, radioactivity, heat or large amounts of organic matter*."

Monitoring Water Quality

General Principles

A monitoring plan is both a guide to and record of decisions about the design of your study. A good monitoring plan will ensure that you ask the right questions and collect the right data in the time and with the resources that you have available. Your plan will help you choose the best monitoring tools for the task and define the scale and complexity of your monitoring work. A well thought out plan at this stage could save an enormous amount of wasted effort later on.

Take some time to consider each of the following questions carefully. This eleven question plan provides a solid foundation should you wish to develop monitoring further.

Monitoring Plan

1. *Why are you monitoring/surveying?*

The first step in planning is to ask why do we want to monitor? Answers may vary but often groups simply want to know what waterway health is like.

2. *Who will use your information?*

Potential users might include students and/or group members, etc. Name the main groups.

3. How will the information be used?

Data could be used for more than one purpose eg: to educate students about the principles of ecology or identify major trouble spots in the waterway. Knowing its main use will help determine the right kind of data to collect. Describe its intended use.

4. What will you monitor?

The things you choose to monitor will depend upon the question(s) you are asking as well as the resources available. For example, if your group wants to learn about the general ecological health of the waterway, then the main types of water bugs (macro-invertebrates) present could tell an interesting story. List the things that you will monitor. Refer to Table 1.

5. How accurate should the data be?

This depends upon the question(s) you are asking and how you intend to use the data. At the very least your data should be accurate enough to indicate the location of grossly polluted sites. Depending on your findings you may then choose to modify your monitoring program. For groups with a focus on education and raising awareness, the quality of the data is secondary to the actual process of collecting it.

6. What methods should be used?

This depends on your objective(s) and resources. There are often several ways of testing the same parameter eg: for high precision turbidity readings from 0 to 1000 NTU, a turbidity meter costing several thousand dollars is required, but a turbidity tube (approximately $35) is suitable for less precise readings between 10 - 400 NTU. Use the same methods at all sites to allow comparison of data. List which methods will be used.

7. Where will you monitor?

The location of monitoring sites depends on whether you are monitoring a river, lake, estuary or ground water, and also on the purpose of monitoring. For example, monitoring at a variety of typical sites in the catchment is good for providing information about its overall condition. On the other hand, sites located above and below a pollution source are needed to indicate its impact. Your sites should be representative of the condition of the waterway. Use a map to show your sites.

8. When will you monitor?

This depends on your resources and the purpose of monitoring. Here are some suggestions:

- a snapshot of the waterway - monitor a number of sites on the same day;
- monitoring pollution events eg: discharges from pipes depends on the timing of the discharge;
- surveying the physical form of the stream is best done during low flows for safety reasons.

Describe when you will monitor.

9. Who is going to be involved and how?

Indicate who will carry out surveys and/or test water samples, who will arrange transport to sites and back, who will prepare the water testing equipment to be used, who will photograph sites, etc.

10. How will monitoring data be managed and presented?

It is important to record and present the data. It helps to raise awareness of the condition of the waterway amongst members and helps you to refine your monitoring activities. Record who is responsible for looking after the data and describe how it will be managed.

11. How will you ensure that your information is credible?

Developing answers to the first ten questions above is the first step in conducting an effective visit to the waterway. For all surveys and tests, ensure that group members are adequately trained. For water quality tests, ensure that any instruments used are calibrated and that any water samples are taken from the main current at about 25 cm below the surface where possible. List what you will do to improve the credibility of your information.

As you work through the questions above, you may find that a more thorough plan is needed to effectively gather data to answer the concerns of your group. If this is the case, your *Waterwatch* coordinator will assist in the development of an Extended Monitoring Plan.

Take a look at Table 1 for some hints on monitoring programs. The *Waterwatch* technical manual, which can be borrowed from your Regional Waterwatch Coordinator, contains further details on how to develop either:

- a short monitoring plan for education and awareness activities, or
- an extended monitoring plan for gaining a full understanding of the condition of the waterway

Please consider this information before proceeding to your water quality sampling exercises.

Quality of Data

There are two important considerations that influence the level of confidence that others will have in your data:

- Data Confidence Measures; and
- Quality Control Checks.

Data Confidence measures refer to those broad activities for maintaining quality in all aspects of monitoring, eg. training, keeping written records, quality control. It will ensure that results from the many hours of monitoring work will lead to achieving the goals set by your group and a greater sense of personal satisfaction. It will also allow you to demonstrate the quality of your program to others so that both you and they can have confidence in the data.

*Quality controls (*QC) are those activities you do to ensure that the amount of error in your results (how far from the real result you are) is acceptable for the question you want to investigate. You will be able to measure the quality of your data and show others just how good your data are.

Table 1 General guidelines for monitoring

How to use this table

1. Identify on your catchment map the potential pollution sources and/or different land uses from the headwaters to the mouth.
2. For each potential pollution source and/or land use read along the row in the table to determine the best things to test, where, when and how often.
3. Choose tests and surveys as determined by your group's expertise, equipment and objectives.

Record your decisions in your Monitoring Plan.

Key: Conductivity (salinity), DO - dissolved oxygen, FC - faecal coliform bacteria, NO_3 – nitrate, $PO_{4\,(o)}$ – orthophosphate, $PO_{4\,(t)}$ - total phosphate, Metal - heavy metals, Temp – temperature, macros - macroinvertebrates

Main purpose	Comments	Critical things to test or survey				Locating your sites			When do you test?	
		Physical/Chemical Tests	Macros	Algae	Habitat	Reference, impact and recovery sites	Sample in paired catchments	Other areas to test	Regular intervals	Other times
Establish a baseline	Essential if condition of waterway is not known.	Ph, Turbidity, Temp, Flow, Conductivity, Velocity, $PO_{4\,(o)}$, NO_3, DO, flow, $PO_{4\,(t)}$, FC	✓	✓	✓			Choose representative sites, bottom of main tributaries.	Weekly - monthly for physical / chemical tests during base flow conditions. Twice yearly for macros.	
Determine suitability for particular uses:										
Protection of aquatic ecosystems	Ecosystems are affected by many pollutants and clearing of riparian vegetation.	Turbidity, Temp, pH, Conductivity, $PO_{4\,(o)}$, NO_3, DO, $PO_{4\,(t)}$	✓	✓	✓			Sample within water body to be protected.	As above	
Drinking water	Quality determined by chemicals, bacteria and taste.	Turbidity, Conductivity, pH, taste, NO_3, FC		✓	✓			Sample drinking water.	Weekly to monthly for physl/chem tests.	
Recreation	Bacteria and aesthetics are main problems.	Turbidity, FC		✓	✓			Sample at recreation site.		During times of recreational use.
Agriculture	Farm productivity may be affected by poor water quality.	Conductivity, pH, NO_3, Pesticides, FC		✓	✓			Sample water used for agriculture.	Weekly to monthly for physical/chemical tests.	Sample water used for irrigation during the Dry Season.

Main purpose	Comments	Critical things to test or survey				Locating your sites			When do you test?	
		Physical/Chemical Tests	Macros	Algae	Habitat	Reference, impact and recovery sites	Sample in paired catchments	Other areas to test	Regular intervals	Other times
Assess impact of land uses / pollution sources:										
Forest practices	Roading, clearing and fires can lead to soil erosion and algal growth. Herbicides may be used.	Turbidity, Velocity, PO_4 (o), NO_3, Flow, Pesticides	✓	✓	✓	✓	✓			During rain
Urbanisation / stormwater	Runoff contamination and flooding are common problems.	pH, Turbidity, Velocity, PO_4 (o), NO_3, DO, Flow, FC, metals pesticides	✓	✓	✓	✓		Sample at run-off points.	Weekly to monthly for physl/chem tests.	During rain and discharge events.
Livestock operations	Manure, bacteria and nutrients from feedlots impact waterways.	Turbidity, PO_4 (o), NO_3, DO, FC	✓	✓	✓	✓			Weekly to monthly for physl/chem tests.	Per discharge from feedlot and rain.
Cropland / pastures	Soil erosion from heavy grazing. Fertiliser or herbicide runoff and salinity problems.	Turbidity, Conductivity, Velocity, PO_4 (o), NO_3, Flow, PO_4(t), FC	✓	✓	✓	✓	✓	Sample within cropping areas. Sample ground water.	Weekly to monthly for physl/chem tests.	During rain and after fertilising.
Mining operations	Sediment, tailings, dust, chemicals can have very long term impact	Turbidity, Conductivity, pH, Velocity, DO, Flow, Metals	✓		✓	✓		Sample at single point discharge sites.		During rain and discharge events.
Construction sites	High sediment and chemical runoff from poorly managed sites.	Turbidity, Conductivity, PH, Velocity, Flow, Metals	✓		✓	✓		Sample at run-off points.		During rain and discharge events.
Septic systems	Leaks, overflows and leachate can severely affect quality and cause health problems.	PO_4 (o), NO_3, FC	✓	✓		✓		sample near and away from pollution source.	Weekly to monthly for physl/chem tests.	During times of high demand, rain and recreational use of waterway
Golf courses /playing fields	Runoff carries nutrients and pesticides.	PO_4 (o), NO_3, Pesticides	✓	✓	✓	✓	✓	Sample at runoff points.	Weekly to monthly for physl/chem tests.	During rain
Dams	Changes in flow rates during filling or releases stresses aquatic ecosystem. Low DO release water is a problem.	Turbidity Temp, pH, Velocity, DO, Flow	✓		✓	✓		Profile temp and DO from top to bottom.	Weekly to monthly for physl/chem tests.	During filling of dam or release of stored water.

How is Water Quality Measured?

Community monitoring programs like the National Waterwatch Program measure a range of physical, chemical and biological aspects of the water and its surrounding environment. What to measure, where and when is the subject of a monitoring plan. Careful sampling techniques and procedures need to be followed to prevent human error and sample contamination that can result in false readings.

Physical aspects of the water that are monitored include; turbidity, temperature, and stream flow. Chemical properties measured include dissolved oxygen, phosphate, nitrates and pH. Biological properties involve collecting, identifying and counting macroinvertebrates that live in the water body, and assessing the health of the aquatic habitat, including vegetation.

Interpretation of Data

The Australian and New Zealand Environment and Conservation Council (ANZECC) is the peak Ministerial Council for inter-governmental consultation and coordination on environmental and nature conservation matters. The Council has developed the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000). The guidelines provide a reference tool for catchment management plans and policies. The most recent edition of these guidelines move away from setting recommended minimum or maximum levels towards assessing the risk to the health of aquatic ecosystems. For advice of the interpretation of your results you can contact Waterwatch NT on (08) 8999 4456.

Assessing Catchment Health

The following provides an introduction to water quality parameters and their importance in measuring the health of our waterways. Aspects of catchment health focus on either on the:

- quality of the water: physical, chemical and biological assessment; or the
- health of terrestrial habitats: habitat rating, site description and catchment survey.

The *Waterwatch* Program can provide support to community groups who wish to be involved in measuring these parameters in their local water bodies. The equipment can be supplied to *Waterwatch* groups, unless otherwise specified.

Safety is vital! Collecting and analysing water samples involves the use and disposal of chemicals which requires certain precautions. Use methods that minimise your contact with chemicals and use goggles and gloves when handling reagents. Read the material safety data sheets that come with reagents. Students must be fully supervised by their teacher in accordance with Education Department guidelines. In general, if proper safety precautions are followed, the tests in these exercises do not present significant health or environmental risks. Please contact *Waterwatch* for safety advice, technical information and materials.

See Activities 1 to 4 (p 74-87)

Physical Water Quality Parameters

Flow

Flow refers to the volume of water discharged over a given amount of time. Flow can be measured in cubic meters per second (m^3/s) or megalitres per day (ML/d). One megalitre is one million litres. An Olympic sized swimming pool is about 2.5ML.

The discharge of any waterway is directly related to the amount of water moving off the catchment into the stream channel. Discharge is affected by the seasons and associated weather patterns. Discharge increases during rain events and decreases during dry periods.

Animals and plants in and near water depend on the natural seasonal discharge patterns for growth, reproduction and the return of nutrients to the land. For example fish migrations need increased flow for spawning, and flood plains get their nutrient-rich soils from floods. Any changes in discharge may harm animals and plants in the ecosystems.

Stream velocity determines the kinds of animals and plants that live in the stream. Some need fast flowing well-oxygenated riffles, while others are adapted to quiet pools.

Velocity is the distance the water travels over a given period of time, ie the speed of the water. Velocity is measured in meters per second (m/s).

How does flow affect water quality?

Natural flow can be significantly changed by building dams or weirs to provide water for irrigation, livestock, industrial and other land uses. Water is stored behind these structures during times of high discharge and is either released downstream during drier months or pumped directly to where the water is needed. Excessive pumping of surface waters can dramatically deplete water discharge. Determining a suitable minimum discharge, or ‘environmental flow’ can assist in minimising the impact of the changed discharge patterns on native flora and fauna and water quality.

The size of a river and its discharge influence water quality. Pollution discharges will have less effect on large swiftly flowing rivers but small streams have less capacity to dilute and degrade wastes.

See Activity 5 (p 88)

Test 1: Investigating Stream Velocity

Aim

To determine the velocity of the flow in the waterway.

Equipment

- a tennis ball, apple or orange (to minimise wind interference)
- a net to capture the ball
- 10m tape or rope
- notepad and pencil
- stopwatch or watch that reads minutes and seconds

Procedure

1. Select a 10m long straight section of a stream that is free of aquatic vegetation or other obstacles that may affect flow. Avoid using a culvert or bridge if the water is speeding up as it goes through. This accelerated velocity will not give a true estimate of the surface velocity of the stream. If the flow is very slow, or if the size of your stream varies a lot over ten metres, then use a shorter distance (eg. five metres).
2. Position a 10m plastic tape (or rope) along the edge of the watercourse.
3. Place the ball on the surface near the middle of the waterway, at least two metres upstream of the end of the tape so that it has time to come up to water speed.
4. When the ball is in line with the beginning of the tape, start the stopwatch.
5. Stop the watch when the ball gets to the end of the 10m section and record the time.
6. If the ball gets caught along the way, start again.
7. Use the net to fish the ball out of the water.
8. Repeat the procedure at least five times and average the results.

Calculations

To calculate the water velocity, divide the distance travelled in metres by the time taken in seconds. Then multiply by a correction factor of 0.9 to compensate for the variability in velocity with depth and across the channel, ie: water will flow more quickly in the middle than at the edges, and more rapidly near the surface compared to the bottom.

Example:

Distance Travelled	Average Time Taken	Correction Factor	Calculation	Stream Velocity
10 m	18 seconds	0.9	$\frac{10 \text{ m x } 0.9}{18 \text{ seconds}}$	0.5 metres per second

Test 2: Determining Stream Discharge

Aim

To investigate the discharge rate of water to and from the catchment.

Procedure Overview

Measuring the cross-sectional area of water flowing through the monitoring site will enable you to calculate the discharge of water and transport rate of nutrients and sediment from the catchment.

You will need to establish a permanent reference marker near or in the water at the site in order to make future measurements of the height of the water in the waterway. You will also need to measure the depth of the bottom at regular intervals across the streambed. The depth measurements are made relative to the reference marker.

The method is best for small streams, culverts, V notch weirs, or sites located at bridges. You may be able to measure depth of slow flowing rivers by very carefully taking the measurements from a boat. If you are monitoring a large river, harbour or estuary you will not be able to do this set of measurements.

You will need to measure the cross-section at each site every time the shape of the channel has changed due to floods, eg: sand and gravel may have been scoured from the stream bed.

Care is needed when measuring the depth and width of your watercourse especially when the streambed is slippery. Do not attempt to measure the water depth if the water is above knee height or the water is flowing swiftly. School students need careful supervision to ensure their safety. Make sure that feet are well protected.

Choosing your reference mark

For man-made structures, put a reference mark such as a painted line, a metre or more above the water level (or the bed of the stream if it is dry). This mark needs to be reasonably permanent and always accessible. You will need to measure from this to the water level every time you measure the discharge. You may need to refresh the mark from time to time.

Circular culvert

For a circular culvert, it may be convenient to put the reference mark at the top of the opening. Mark the side with depth measurements to give you a permanent measuring stick.

Bridge

For a bridge**,** use the edge of the deck as the horizontal datum line and mark the bridge supports with depth measurements to give you a permanent measuring stick.

Natural channel

For a natural channel**,** the reference mark can be a spot on a tree or rock near the water's edge or, if appropriate the top of a star picket. Hammer a star picket into the bank (with the permission of the land owner) where it will be accessible when the stream is flowing but not so that it obstructs the flow. Your reference marker picket may be washed away in floods so, before choosing your site, find out the maximum height the water may reach later in the season. Look for signs of flooding like debris in tree branches, or ask the neighbours. If the stream regularly overflows the banks, choose another site. The reference marker picket should be at the spot where you do your water quality testing and above the maximum height you intend to measure. Be sure to record the position of the reference marker very accurately on your bird's eye view map and your stream cross-section diagram (when it is completed) in your Site Description.

Equipment for measuring cross-sectional area

- 50m or 100m plastic tape
- 5m metal tape, long wooden or metal ruler or weighted string
- spirit level
- clipboard, pen, paper, pencils, rubbers, short ruler
- gum-boots or wetsuit boots
- optional peg or star picket and hammer
- graph paper
- note pad and pencil

Procedure for measuring the cross-sectional area of a culvert

At a culvert, the cross-section is usually either circular or rectangular. Measure the width or diameter of the pipe. On graph paper, make a scale drawing of the culvert and count the number of squares to find the cross-sectional area.

Procedure for measuring the cross-sectional area of a stream

1. Hammer a peg into each bank above the maximum height you intend to measure discharge. The two pegs and reference marker picket should line up across the stream.
2. From one peg, stretch your measuring tape across the stream past the reference marker picket to the adjacent peg. Use the spirit level to ensure the tape is horizontal.
3. Starting from the peg on the left-hand bank (facing downstream), measure the depth (vertical distance) from the measuring tape to the stream bed with a long wooden or metal ruler, or weighted string. Aim for at least 15 to 20 measurements across the stream at regular intervals, eg: 0.1m for small streams, 0.5m for larger streams.
4. Record your measurements in the Velocity and Discharge Results Sheet. See Tables 3 and 4.
5. Mark the height of the tape on the reference picket. This is the zero depth point. Mark the side with depth measurements (0.1m intervals) to give you a permanent measuring stick for future measurements of stream discharge.

Table 2 **Example of cross-sectional data showing depth (vertical distance) from the reference height to the stream bed at 0.1 m intervals along the horizontal tape.**

Distance across stream (m)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Distance from string to bed (m)	0.88	0.9	0.93	0.97	1.03	1.09	1.18	1.24	1.27	1.29	1.3	1.28	1.27	1.24	1.18	1.13	1.06	1.01	0.95

Calculating your results

Step 1

On graph paper, plot the depth (vertical distance) from the horizontal tape (zero reference height) to the stream bed as measured at each interval. See Figure 1. Plotting the stream channel on graph paper.

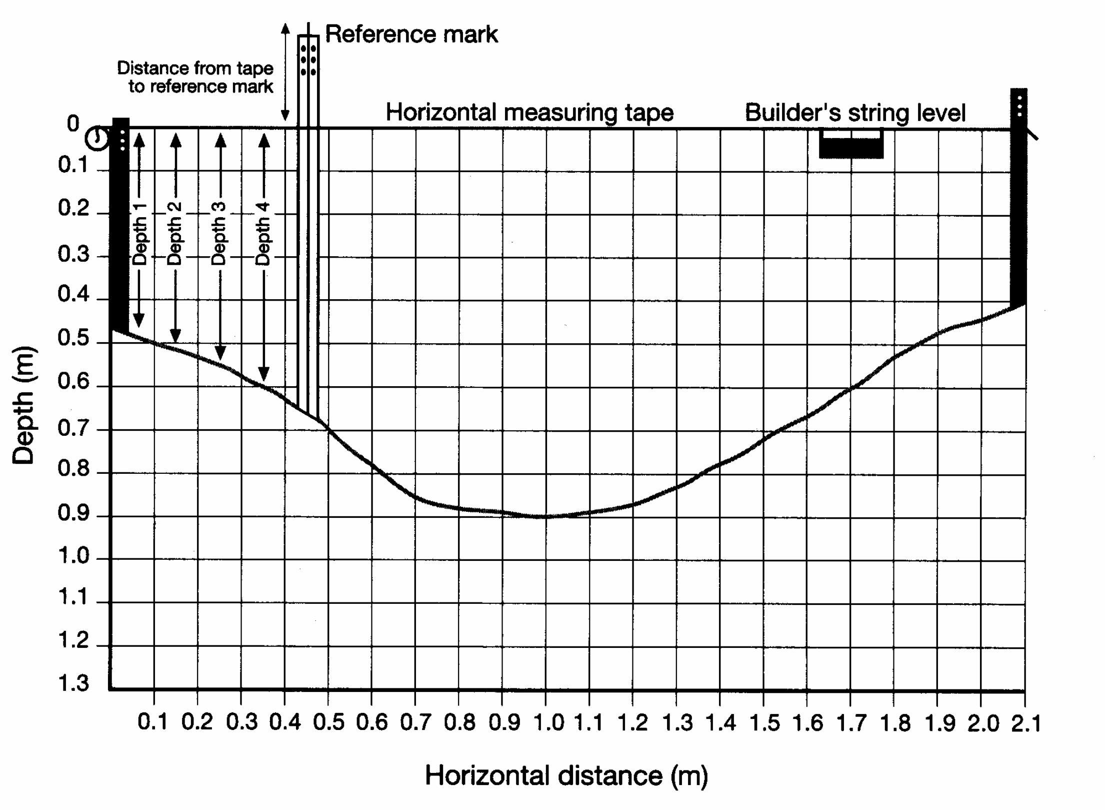


Figure 1 **Plotting the stream channel on graph paper. (Waterwatch South Australia, 1996)**

Step 2

Calculate the cross-sectional area of the watercourse. Depending upon the scale that you used on your graph paper, count the squares to calculate the area in square metres. See Figure 2: Calculating the cross-sectional area of a natural stream.

Velocity and discharge data record sheet

Use these tables if you are establishing a discharge curve for a site that does not have a gauging station or V notch weir.

Table 3 Cross-sectional data table

Distance across stream (m)																			
Distance from string to bed (m)																			

Depth (vertical distance) from the reference height to the stream bed at___m intervals along the horizontal tape.

Table 4 Discharge results table.

Date	Time	Float method				Head Rod method	Vertical distance (m) from reference mark to water surface	Cross-sectional area (m^2)	Discharge L/sec
		Distance travelled by float (m)	Average Time (sec) (at least 5 readings)	Average Velocity (m/s)	Corrected Average Velocity (m/s)	Average Velocity (5-10 readings)			

Enter your data according to the velocity method used

Step 3

Prepare a second graph of vertical distance (m) from the reference mark to the water surface (horizontal axis) and cross-sectional area m² (vertical axis). See Table 2 Depth from reference mark and cross sectional area, and Figure 3 Vertical distance from the reference mark to the water surface and cross sectional area.

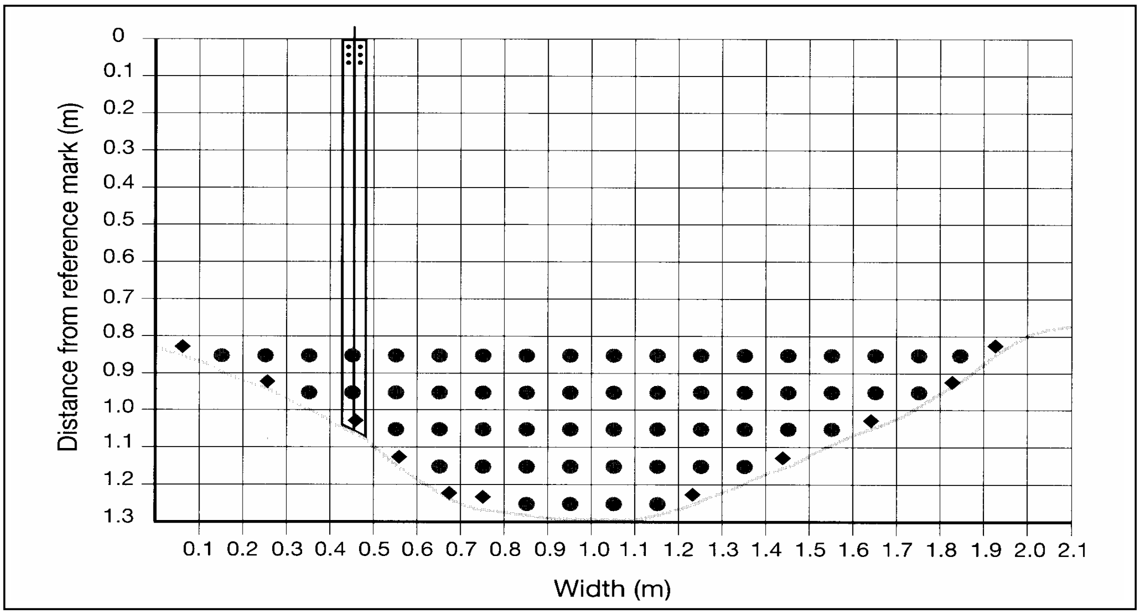


Figure 2 **Calculating the cross-sectional area of a natural stream (Waterwatch South Australia 1996)**

Table 5 **Depth from reference mark and cross-sectional area (Waterwatch South Australia 1996)**

Depth (m) from mark	Area (m^2)
1.3	0
1.2	0.055
1.1	0.145
1.0	0.265
0.9	0.425
0.8	0.615

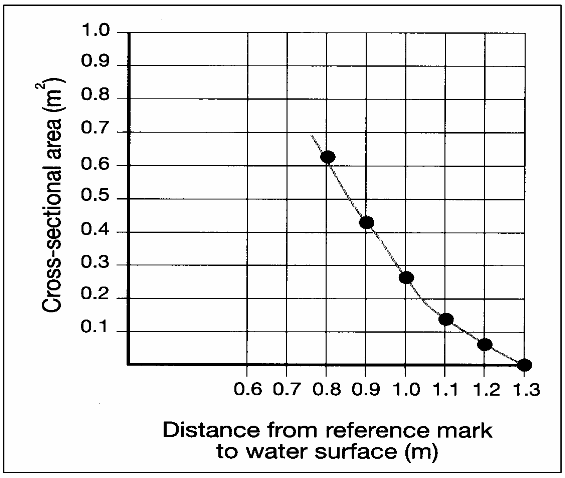


Figure 3 **Vertical distance (m) from the reference mark to the water surface and cross-sectional area (m^2) (Waterwatch South Australia 1996).**

Step 4

Every time you monitor water quality, record the height of the water in relation to your reference point. By referring to your graph of depth and cross-sectional area for the site you will be able to read off the cross-sectional area and use it to calculate the volume of water (discharge) that passed through the site at the time of monitoring. See Figure 3 above.

Calculating the discharge at your site

To calculate the discharge, multiply the stream velocity by cross-sectional area of the stream under water at your site.

Formula:

Discharge (m^3/sec) = Cross-sectional area (m^2) x Velocity (m/sec)

To convert litres per second to megalitres per day multiply by 0.0864, ie:	
1 L/sec =	$\frac{60 \text{ sec} \times 60 \text{ min} \times 24 \text{ hr}}{1{,}000{,}000}$
=	0.0864 ML/day

Example:

Cross-sectional area =	0.6 m^2
Velocity =	0.3 m/sec
Discharge =	0.6 m^2 x 0.3 m/sec
=	0.18 m^3/sec
=	180 L/sec
Discharge (megalitres/day) =	180 L/sec x 0.0864
=	15.6 ML/day

Turbidity

Turbidity is a measure of water clarity. Particles such as clay, silt, sand, algae, plankton and other substances suspended in the water, scatter the passage of light through water. To the naked eye, turbidity appears as cloudy or muddy water. It differs from colour - water can have high colour and low turbidity, eg. tannin rich waters can be tinted brown, but are very clear.

Sources of turbidity include soil erosion; waste discharge; urban runoff; eroding river banks; excessive algal growth; disturbances to a waterway channel or banks such as sand mining; disturbances to the surrounding land including logging, grazing, development, construction, road drainage, excavation for buildings, and mineral extraction.

Turbidity often increases sharply during and after a rainfall. The energy of falling and flowing water is the primary way that sediment gets dislodged and carried into rivers.

How does turbidity affect aquatic life?

Suspended particles absorb more heat, so high turbidity can raise the water temperature. This in turn can reduce the concentration of dissolved oxygen, since warm water holds less dissolved oxygen than cold water.

High turbidity reduces the amount of light passing through water from the surface. Reduced light in turn can reduce the rate of photosynthesis and subsequently lower dissolved oxygen levels.

Those plants or algae able to either photosynthesise with less light, or control their position in the water column, have an advantage over other plants or algae. This is one of the reasons why blue-green algae have a competitive advantage, as they can rise up in the column to make maximum use of the available light.

Suspended materials can clog fish gills – effectively suffocating them, reducing resistance to disease, lowering growth rates, and affecting egg and larval development. As suspended particles settle in slow flowing waters, fish eggs may be smothered.

Particles can settle into the spaces between the rocks on the bottom and decrease the amount and type of habitat available for aquatic invertebrates.

Suspended particles also provide a place both for harmful bacteria to breed and to carry attached pollutants such as excess nutrients and toxic materials. This is a concern for water supply authorities drinking water, which often requires disinfection with chlorine to kill harmful bacteria. Turbidities of less than 1 nephelometric turbidity unit (NTU) are desirable for effective disinfection.

See Activities 6 and 7 (p 89-92)

Test 3: Turbidity Testing

Aim

To measure the turbidity of a waterway.

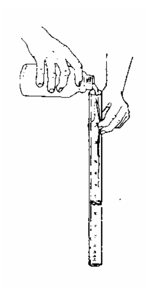
Equipment

- turbidity tube
- clean bottle or beaker
- note pad and pencil

Procedure

1. Collect a litre of water, being careful not to disturb the bottom of waterway.
2. Pour the water into the turbidity tube until the lines on the bottom can barely be seen.
3. Record the hight of the water column as an NTU value.

Using a turbidity tube



The turbidity tube measures clarity in terms of nephelometric turbidity units (NTUs). The units used for reporting turbidity are equipment specific but NTUs are the preferred standard unit for measurement. Natural (or background) turbidity levels in waterways vary from less than 1 NTU in mountain streams to more than hundreds of NTUs in lowland rivers during rainfall events.

The main limitation is that the tube is not as precise as meters and does not read low turbidity levels (< 7 NTUs) common in natural waterways and coastal rivers. The turbidity tube is adequate for most purposes but, if your waterways are generally very clear, then you may consider using more scientific equipment, such as probes.

As the tube reads turbidity by absorption of light rather than scattering of light, it over-estimates turbidity in samples that are highly coloured and under-estimates turbidity of samples containing very fine particulates such as clay.

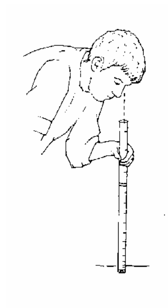


Figure 4 Using the turbidity tube (Waterwatch Aust 2000)

Interpreting your results

Interpreting turbidity readings requires information about the natural level of turbidity in your area. There are large variations in turbidity in Australian river systems; inland rivers tend to be naturally more turbid than coastal rivers. See your *Waterwatch* coordinator for assistance.

Aquatic Temperature

Water temperature is important because it affects the rate of many biological and chemical processes in the waterway and the amount of oxygen gas that can dissolve in the water. The well-being of aquatic life, from bacteria to fish, is influenced by temperature.

In general, increasing temperature tends to speed up the rate of chemical reactions, including those that occur in the body. At higher temperatures the rate of energy production in the body rises and more oxygen is consumed. At low temperatures, cold-blooded (ectothermic) animals tend to be more sluggish.

On an atomic scale, the electrons contained within atoms become more energised and tend to move more quickly around the atom at higher temperatures. As electricity is the movement of electrons, warmer waters will conduct electricity better than cooler water. For this reason, electrical conductivity (or ability of a water sample to conduct electricity) is increased in warmer water. This means that the measured electrical conductivity of a sample containing dissolved salts will be higher at warmer temperatures. To compensate for the effect of temperature on conductivity, all conductivity results are normally reported at a standard temperature (25°C).

How does temperature affect aquatic life?

An increase in temperature can have a significant effect on an aquatic ecosystem, as temperature changes affect:

- the dissolved oxygen content of water as warmer water holds less oxygen than cooler water, decreasing the amount of oxygen for the animals to respire;
- the rate of photosynthesis by aquatic plants;
- the number and metabolic rate of animals, the rate at which they process food;
- the number of bacteria and rate of activity; and
- the sensitivity of animals to toxic wastes, parasites, and diseases.

Every aquatic animal has an optimal temperature range that is best for its health. Most aquatic animals are strongly affected by temperature and can sense very small temperature changes. Since fish and most aquatic animals are cold-blooded, their metabolic rate and growth rate change with the temperature. Each species of fish has a best temperature range for growth and temperatures above or below this range reduce their growth rate.

Spawning (mating and laying eggs) success also depends on temperature. Each species has its own preferred temperature range for spawning. The survival of newly hatched embryos is dependent on the temperature being within a certain range. If temperatures are above the maximum for a long time, the embryos may die.

Macro-invertebrates that live on the bottom of a waterway are also sensitive to water temperature. Many species move along the stream to find the temperature range that suits them best.

What factors influence temperature in a water body?

Water temperature is affected by a number of factors, which include:

- temperature of the air;
- groundwater inflows to the river;
- stormwater runoff;
- cloudiness of the water;
- amount of shading; and
- warm or cold water discharges.

Shaded areas tend to be cooler than exposed reaches. The magnitude of this variation increases with the size and depth of the water body.

Water temperature of streams changes over time. Daily changes may be significant in smaller streams, with the warmest temperatures in the afternoon and the coolest at night. Streams that are deep, spring-fed, and shaded streams do not heat up as quickly. The temperature of larger streams does not change as rapidly because of the larger volume of the water.

Small upland streams have a more consistent temperature than larger rivers due to greater mixing of the water. In larger, deeper rivers, the water across the river and from top to bottom of the water column may not mix as uniformly.

Surface water tends to be warmer than the bottom. Warmer water is less dense than cold water and therefore floats on top, creating a stable warm layer which is only disturbed by strong winds. A temperature versus depth profile of a lake or dam will often show a sharp change (thermocline) where the warm layer meets the colder bottom layer.

Because of a lack of mixing of water at the thermocline, oxygen diffuses slowly from the upper layer to the lower layer. As bacteria, animals and chemical processes in the bottom layer consume what dissolved oxygen is available, the level falls. In a stratified waterbody, oxygen levels can drop to near zero (anoxic conditions) in the bottom layers. All processes requiring oxygen slow down or stop, and animals must either move to the surface waters or die.

Under anoxic conditions a different series of chemical reactions can commence, many of which involve exchange of chemicals between the sediment and the water. Several of these are of concern from an environmental point of view, including the release of biologically available phosphorus, and the production of hydrogen sulfide (rotten egg gas).

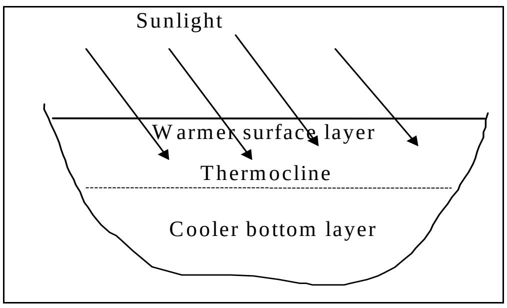


Figure 5 Temperature versus depth profile in a water body

Water quality readings taken from various depths in a stratified water body will differ. Bottom water samples would be expected to be lower in dissolved oxygen and temperature and higher in phosphorus levels compared to surface water samples. Diversity of biological communities from anoxic or low oxygen bottom waters would be low.

Human effects on temperature

Human activities can cause thermal pollution in an aquatic ecosystem. These activities raise the temperatures of streams and rivers and are most critical during the Dry Season, when lower flows and higher temperatures create more stress on the aquatic life. Human activities, which lead to higher temperatures, include:

- removal of trees and other bank vegetation which allows more sunlight to penetrate and heat the water;
- impoundments such as dams which cause the river to slow down and absorb more heat from the sun. If the pool behind the dam is larger than the original river channel, more of the water surface is exposed to sunlight;
- discharge of warmed water from industry and power plants;
- urban stormwater that has absorbed heat from the paved surfaces (streets, parking areas) before it runs into the stream; and
- erosion, which adds more particles in suspension in the water; these particles absorb heat from the sun.

See Activity 8 (p 93-94)

Test 4: Temperature Testing

Aim

To measure surface water temperature.

Equipment

- thermometer
- sample bottle and extension pole
- notepad and pencil

Procedure

1. Take a sample from the main current using the extendable pole if necessary. Place the thermometer a few centimetres into the water sample.
2. Wait one minute, until the reading stabilises.
3. Read the temperature immediately and as accurately as possible (to within 0.5°C) while the thermometer bulb is still in the water.
4. Record the result on a record sheet.
5. Rinse the thermometer with clean water, dry it and return it to its protective container.

Interpreting your results

Aquatic organisms can experience thermal stress where a temperature change of more than 2°C occurs in a 24 hour period. Observe the trend of temperature variation over the seasons and note any temperature that is unusually high or low. In estuarine waters, temperature may change between an incoming tide and on outgoing tide. See your *Waterwatch* coordinator for assistance.

Chemical Water Quality Parameters

Introduction

The way you collect your sample can have a large influence on the accuracy of your data. Your sampling procedure should not influence the parameter you are measuring. For example, if you are collecting a sample to measure turbidity you should not stir up the bottom where you are sampling as this will give a higher turbidity reading.

Some natural variation in water quality within a waterbody is to be expected. The impact that this variation can have on the data can be quite large. That means that the sample should be collected from a place in the waterway that is typical of the site you are sampling. To minimise the effect of natural variation in the data collected, you should take samples:

- from exactly the same location;
- at approximately the same time each day;
- in the same way; and
- analyse them in the same way.

Every time you collect a sample, you should record your result on field data sheet. This information is essential when you analyse your results. For example, weather and flow can affect nutrient levels, and also your interpretation of data may depend on the methods used.

It is very important to keep samples in a condition that ensures they are not modified over time. Different techniques are required to preserve different samples. See Table 6: Preservation methods and holding times for water samples.

Table 6 Preservation methods and holding times for water samples (Source: Australia/New Zealand Standard 1998).

Parameter	Preservation method	Maximum holding time	Comments
pH.	Refrigeration.	6 hours.	Fill sample bottle completely. Test sample as soon as possible.
Conductivity.	Refrigeration.	30 days.	Fill the sample bottle completely.
Turbidity.	None required.	24 hours.	Preferably test on site.
Dissolved oxygen and temperature	Not applicable.	Not applicable.	Must be analysed on site.
Faecal bacteria.	Refrigeration.	6 hours.	Use sterile sampling bottle. Fill bottle to ¾ capacity.
Nitrate.	Refrigeration. Freezing.	24 hours. 30 days.	Fill bottle to ¾ capacity. Filter on site with 045μm cellulose acetate membrane and freeze.
Phosphate.	Refrigeration. Freezing.	24 hours. 30 days.	Fill bottle to ¾ capacity. Filter on site with 045μm cellulose acetate membrane and freeze.
Pesticides, heavy metals.	Contact analytical lab for details.		

Dissolved Oxygen

Oxygen is necessary for all living things and for many of the chemical processes that take place in water. Most aquatic animals respire the oxygen dissolved in water. Waters with consistently high dissolved oxygen levels are capable of supporting many different kinds of aquatic animals.

Oxygen is both added and removed from water. Water gains oxygen from the atmosphere and from plants as a result of photosynthesis. In addition, the churning of running water helps add dissolved oxygen. Respiration (breathing) by aquatic animals, decomposition, and various chemical reactions, consume oxygen from the water body. If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken or die.

What factors influence dissolved oxygen levels?

Dissolved oxygen levels are affected by a number of factors including (See figure 6):

- water temperature;
- water movement and mixing;
- depth;
- daily and seasonal cycles; and
- industrial discharges and/or dissolving of certain gases into solution.

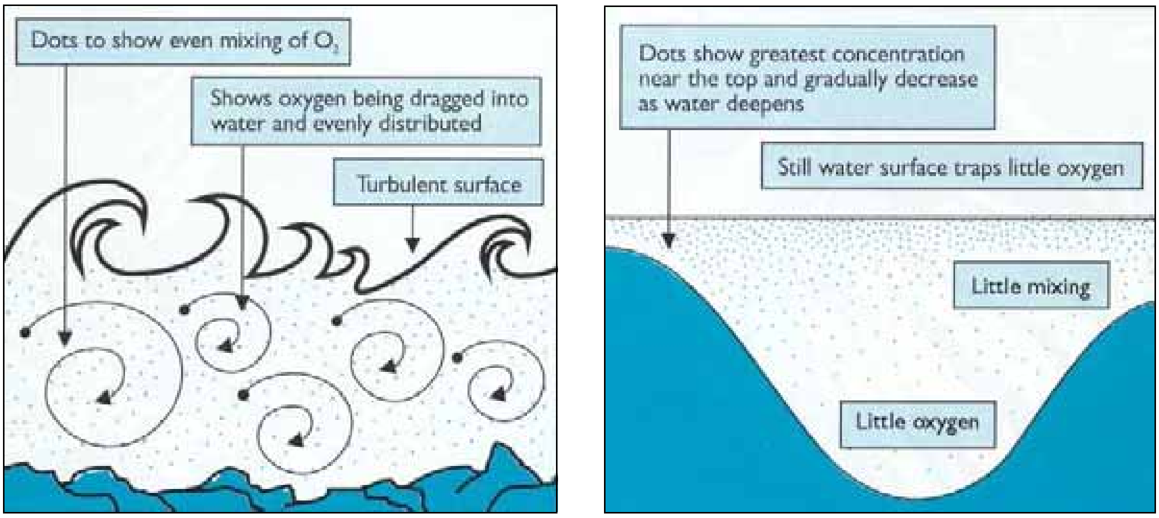


Figure 6 **Oxygen entering shallow flowing water (L) and oxygen in deep still water (R) (Waterwatch Queensland 1996)**

Water temperature

As water temperature rises the oxygen diffuses out of the water and into the atmosphere, see Figure 7. Changes in flow affect water temperature and in turn dissolved oxygen levels. Low discharge rates above and below a dam, and water removal for irrigation or water supply, particularly in the Dry Season months leads to warming and lower dissolved oxygen levels.

Removing the vegetation from stream banks exposes the water to more sunlight and higher temperatures. Thermal pollution of streams also occurs from the release of water used to cool industrial processes and power plants.

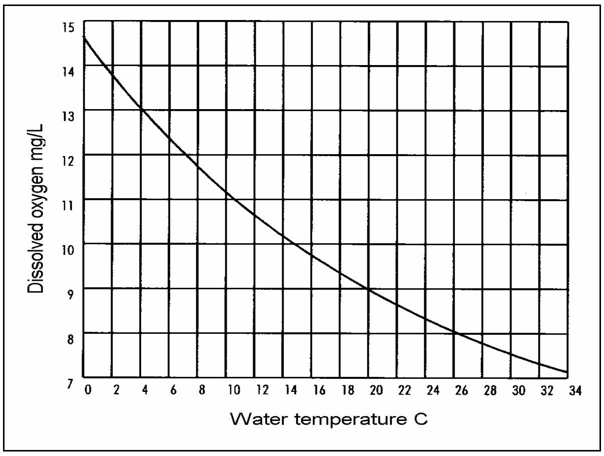


Figure 7 **Effect of temperature on dissolved oxygen levels (TVA 1992).**

Water movement and mixing

Changes in dissolved oxygen are likely to occur along the course of a waterway because all of the processes that add or remove oxygen change from upstream to downstream. For example, aeration from falling water and cooler water temperatures tends to cause high and relatively stable dissolved oxygen levels. At lower elevations, reduced shading, warmer air temperatures, less aeration, and more biological activity may lower dissolved oxygen levels. The dissolved oxygen levels in and below shallow, fast-moving rocky stretches (riffles) or waterfalls are typically higher than in slower moving stretches.

Too much dissolved oxygen can also be a problem. Below some dams, highly turbulent waters passing through turbines and spillways can create supersaturated conditions that are dangerous to fish. Fish can develop a condition called gas bubble disease by swimming through turbine blades or over the spillway to get upstream. As fish pass through this supersaturated environment, the oxygen level in their blood rises. When the fish leave, oxygen gas bubbles quickly form in their blood harming their circulation. Supersaturated conditions do not last long as excess dissolved oxygen diffuses into the air.

Depth

Shallow flowing waterways have high dissolved oxygen concentrations. In still waters such as lakes, the dissolved oxygen levels will often vary from the surface to the bottom with little dissolved oxygen in the deep, poorly mixed layers.

Daily and seasonal cycles

Dissolved oxygen levels often show a clear rising and falling pattern over 24 hours with the lowest levels occurring in the early morning. Throughout the night, the process of respiration continues and the level falls. Plant photosynthesis occurs during the day. Associated dissolved oxygen levels increase, reaching a high point in the afternoon.

Figure 8 shows a hypothetical daily cycle for dissolved oxygen concentrations. The most critical time for many aquatic animals is early morning during dry periods when dissolved oxygen levels are likely to be at their lowest. This is because river flow is low, there is little aeration, water temperature is high, and there has been no photosynthesis since sunset to offset the fall in dissolved oxygen.

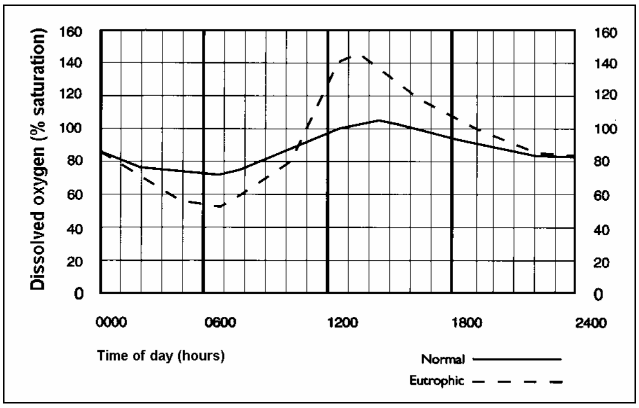


Figure 8 **Variation of dissolved oxygen in a river with lots of plant growth (eutrophic) compared with a normal river (Foster 1994)**

Industrial discharges
The discharge of waste materials, either from a point source or a diffuse source, can influence the concentration of dissolved oxygen by influencing the biological oxygen demand. Some chemicals from industrial wastes react with oxygen and decrease dissolved oxygen levels.

Biochemical Oxygen Demand

Biochemical oxygen demand, or BOD, is a measure of the amount of oxygen needed by aquatic micro-organisms, such as bacteria, to decompose organic and inorganic matter. The BOD test measures the amount of oxygen consumed by these bacteria during a specified period of time (usually 5 days at 20°C).

The demand for oxygen by micro-organisms directly affects the amount of dissolved oxygen in rivers. The greater the BOD, the more rapidly oxygen is depleted in the water. This means less oxygen is available to other forms of aquatic life, such as macro-invertebrates and fish. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic animals become stressed, suffocate, and may die.

What factors contribute to BOD?

Sources of organic matter which stimulate a high BOD include leaves and woody debris; dead plants and animals; animal manure; effluent from pulp and paper mills, waste water treatment plants, feedlots, and food-processing plants; failing septic systems; and urban stormwater runoff.

Human activity can influence the amount of dissolved oxygen in water by:

- the addition of oxygen-consuming organic wastes to the water; and/or
- the addition of nutrients

Addition of oxygen-consuming organic wastes to the water

During decomposition of organic wastes, bacteria and other micro-organisms use oxygen. If there is a large amount of organic waste in the water, then dissolved oxygen levels may fall to levels too low to support fish and other animals. Organic waste includes sewage and animal manure, organic fibres from textile and paper processing, and food wastes. Sources of organic waste include waste water from sewage treatment plants, failing septic systems; animal feedlots; stormwater runoff; discharges from food processing plants; dairies; meat packing plant discharges; and effluent from textile and paper processing plants.

Addition of nutrients

Nutrients such as nitrates and phosphates, entering the water can cause great increases in biological activity that both add and remove oxygen from the water. Nutrients stimulate extensive growth of algae and other aquatic plants, a process called eutrophication, initially increasing the dissolved oxygen due to the increase in photosynthesis. When these plants die and are decomposed by bacteria, oxygen levels fall.

See Activities 9 and 10 (p 95-98)

Test 5: Dissolved Oxygen

Aim

To assess levels of dissolved oxygen in the waterway.

Equipment

- sample bottle and stopper
- gloves
- reagents – Dissolved Oxygen Reagent Number 1, 2 and 3
- Sodium thiosulphate
- 5ml tube
- bucket
- plastic tube
- eye-dropper
- pencil and notepad

The Winkler Method Overview

The Winkler method involves filling a sample bottle completely with water (no air bubbles). The dissolved oxygen is then "fixed" using a series of reagents that form an acid compound that is titrated. Titration involves the drop-by-drop addition of a reagent that neutralises the acid compound and causes a change in the colour of the solution. The point at which the colour changes occurs is the "endpoint" and is equivalent to the amount of oxygen dissolved in the sample. The sample is usually fixed and titrated in the field at the sample site. It is possible, however, to "fix" the sample in the field and deliver it to a lab for titration.

The titration step can be completed using either an eye-dropper (resolution = 1 mg/l), syringe (resolution = 0.2 mg/l) or a digital titrator (resolution = 0.1 mg/l). The method you choose will depend on the magnitude of tolerable error specified in your monitoring plan.

Winkler method kits are easy to use, reasonably cheap per test and have good learning applications for school groups. The low cost of this type of dissolved oxygen field kit is attractive if you are relying on several teams of samplers to sample a number of sites at the same time.

The Winkler titration test uses a number of potentially hazardous chemicals so take care that the chemicals are not flicked into eyes or spilt onto skin or clothes - wear safety glasses and rubber gloves. When testing, place the liquid waste bottle, paper towels and a squirt bottle of deionised water nearby.

Manganous Sulfate can irritate eyes and skin.

Alkaline Potassium Iodide Azide can cause severe burns and is poisonous if swallowed.

Sulfuric Acid will cause severe burns, ingestion may be fatal, and inhalation can cause coughing and chest problems.

Method

1. Collect the water sample by submerging the glass bottle with the lid off into the stream. Ensure it is completely full with no air bubbles, then stopper the bottle **while still submerged** before lifting it out. (Inclining the bottle helps to remove the air bubbles).
2. Collect some more sample water in the small square bottle for use later.
3. Using gloves, open the Dissolved Oxygen Reagent No 1 and shake its contents into the bottle, avoid spillage of the contents. Top up the water level to make sure there are no air bubbles in the bottle and shake. Then open the Dissolved Oxygen Reagent No 2 and shake its contents into the bottle, repeat as above. Avoid spillage of any contents.
4. While re-stoppering the bottle, hold it over a bucket so that any spillage can be safely discarded. Add a small quantity of sample water from the small square bottle while re stoppering the bottle. This avoids air bubbles being trapped in the neck of the bottle.
5. Now holding the lid on the bottle shake it to dissolve the chemicals in it. Allow the sample to stand until the flocculent that has developed has settled. It should settle to the line marked onto the bottle (this may take longer for more saline water samples). The top half of the sample should now be clear.
6. Shake the bottle again and let it settle once more.
7. Remove the stopper from the bottle and add Dissolved Oxygen Reagent No 3. As before re-stopper the bottle over a bucket and use some more sample water. Shake once again. The third reagent should dissolve the sediment and turn the solution clear again.
8. Fill the small narrow plastic tube provided in the kit to the mark. Discard any sample water from the small square bottle. Empty the solution from the small narrow plastic tube into the square bottle. Hold the bottle with this solution in it against something white. Holding the sodium thiosulphate dropper vertical, add it drop by drop to the solution, counting each drop and swirling to mix as you do. Stop adding the drops when the change in colour occurs. Note the number of drops added to make the solution (yellow) go completely clear.
9. Each drop is equal to 1mg/l of dissolved oxygen. You may add one drop further once the colour change has occurred to be sure, if no further change occurs don't count the last drop.
10. Record your results.

Interpreting Your Results

Calculating % saturation of dissolved oxygen for fresh water samples (< 1500µS/cm)

1. Refer to Figure 9: Percentage saturation of dissolved oxygen nomogram.
2. Plot temperature (°C) on the upper scale.
3. Plot oxygen (mg/l) on the lower scale.
4. Hold a ruler between the two points.
5. The point where the ruler crosses the middle scale is the % saturation.
6. Record this result.

Calculating % saturation of dissolved oxygen for saline water samples (> 1500µS/cm)

1. You need to know the:
   - measured conductivity (µS/cm);
   - water temperature (°C); and
   - measured dissolved oxygen (mg/l).
2. Use Table 7 Effect of conductivity and temperature on potential dissolved oxygen levels (mg/l) in waters at sea level below to establish the potential dissolved oxygen:
   - locate the nearest conductivity level across the top;
   - locate the nearest temperature on the left hand side; and
   - where they cross, registers the potential dissolved oxygen for the water (mg/l).
3. Finally:
   - divide the measured dissolved oxygen by the potential dissolved oxygen; and
   - multiply this by 100 to get the per cent saturation.

Table 7 Effect of conductivity and temperature on potential dissolved oxygen levels (mg/l) in waters at sea level (Foster, 1994)

Temperature (°C)	Conductivity µS/cm				
	0	14400	28800	43200	57800
0	14.6	13.7	12.9	12.1	11.4
5	12.8	12.0	11.3	10.7	10.1
10	11.3	10.7	10.1	9.5	9.0
15	10.1	9.5	9.0	8.5	8.1
20	9.1	8.6	8.2	7.7	7.3
25	8.2	7.8	7.4	7.1	6.7
30	7.5	7.2	6.8	6.5	6.2
35	6.9	6.6	6.3	6.0	5.7

Interpreting your results

Dissolved oxygen concentrations should not fall below the 20th percentile of values typical for a waterbody in your region (ANZECC, 2000). As a guide dissolved oxygen concentrations below 3mg/l are stressful to most aquatic animals (Waterwatch Australia National Technical Manual, 2002).

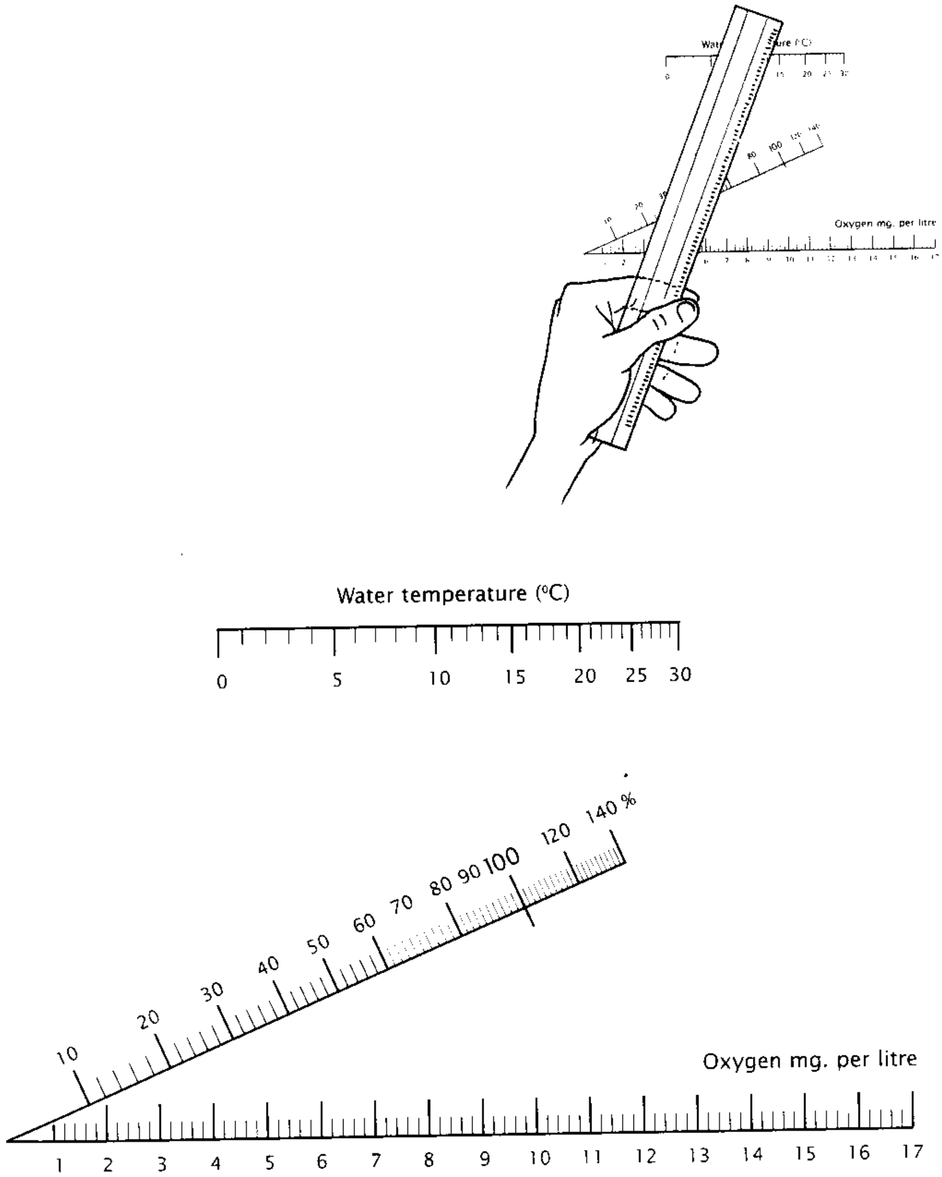


Figure 9 Percentage saturation dissolved oxygen nomogram (West 1998).

pH

pH is a measure of acidity or alkalinity of water and varies on a scale from 0 to 14 units. The acidity of water increases as the pH gets lower. Figure 10 shows the pH of some common liquids.

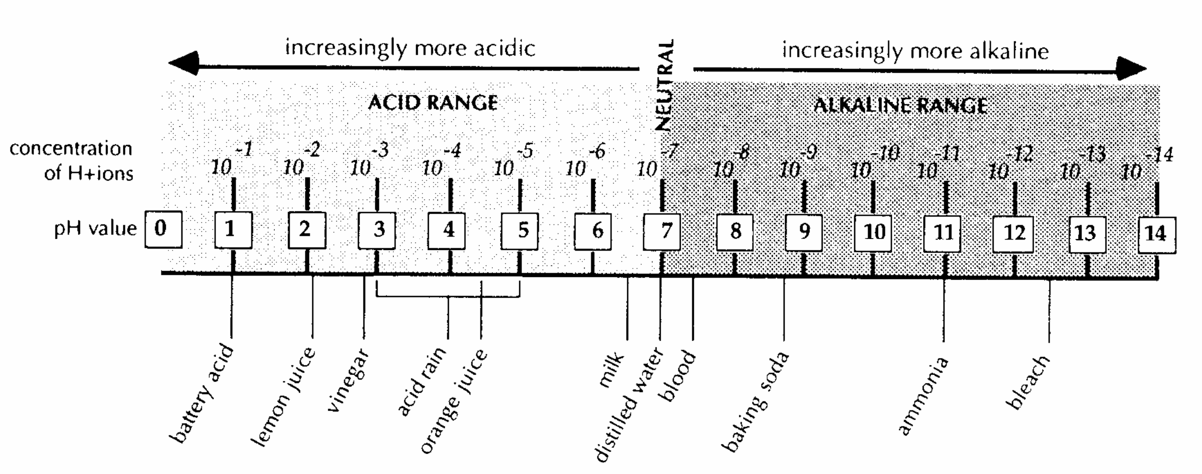


Figure 10 pH scale and pH of selected liquids (Waterwatch Aust. 2000)

All animals and plants are adapted to a certain pH range but most prefer 6.5-8.0. An increase or decrease in pH outside the normal range of a water body will cause a loss of species depending on their sensitivity.

Lower pH levels (below pH 5.5) in particular affect the immature stages of aquatic insects and fish by dissolving (leaching) toxic heavy metals into the water from the soil and sediment. Fish and other aquatic animals suffer from skin irritations, tumours, ulcers and impaired gill functioning in acidic water. Detection of low pH events requires sampling during or soon after rain events, because the acid water is soon flushed away and/or pH is returned to normal values by natural stream processes.

Extremely high or low pH values will lead to the death of all aquatic life, so to retain a healthy diversity of life in your stream, pH must be kept within a normal range.

Technical note:

Acids produce hydrogen ions (H^+); bases produce hydroxide ions (OH^-). A pH of 7 has equal amounts of hydrogen ions (H^+) and hydroxide ions (OH^-) and is considered neutral. A water sample with a pH less than 7 is acidic, and has more H^+ ions. A sample with a pH greater than 7 is basic and has more OH^- ions. The lower the number (below 7), the stronger the acid. The higher the number (above 7), the stronger the base, or the more alkaline.

pH is measured on a logarithmic scale. A drop in the pH of a water sample by 1.0 unit is equivalent to a 10 fold increase in acidity. This means that a river with a pH of 5.0 is 10 times as acidic as one with a pH of 6.0 and a water body of pH 4.0 is 100 times more acidic than one with a pH 6.0.

What affects the pH of a waterway?

pH is affected by a number of factors which include:

- respiration and photosynthesis;
- buffering capacity;
- catchment geology; and
- human caused changes in pH eg: disturbance of acid sulphates soils and industrial discharges /or dissolving of certain gases into solution.

Respiration and photosynthesis

Respiration and the photosynthetic activities of aquatic plants and algae can cause large changes in pH. Carbon dioxide (CO_2) is produced during respiration by both plants and animals twenty four hours per day. It is also consumed by plants during photosynthesis in the daylight hours.

Carbon dioxide dissolves in water to form carbonic acid H_2CO_3.

$$CO_2 + H_2O \leftrightarrow H_2CO_3$$

Carbonic acid is a weak acid. Some of its molecules ionise to make hydrogen ions H^+.

$$H_2CO_3 \leftrightarrow HCO_3^- + H^+$$

Some of the hydrogen carbonate ions (HCO_3^-) ionise further to produce more hydrogen.

$$HCO_3^- \leftrightarrow CO_3^{2-} + H^+$$

Therefore, adding more carbon dioxide to water, eg. by respiration, will increase the number of hydrogen ions and lower the pH. On the other hand, removing carbon dioxide, eg. by photosynthesis, will increase the pH. A cyclic pattern of addition and removal of carbon dioxide takes place over a 24-hour period due to photosynthesis during the day. The highest pH values usually occur at mid-afternoon (see Figure 11).

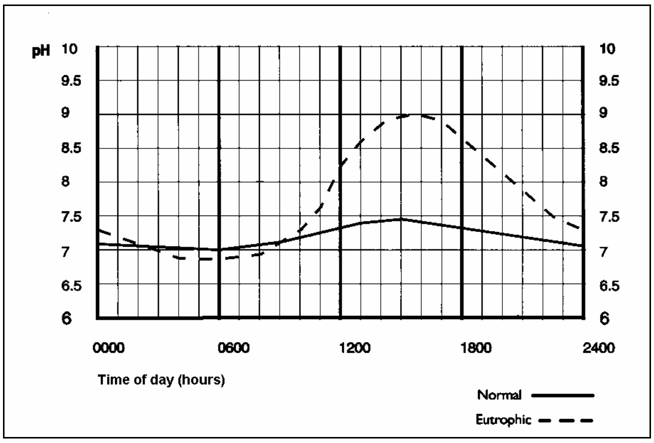


Figure 11 **Daily variation of pH for normal and nutrient enriched waters (Waterwatch Aust. 2000).**

Buffering capacity

Buffering capacity is defined as the ability of a water body to cope with the addition of an acid or a base without changing its overall pH.

Water containing low concentrations of ions eg. calcium, magnesium, sodium, chloride, sulphate and carbonate tend to be poorly buffered. The more of these ions present in the water body, the better able the water body is to accept acidic or basic inputs with little change to the overall pH. This is because the various ions bind with the added H^+ (Acid) or OH^- (Base) to neutralise their effects.

The impact of the carbonate equilibrium and the buffering capacity of a water body are linked mainly to pH. Poorly buffered waters (in general low salinity waters) are more likely to have large fluctuation in measured pH than more strongly buffered waters. In general, small streams in pristine areas tend to be poorly buffered, whilst larger lowland rivers are normally well buffered. Large variations in pH readings may not necessarily indicate problems with the testing procedure, rather the normal variation at that site.

Catchment geology

Wide variations in pH can also occur because of catchment geology. Even under natural conditions, the animal and plant communities of acid streams contain many different species from those in alkaline streams. The pH of natural waters is largely determined by the geology and soils of the catchment. Water running off limestone areas would, for example, have relatively high pH levels. On the other hand, streams and lakes in coastal dune areas may have very low pH values (sometimes less than 5) due to the presence of humic acids. These cause the brown tea colour in water.

Increasing salinity causes an increase in pH. In a typical estuary, pH would rise in line with increasing salinity levels from values of 6.5 to 7.5 in the upstream fresh water reaches, to between 8 and 8.5 in downstream fully saline coastal areas. Salinity of sea water is around 35 g/l or 35000 mg/l.

Human caused changes in pH

The most common cause of unnatural changes to pH occurs in catchments where certain types of soils (acid sulphate soils) have been disturbed and exposed to the atmosphere. Such disturbance may be the result of mining, agricultural practice or urban development. Exposure of these soils to oxygen in the atmosphere causes acids to be formed. During rain events, these acids are washed into streams where they cause short-lived, but sometimes quite large, falls in pH.

Some industrial wastes have pH values outside the normal range and thus have the potential to affect pH in receiving waters. Changes in pH can be caused by atmospheric deposition (acid rain, dry particle deposition) and from the burning of fossil fuels by cars, factories, and smelters.

See Activity 11 (p 99-101)

Test 6: pH Testing

Aim

To determine the pH of a water way.

Equipment

- sample bottles
- notepad and pencil
- pH meter
- two point calibration meter
- buffer tablets

Method

1. Prepare 250ml polyethylene sampling bottles for use by washing in phosphate free detergent and rinsing three times with tap water and three times with deionised water.
2. As per general collection procedures. If testing later, fill the sample bottle completely because the pH will change due to carbon dioxide from the air dissolving in the water completely.
3. Insert the probe into the sample and wait several minutes for it to reach equilibrium. If analysis is not carried out in the field refrigerate (or place on ice) and test within 6 hours.
4. Record results

Calibration

Meters must be calibrated with buffer solutions prior to sampling and periodically during sampling, eg: every fifth sample, to check if the meter has drifted off calibration.

If you are using a two point calibration meter, use two buffer solutions at 4.0 and 7.0. Buffer tablets can be purchased from test kit supply companies and must be used within their expiry date. A buffer solution of pH 4.0 will last three months, but a solution of pH 7.0 will last six months if stored in a cool dark place.

Interpreting your results

For baseline monitoring, interpretation of pH values requires some knowledge of the natural ranges likely to be found in the catchment. For example, a pH of 6.5 might be normal in some streams, but if found in a limestone catchment would indicate a possible problem.

Be aware of the potential effect on pH of daily and seasonal changes in photosynthetic activity of aquatic plants. If sampling in estuaries, note the state of the tide and also record the conductivity readings before attempting to interpret variations in pH.

Conductivity

Electrical conductivity can be measured in terms of the ability of water to pass an electrical current. This ability depends on the presence of salts and hence conductivity is used as a measure of salinity. Inorganic solids dissolved in water produce ions that conduct an electric current. These ions include chloride, nitrate and sulfate (anions which carry a negative charge), and sodium, magnesium, calcium, ammonium, iron and aluminium (cations which carry a positive charge). Organic compounds like oil, alcohol and sugar conduct electricity poorly and have a low conductivity when measured in water. Pure deionised water does not conduct at all since it contains no ions.

Aquatic plants and animals need the natural salts contained in water for growth. Some species are adapted to a low range of salts while others need higher levels. However, if conductivity increases above the normal range of a particular waterway, the natural community will become stressed and, depending on their degree of sensitivity, species will start to disappear.

Salt water intrusion of the previously freshwater floodplains of the Mary River has resulted in extensive die back of Melaleuca forests.

As inland waterbodies dry up conductivity levels dramatically increase, as salt levels concentrate. Some species, such as the central Australian fish the Lake Eyre Hardyhead (*Craterocephalus eyresii*), have adapted to become tolerant of increased salinity.

What factors influence the conductivity of a water body?

Conductivity is affected by a number of factors including:

- temperature;
- geology;
- flow;
- water extraction and vegetation clearance; and
- saline discharges.

Temperature

Conductivity is affected by temperature and increases 2% for every 1°C rise in temperature. The warmer the water, the higher the conductivity. For this reason, results are reported as conductivity at 25°C.

Geology

Conductivity in rivers is affected primarily by the geology of the area through which the water flows. Rivers that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionise (dissolve to form ions) when washed into the water. On the other hand, rivers that run through areas with clay soils tend to have higher conductivity due to the presence of materials that ionise when washed into the river. Groundwater inflows can have the same effects depending on the bedrock they flow through.

Flow

Conductivity varies with flow. Levels are generally lowest during high flows because of the high proportion of surface runoff water to base flow. Conductivity increases as the river returns to normal flow, with extreme levels occurring during droughts.

Water extraction and vegetation clearance

Changes to vegetation or agricultural activity, particularly irrigation, affect groundwater levels and natural water balances. The serious problems that occur in the Murray-Darling Basin are caused by removal of vegetation, application of irrigation water and the subsequent rise in water tables, bringing salt to the surface. The salt affects crops and is eventually flushed into the river causing salinity problems.

Saline discharges

Human-caused changes to catchments can affect the conductivity of run-off water. Relatively small changes can occur due to general agricultural and/or urban development. However, discharges to rivers can change the conductivity depending on their make-up. A failing sewage system raises the conductivity because of its chloride, phosphate, and nitrate content, but an oil spill would lower the conductivity. The discharge of heavy metals into a river ecosystem could raise the conductivity as metallic ions are introduced into the river. Water used for irrigation can pick up salts in the soil, raising conductivity when returning to the river.

Table 8 **Normal conductivity ranges of various water bodies (Suttar 1990)**

Water type	Conductivity (µS/cm)
Pure rainwater	< 15
Freshwater rivers	0 – 800
Marginal river water	800 – 1600
Brackish water	1600 – 4800
Saline water	> 4800
Seawater	51 500

See Activities 12 and 13 (p102 to 107)

Test 7: Conductivity Testing

Aim

To determine the conductivity of the waterway.

Equipment

- sample bottles
- electrical Conductivity probe
- calibration standards
- deionised water
- notepad and pencil

Method

1. Prepare 500 ml polyethylene sampling bottles for use by washing in phosphate free detergent and rinsing three times with tap water and three times with deionised water.
2. Sample as per general collection procedures filling the bottle to 250ml
3. Insert the probe into the sample and wait several minutes for it to reach equilibrium. If analysis is not carried out in the field, refrigerate and test within 30 days.
4. Record results in µS/cm (EC units).

Note: If the sample container is too small (<100 ml), the conductivity reading will be erroneously low.

Calibration

Use a conductivity calibration solution (usually potassium chloride - KCL) to calibrate the meter to the range that you will be measuring. For example, a 0.01 molar KCl solution will have a conductivity of 1413µS/cm, and a 0.001 molar KCl solution will have a conductivity of 147µS/cm.

A small volume (100mls) of calibration solution should be tipped into a clean container for use when calibrating the meter. Do not immerse the meter or probe in the stock solution because this will contaminate it, making it unusable. Rinse the electrodes with deionised water.

Interpreting your results

Each waterway tends to have a relatively consistent range of electrical conductivity values that, once known, can be used as a baseline against which to compare regular measurements of conductivity. Significant changes in conductivity (ie. equal to or greater than defined trigger values) may then indicate that a discharge or some other source of contamination has entered the waterway (Waterwatch Australia National Technical Manual, 2002). The ANZECC (2000) trigger values range from 20 µS/cm (in upland rivers in tropical Australia and lakes in south-east Australia) to 5000µS/cm (in lowland rivers in south-central Australia). The typical conductivity of various types of water is included in Table 8 (previous page).

Phosphates

Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. If phosphorus in the waterway is in short supply, an increase can, under the right conditions, set off a chain of events in a river including accelerated plant growth, algal blooms, low dissolved oxygen and the death of certain fish, invertebrates and other aquatic animals.

There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilised lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, detergents in stormwater runoff and commercial cleaning preparations.

Forms of phosphorus

Phosphorus has a complicated story. Pure "elemental" phosphorus (P) is rare in nature. Phosphorus usually exists as part of a phosphate molecule (PO_4^{3-}). Phosphates are classified as:

- *Condensed phosphates* - which include pyrometa and other polyphosphates in laundering and cleaning agents.
- *Inorganic or orthophosphates* - eg. detergents and fertilisers. The term "ortho" refers to the configuration of covalent bonds between phosphorus and oxygen. Orthophosphates are in the form required by plants for growth.
- *Organic phosphate*s - which consists of a phosphate molecule associated with a carbon-based molecule in solution and occurs in detritus and particles and in the bodies of plants and animals. Animals that eat plants use organic phosphate for growth eg. bones and teeth.

Both inorganic and organic phosphate can be either dissolved in water or attached to suspended particles in the water column or in bottom sediments.

How do phosphates influence water quality?

In many water bodies, it appears that low levels of phosphate limit the growth of aquatic plants. A sudden increase in phosphorus can stimulate great increases in large aquatic plants (macrophytes) or microscopic plants (algal bloom). An algal bloom may cause an initial increase in dissolved oxygen due to additional photosynthesis. After the mass of algae die however, decomposing bacteria consume large amounts of oxygen, ultimately decreasing levels of dissolved oxygen available to other organisms in the aquatic system.

Continued addition of phosphate can lead to choking with aquatic weeds and decaying vegetation, which in turn elevates temperature and changes other river characteristics, eg. macro-invertebrate and fish populations. Rivers in this condition are described as *eutrophic* and the process of nutrient enrichment is *eutrophication***.**

Increased phosphate levels stimulate blue-green algal blooms which in turn leads to increased turbidity, pH changes, a reduction in biodiversity, and the occasional production of toxins and unpleasant odours. The toxins can cause the death of stock, birth defects and inhibit the immune and nervous systems. Australia has the "world record" for the largest blue-green algal bloom of approximately 1,000km in the Darling River in 1991/92.

Increased nutrients in a river system eventually affect lakes and oceans. The input of nutrients in a lake can cause large increases in weed growth and lower oxygen levels.

Phosphates do not pose a human or animal health risk unless they are present in very high concentrations. Even then, they probably do little more than interfere with digestion. Therefore, phosphate is not regulated in our drinking water.

What factors influences the presence of phosphorus in a water body?

The phosphorus cycle

Phosphorus moves through the environment, changing form as it does so (see Figure 12).

Biological activity

Aquatic plants take in dissolved inorganic phosphate and convert it to organic phosphate in their tissues, eg. leaves and stems. Aquatic animals get the organic phosphate they need by eating either aquatic plants, other animals, or decomposing plant and animal material. As plants and animals excrete wastes or die, the organic phosphate they contain sinks to the bottom. Bacterial decay converts it back to inorganic phosphate. Inorganic phosphate gets back into the water column when the bottom is stirred up by animals, human activity, chemical interactions, or water currents. Then it is taken up by plants and the cycle begins again. Mechanical disturbance of sediments, through the actions of burrowing animals or wind and wave action, can increase the rate of phosphate release from sediments.

Stratification

There is some evidence that stratification in lakes can indirectly influence phosphate levels in the water by lowering pH and dissolved oxygen levels. Under these conditions phosphate release from sediments increases. The presence of high levels of some other chemicals, namely iron and manganese, can also enhance the release of phosphate from sediments.

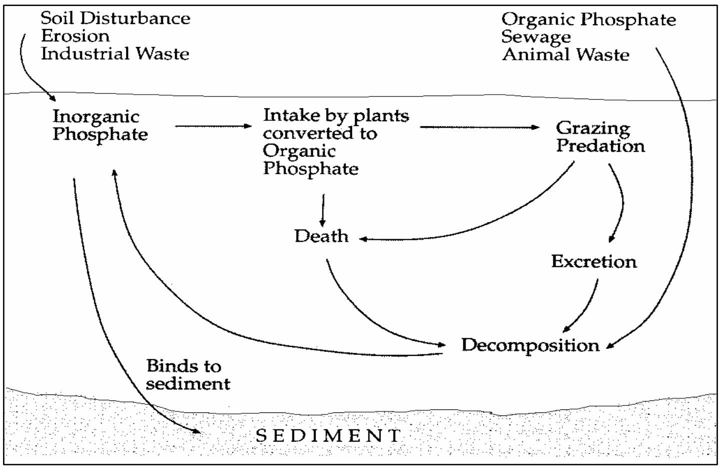


Figure 12 The phosphorus cycle. Phosphorus changes form as it cycles through the aquatic environment (Behar 1997).

Flow

In a river system, phosphate tends to move downstream as the current carries decomposing plant and animal tissue and dissolved phosphate. It becomes stationary only when it is taken up by plants or is bound to particles that settle to the bottom of pools and lakes.

See Activities 14 to 16 (p 108-115)

Test 8: Testing for Phosphates

Aim

To determine the concentration of phosphorus in the waterway.

Equipment

- stop watch or watch with a second hand
- test tubes
- photometer
- reagents No 1 and No 2 (*Waterwatch* kit)
- phosphate LR calibration chart
- notepad and pencil

Procedure using a photometer

1. Fill the both 10 ml test tubes with sample water to the 10 ml mark
2. To one of the 10 ml samples, clean with a tissue and then place in the hollow of the photometer for later
3. To the other 10 ml sample do the following:
4. Add one phosphate No 1 LR tablet, crush and mix to dissolve
5. Add one phosphate No 2 LR tablet, crush and mix to dissolve
6. Stand for 10 minutes to allow for full colour development
7. Select wave length 640nm on the photometer
8. Just before reading the sample with the reagents, set the meter to 100 using the blank (the sample without reagents), keeping your finger down on the button until the meter reads '100', then quickly take out the blank and put in the sample with the reagents
9. Take photometer reading and consult the Phosphate LR calibration chart

Interpreting your results

With access to a database about the waterway or similar waterways it becomes clear if the detected phosphate levels are significant. Contact *Waterwatch* in your area for advice on the ANZECC (2000) Guidelines.

Nitrates

Nitrate is one form of nitrogen. Nitrogen is found in several different forms in terrestrial and aquatic ecosystems, including ammonium ions (NH_4), ammonia (NH_3), nitrate (NO_3), and nitrite ($N0_2$). High nitrate levels can upset the delicate balance of an aquatic ecosystem and pose a threat to human health in drinking water.

The nitrogen cycle

Nitrogen is recycled continually by plants and animals. Most of the conversions from one form of nitrogen to another are carried out by bacteria. Most plants cannot use nitrogen gas (N_2) which is the form of nitrogen in the air. However, blue-green algae in waterways and some kinds of land plants (legumes) that have nitrogen-fixing bacteria, convert N_2 from the atmosphere into nitrate (NO_3), the form used by plants. Lightning also converts nitrogen gas (N_2) to nitrate. Nitrates are taken up by the plants and used to build proteins (organic nitrogen). Animals eat the plants and use the organic nitrogen to build their own proteins. When plants and animals die or when animals excrete their wastes, nitrogen is released in the form of ammonium (NH_4), which is oxidised (addition of oxygen) to nitrates by nitrifying bacteria. This process is known as *nitrification*:

Ammonium (NH_4) converts to nitrite ($N0_2$) which converts to nitrate ($N0_3$)

Nitrites ($N0_2$), ammonia (NH_3), and ammonium ions (NH_4) are intermediate forms of nitrogen in aquatic systems and are rare because they are quickly oxidised by bacteria to nitrate or, in the case of ammonia and ammonium, are quickly returned back to the atmosphere as nitrogen gas. Some bacteria convert nitrate back to nitrogen gas (N_2) through a process known as denitrification.

Nitrate ($N0_3$) from the breakdown of plant and animal matter can make its way into the groundwater, where it moves easily through aquifers to reach the surface or remain underground for long periods.

Nitrate is relatively plentiful in fresh water, while phosphate is relatively scarce, making phosphate a limiting nutrient in plant growth. In salt water ecosystems, nitrogen is much less abundant, making it the key nutrient limiting algal growth.

What factors influence the presence of nitrate in a water body?

Nitrate tends to move from the land into rivers more quickly than phosphate because it dissolves in water more readily. Natural sources of nitrate include the soil, animal wastes, and decomposing plants. The main human sources of nitrate are sewage, fertilisers, and wastes from farmyards and domesticated animals.

Sewage can enter the water from sewage treatment plant discharges and failing on-site septic systems. In the effluent of sewage treatment plants, nitrate can range up to 30mg/l as N.

Fertilisers enter as runoff from lawns, golf courses, and crop land.

Industrial discharges that contain corrosion inhibitors and runoff from erosion areas also contribute to nitrate levels in waterways.

The Nitrogen cycle

Nitrogen cycles through the environment, changing form as it does so, see Figure 13: The nitrogen cycle.

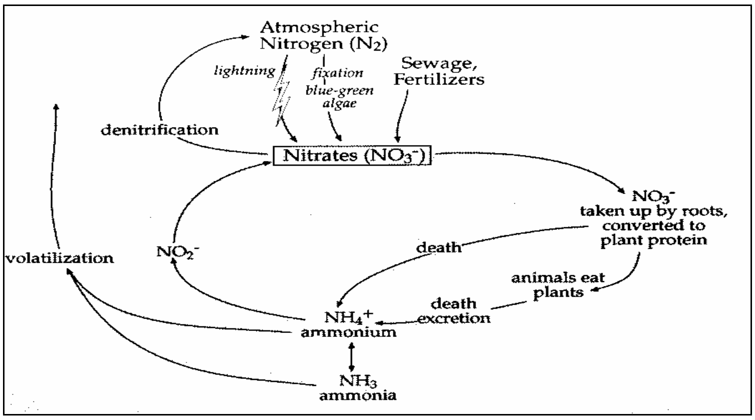


Figure 13 The nitrogen cycle (Behar 1997).

For more information on the fixation of nitrogen by marine blue green algae (which occurs off the NT coastline) Link to http://www.lpe.nt.gov.au/enviro/Fact/faq6.htm.

How do nitrates, nitrites, and ammonium affect water quality and human health?

Nitrate is an essential plant nutrient. The background level of ammonia or nitrate in surface water is typically low (less than 1mg/l). Nitrite is commonly less than 10 percent of the nitrite/nitrate total (sometimes called NOx). In excessive amounts, nitrates can cause significant water quality problems. Excess nitrate, together with phosphorus, can accelerate *eutrophication****,** causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the waterway. This, in turn, may lower dissolved oxygen levels and increase temperature.

Nitrate is changed to nitrite in the intestine of warm blooded animals. Excess nitrite can cause hypoxia (low levels of dissolved oxygen in the blood) and can become toxic to warm blooded animals at higher concentrations (1mg/l or higher) under certain conditions. Methaemoglobonaemia (blue baby syndrome) is caused by excess nitrite. The upper limit for nitrate in drinking water is 11mg/l as N.

*Continued addition of nutrients can lead to choking with aquatic weeds and decaying vegetation, which in turn elevates temperature and changes other river characteristics, eg. macro-invertebrate and fish populations. Rivers in this condition are described as *eutrophic* and the process of nutrient enrichment is *eutrophication.*

See Activity 17 (p 116-117)

Test 9: Testing for Nitrates

Aim

To determine the concentration of nitrates in the waterway.

Equipment

- stop watch or watch with a second hand
- test tubes
- photometer
- reagents including nitrate test powder, 'Nitratest' tablet and 'Nitricol' tablet. (*Waterwatch* kit)
- Nitratest calibration chart
- notepad and pencil

Procedure

1. Fill the 20 ml test tube with sample water to the 20 ml mark
2. Fill another 10 ml test tube with sample water and place in the hollow of the photometer for later.
3. Add one level spoonful of the nitrate test powder and one 'Nitratest' tablet. Do not crush the tablet. Replace the screw cap on the plastic tube and shake well for one minute.
4. Allow the tube to stand for about one minute and then gently invert three to four times to aid mixing of the sediments. Allow the tube to stand for two more minutes or longer to ensure complete settlement.
5. Remove the screw cap and wipe around the top of the tube with a clean tissue. Carefully decant the clear solution into a 10 ml test tube filling to the 10 ml mark.
6. Add one 'Nitricol' tablet, crush and mix to dissolve.
7. Stand for 10 minutes for full colour development
8. Select wavelength 570nm on the photometer
9. Just before reading the sample with the reagents, set the meter to 100 using the blank (the sample without reagents), keeping your finger down on the button until the meter reads '100', then quickly take out the blank and put in the sample with the reagents
10. Take the photometer reading and consult the Nitratest calibration chart

Interpreting your results

With an understanding of the typical background nitrogen levels in the catchment the relevant trigger levels can be determined. The natural concentration of ammonia or nitrite in surface water is typically low (less than 1mg/l). Nitrite is commonly less than 10% of the nitrite/nitrate total. In excessive amounts, nitrates can cause significant water quality problems (Waterwatch Australia National Technical Manual, 2002). See your local *Waterwatch* coordinator for assistance.

Water Quality Results

Table 9 Water quality results

Record your results and the type of equipment and method you used, and mystery or replicate sample results

Site:

Date:

Time:

Parameter	Equipment item and number	Sample result (delete units that do not apply)	Replicate sample results
Flow velocity		m/s	m/s
Discharge		L/s	L/s
Temperature		°C	°C
Turbidity		NTU metres	NTU metres
Conductivity		µS/cm	µS/cm
pH		pH units	pH units
Dissolved oxygen		mg/l % sat	mg/l % sat
Total phosphorus		mg/l P	mg/l P
Nitrate		mg/l N	mg/l N

Pesticides and Heavy Metals

Pesticides

Pesticides are chemical substances (or mixtures of substances) used to control the growth of insects (insecticides), fungi (fungicides) and weeds (herbicides). They play an important part in the economic production of many agricultural commodities, in insect and weed control in urban areas and in the control of diseases such as malaria. By law, all pesticides are thoroughly screened for health and environmental effects before registration.

Pesticides get into water from direct use in the waterway - for example to control mosquitoes or aquatic weeds - or from land-based applications, aerial drift, or in runoff waters. Leaching through soils can lead to some pesticides being found in groundwater supplies.

Pesticides remain active in the environment for some time after they have been used. This is referred to as the persistence of the pesticide. In aquatic environments, the persistence of different pesticides varies widely from days to years, depending upon the type of pesticide. Each pesticide's persistence is also influenced by factors such as temperature, light, acidity and salinity. Most insecticides in current use are relatively non-persistent (in contrast to earlier insecticides) but some of the herbicides can persist for several months or longer.

Many pesticides are very soluble in water while others are less soluble and are more likely to be found attached to suspended soil particles or sediments. Some persistent pesticides tend to accumulate in animal tissues.

Some insecticides are highly toxic to aquatic animals. Effects can be lethal, although it is worth noting that the presence of pesticide residues in fish sampled following a fish kill, is not conclusive evidence that the pesticide was the cause of death. For example, low dissolved oxygen may have triggered the fish kill. Other insecticides can have more subtle, sub-lethal effects on aquatic animals, such as a reduction in vigour or reproductive ability.

Herbicides are generally considered to have low toxicity to aquatic animals, but they may have adverse, chronic effects. They may also impair growth of some aquatic plants and algae.

Heavy Metals

Heavy metals are a group of metals which are often associated with pollution and toxicity. Examples of these metals include copper, zinc, cadmium, lead and mercury. Although trace amounts of some heavy metals such as copper and zinc are essential nutrients for the growth of plants and animals, excessive amounts of these metals cause severe disease problems.

Heavy metals are found naturally in many aquatic environments. They are a result of rocks weathering in the catchment. Natural concentrations in mineral-rich areas can be quite high. Heavy metals are most often attached to suspended soil particles in the water and to bottom sediments. Concentrations of metals dissolved in water are generally very low.

Many heavy metals are very toxic to aquatic animals. Even those, essential for growth can have adverse effects at only slightly higher than normal concentrations. The ability of aquatic animals to absorb heavy metals, and the degree of toxicity to those animals, can be influenced by several factors. These include the chemical form of the metal, the presence of other metals, salinity levels, temperature and dissolved oxygen levels. Some heavy metals can accumulate in the tissues of aquatic animals.

What are some sources of heavy metals?

Industrial and mining activities are the major sources of heavy metal contamination in Australian waters. Discharge to waterways often occurs when mines are being drained. Other sources of heavy metal contamination can be from stormwater runoff from urban areas. In agriculture, copper and zinc are sometimes applied in small amounts to fertilisers, while cadmium and zinc may occur as impurities in some phosphate fertilisers. Copper is also used in several pesticide formulations. In the Northern Territory there are also instances where heavy metals are naturally occurring in substrates that are in contact with waterways.

Testing for Pesticides and Heavy Metals

It is recommended that you contact your closest laboratory for advice on collecting and analysing water for evidence of pesticides or heavy metals. Obtain further advice from your local *Waterwatch* coordinator. Be aware that there will be a cost involved to test pesticides and heavy metals.

There are many issues to be considered when monitoring for pesticides and heavy metals, including where to sample, what to sample and what to measure. No single test can indicate what pesticides and heavy metals are present in a sample. Some companies now market a range of semi-quantitative field kits but accurate pesticides and heavy metal analyses can only be carried out by specialised laboratories.

Specially treated bottles are required for pesticides and heavy metal sample collection and can be obtained from the testing laboratory.

See Activities 18 and 19 (P 118-119)

Biological Water Quality Parameters

Macro-invertebrate Sampling

What are Macroinvertebrates and why are they important?

Within Australia there is a huge diversity of animals which live together in our waterways. They include frogs, turtles, snakes, fish, birds and macro-invertebrates. Of all the animals however, it is the macro-invertebrate group that appears to be the best indicator of waterway health.

An aquatic macro-invertebrate is an animal without a backbone, that spends all or part of its life in water ie. streams, rivers, ponds, estuaries, wetlands, drains and lakes. The word ‘macro’ means large enough to be seen with the unaided eye and contrasts with the word “micro” which is used for microscopic organisms that are best seen with a magnifying lens.

There are many kinds of macro-invertebrates in our waterways. They include worms, snails, mites, bugs, beetles, dragonflies and freshwater crayfish. Some of these, like mites, are very small, less than a millimetre in length. Others, like needle bugs can grow to over 4 cm in length.

A group of different macro-invertebrate organisms living together in the same aquatic habitat is called a biological community. Macroinvertebrate communities inhabit all types of waters from fast flowing rivers with rocky bottoms, to sluggish meandering rivers with sand and mud bottoms, to heavily vegetated lagoons or dams.

Other aquatic animals like fish, frogs and birds depend on macro-invertebrates as their main source of food. The greater the variety of waterbugs in a stream, the more chance that animals higher up the food chain will also be living there.

Classification of macroinvertebrates

It can be quite confusing dealing with the huge variety of living things, so biologists have developed a system which puts living things into groups. The names of the groups are kingdom, phylum, class, order, family, genus and species. Within a kingdom there are groups called phyla (plural) or phylum (singular); within a phylum there are classes and so on. A kingdom contains the widest variety of animals whilst the species group contains animals that are most alike. Macroinvertebrates are part of the Animal Kingdom. The list below shows how the freshwater prawn is scientifically written:

- Kingdom: Animalia
- Phylum: Arthropoda
- Class: Crustacea
- Order: Decapoda
- Family: Palaemonidae
- Genus: it could be one of four eg *Macrobrachium*
- Species*:* it could be one of many eg *Macrobrachium australiense*

(Note: Both genus and species are written in italics: the name of the genus always begins with a capital letter and the species with a lower case letter.)

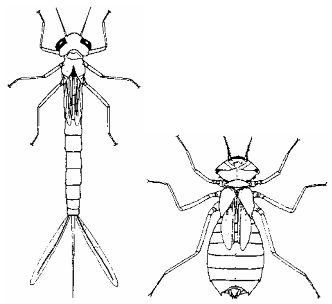
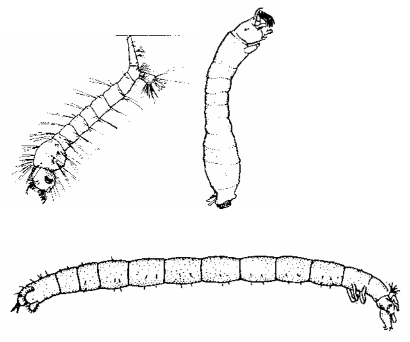
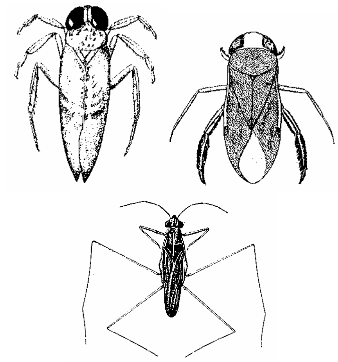
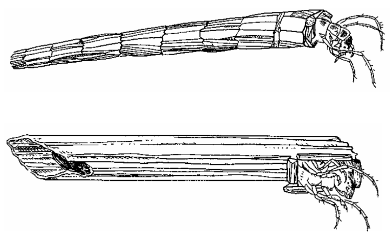
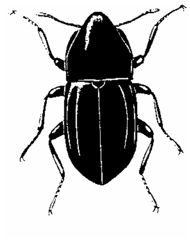
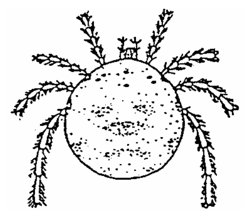
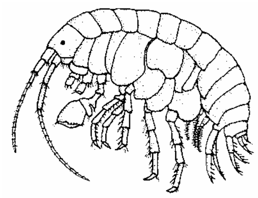
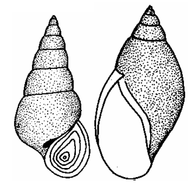
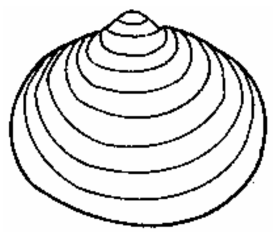
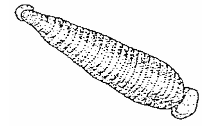
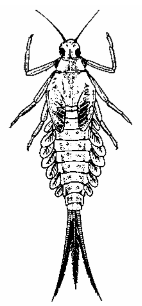
ODONATA (Damsel & Dragonflies) 	DIPTERA (Flies and Midges) 	HEMIPTERA (Waterbugs) 
TRICHOPTERA (Caddis Flies) 	COLEOPTERA (Beetles) 	ARACHNIDA (Water Mites) 
DECAPODA (Crayfish & Freshwater Shrimp) 	AMPHIPODA (Side Swimmers) 	GASTROPODA (Snails) 
BIVALVIA (Mussels) 	 PLATYHELMINTHES (Flatworms) ANNELIDA (Leeches) 	EPHEMEROPTERA (Mayflies) 

Figure 14 Examples of common Macroinvertebrates (Waterwatch 1997).

What can macro-invertebrate communities indicate about the health of waterways?

Sampling will reveal information about the macro-invertebrate community and will help tell the story about a waterway. As a group, the animals have useful characteristics that an individual animal cannot have. These are abundance, diversity, composition, and pollution tolerance.

Abundance

Abundance refers to the number of animals present. Excessively large numbers of macro-invertebrates, particularly gastropod snails, tend to be found in water enriched with nutrients. However, small numbers may indicate erosion, toxic pollution or scouring by floodwaters.

Diversity

Diversity refers to the number of different types of animal present. Healthy streams usually have a greater diversity than degraded streams, although the diversity in headwaters may be naturally low due to a lack of different types of food. Communities with many different species appear to be more stable and healthy than less diverse ones.

Composition

Composition of the community refers to the proportion of different types of animals living together. A sample from healthy streams tends to contain a good number of mayflies, stoneflies and caddis flies. However, if the sample contains a lot of worms and midge larvae (chironomids), the stream is probably degraded. One way of analysing the composition is through the pollution tolerance of the macroinvertebrates in the sample.

Pollution tolerance

Pollution tolerance refers to the tolerance of animals to organic pollution from nutrients, sewage, etc. For example, most mayfly families are intolerant of pollution whilst worms are more tolerant. Pollution tolerant animals do occur in natural streams where there is low dissolved oxygen.

What are the characteristics of the aquatic environment that affect macro-invertebrates?

The physical, chemical and biological characteristics of a river vary from its headwaters to the lowlands and in turn influence the composition of macro-invertebrate communities downstream. Macroinvertebrates are affected by a number of biological, physical and chemical factors including:

Table 10 Characteristics of the aquatic environment that affect macro-invertebrates

Physical factors	Chemical factors	Biological factors
Types of habitats present	pH	Seasons
Velocity of current	Dissolved O_2	Amount of available food
River base composition	Nutrients	
Total flow		
Water depth and clarity		
Temperature		
Shade		

Physical characteristics

Riffle, edgewater and pool habitats vary in physical conditions which influence the type of macro-invertebrate communities that live there.

Current velocity refers to how fast the water is moving. Riffles with current velocities of about 0.5m per second support the most diverse communities (ie on the water's surface a floating object will move 0.5m downstream in 1 second). Occasional floods may disturb your site and flush away some macro-invertebrates and plants downstream.

Bottom composition - the river bottom is made up of different materials rocky bottoms are thought to provide the best bottom habitat for macro-invertebrates.

Flow - the amount of water in the channel determines how much of the river bed is exposed to air. When the river is drying up, animals will concentrate into remaining water holes. Some macro-invertebrates are better at coping with these conditions than others so that the composition of the community changes.

Depth and water clarity of the stream affect whether light can penetrate through the water column to the bottom and allow plants to grow. Plants provide shelter and food for macro-invertebrates.

Shading provided by trees and other vegetation helps moderate water temperature extremes and provides food (leaves, branches, bark) for aquatic animals. The growth rate of aquatic plants in heavily shaded streams tends to be slower.

Temperature - small creeks in the upper end of the catchment are typically colder than downstream. Some macro-invertebrates cannot tolerate warm water or wide variations in water temperature. In addition, as water warms, the level of dissolved oxygen falls and eventually stresses aquatic animals.

Degradation of the physical habitat

Physical changes to the waterway can result from removal of woody debris and streamside vegetation, erosion and straightening of the natural stream meanders. These changes reduce the variety of aquatic habitats available, this in turn reducing the abundance and diversity of macro-invertebrates.

Clearing of riparian vegetation, construction works and removal of gravel from the stream bed increases erosion and levels of suspended solid in the waterway. In rural areas, grazing by stock around waterways destroys riparian vegetation, causes banks to slump and increases erosion. This blocks light from reaching aquatic plants, reducing growth and resulting in fewer macro-invertebrates in the stream. In addition, sediment deposited on the stream-bed can fill in deep holes, smother bottom dwelling plants and fill in gaps between rocks that normally are occupied by macro-invertebrates. Deep holes in the stream bed are the preferred habitat of some native fish, providing cool water refuges.

Removal of overhanging stream-side vegetation reduces food availability to shredder macro-invertebrates and increases the amount of light reaching the stream. Loss of shade may result in algal growth, a condition which will favours grazer macro-invertebrates. So, as shredders decrease, grazers become more common. More sunlight will also raise surface water temperatures and lower dissolved oxygen levels harming sensitive macro-invertebrates.

In large rivers large woody debris is often removed (de-snagging) so that boat travel is safer. Removal of this debris will significantly reduce the variety of living places available for macro-invertebrates. Woody debris is particularly important in sandy reaches of the stream where it may be the only suitable habitat available. De-snagging can also destabilise the river-bed and further reduce the variety of habitats available to macro-invertebrates.

Flow regulation and water extraction

Dams and weirs can change the natural seasonal flow pattern of rivers. They can also reduce the size and frequency of floods. Flow in some rivers is greatly reduced by the large amount of water taken for irrigation. These changes can lead to increases in salinity and disruption of the reproductive cycles and growth of fish, macro-invertebrates and plants.

Water in deep dams tends to form layers (strata) with a warmer layer floating on top of a colder, denser bottom layer. Oxygen levels in the bottom layer can dramatically reduce due to bacterial decomposition and isolation from the atmosphere. Dissolved oxygen levels quickly return to normal when the discharge water in the river mixes with the air at the end of the discharge pipe. However, fish have been known to die beyond the end of the discharge pipe when there are large releases of water. Dams also block drift or movement of animals downstream to new habitats.

Chemical characteristics

The water within a catchment is a complex mixture of chemicals. The stream is affected by the composition of rain water; the geology of the catchment itself eg. limestone; animals in the water and by human activities. The most important chemical characteristics that affect macro-invertebrates are:

pH. Acidity of the water is measured on a scale from 0 - 14 pH units. Extreme pH conditions, less than 5 and more than 9 pH units, can be toxic to aquatic life.

Dissolved oxygen. Macro-invertebrates and other aquatic animals take up oxygen that is dissolved in water. In still or slow flowing waterways with a high density of aquatic animals and plants, biological activity can lower dissolved oxygen to dangerous levels (less than 5 mg/l). Dissolved oxygen is added by plants during the day time and by water mixing with air as it flows over rocks.

Nutrients (phosphate and nitrate) are essential for life. Lakes, ponds and slow moving streams tend to trap nutrients and silt. If nutrient levels are low, the water is usually clear and the number of macro-invertebrates is low. Increasing concentrations lead to more plant growth and more abundant grazing macro-invertebrates. An overabundance in nutrients can modify habitat over time through an increase in plant growth.

How does pollution affect macro-invertebrates?

Macro-invertebrates are sensitive to a range of pollutants and changes to habitat as outlined below.

Organic pollution

Organic pollutants come from sewage treatment plants, animal manure, and food processing industries. Organic wastes generally increase the abundance of invertebrates that filter the water for food or gather decaying plant matter, lower dissolved oxygen and increase nutrient levels and promote rapid growth of plants, which may include nuisance plants such as blue-green algae.

The initial release of organic pollutants in small amounts may cause an increase in abundance of all macro-invertebrates. However, as the amount of organic waste increases further, those macro-invertebrates that are best adapted to it will become more and more abundant. Poorly decomposed sewage or animal manure from upstream will be deposited on the bottom favouring gathering collectors eg: caddis flies. Fine particles of organic waste suspended in the water such as well decomposed sewage, manure or processed coarser material from upstream, favour filtering collectors eg: black fly larvae. The abundance of animals in each feeding group at a site can suggest the type of pollution impact.

Heavy organic pollution will reduce macro-invertebrate diversity. Decay of dead plants and organic waste may lower dissolved oxygen to critical levels reducing the number of sensitive macro-invertebrates.

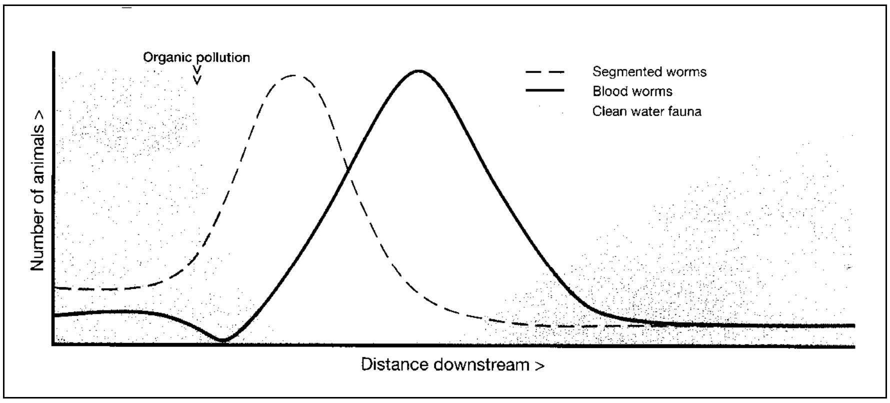


Figure 15 Impact of point source organic pollution on macro-invertebrates in a stream.

Figure 15 illustrates what may happen when point source organic pollution, such as sewage, enters a stream. Increasing amounts of fine organic matter and lower oxygen levels favour chironomids and tubifex worms. Many of the more sensitive aquatic invertebrates including mayflies, stoneflies, caddis flies, dragonflies and damselflies disappear. If no further pollutants enter the stream, clean water animals will return as conditions improve downstream.

Toxic pollution

This type of pollution can come from various sources such as tip sites, industries and mines, and includes acids, solvents, petroleum compounds, pesticides, herbicides and heavy metals, such as cadmium, lead and zinc. Low abundance and low diversity of macro-invertebrates suggest high concentrations of toxic pollution possible from a point source.

If pollutants are present in low concentrations, possibly originating form a diffuse source such as intensive horticulture, only the most sensitive invertebrates will be affected. Macro-invertebrates from the mayfly and stonefly groups are usually the most sensitive to toxic pollutants. Caddis flies are considered moderately sensitive.

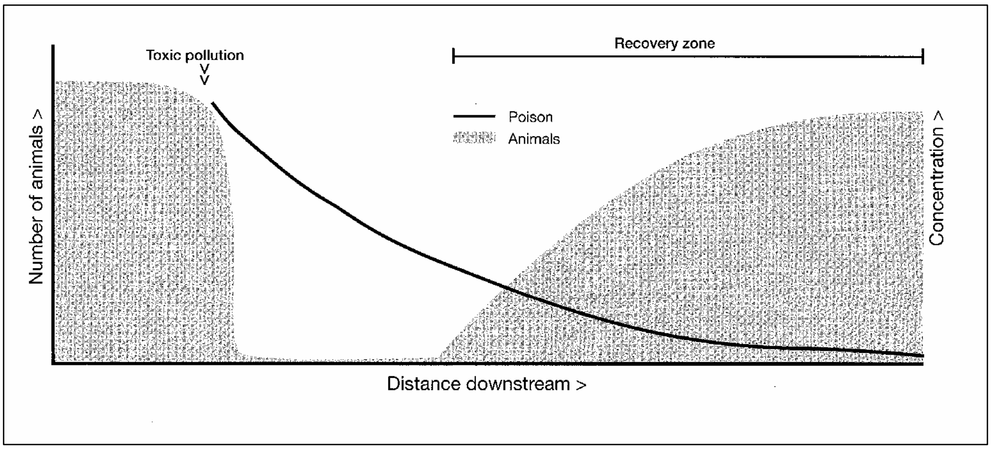


Figure 16 **Effect of point source toxic pollution on macro-invertebrates in a stream.**

Biological characteristics

Waterways are living communities of plants and animals which are dependent on food, oxygen and sunlight. The pattern of activity varies with the seasons. Macro-invertebrates are affected by:

Amount of available food. Food comes from small aquatic organisms, algae, streamside vegetation and decaying food particles from upstream. Some macro-invertebrates feed mainly on leaves and other food that drops into the stream from overhead vegetation. Other macro-invertebrates eat algae. The amount of algal growth is affected by sunlight and nutrients. As the vegetation cover over the stream opens up from the headwaters downstream, the type of food available changes and with it the composition of the macro-invertebrate community.

What is the Best Habitat to Sample?

Three habitat types have been identified as providing good macro-invertebrate sites for sampling: runs, riffles or pools. Each habitat is home to a distinct group of macro-invertebrates. Other habitats that can be sampled include macrophytes (large water plants), sand beds or midstream substrates.

Riffles have the most diverse habitats for macro-invertebrates, and are the most desirable collecting places. Under good conditions, they contain organisms that vary from tolerant to very sensitive. By comparing riffle samples from one site to the next, the impact of human activities will become more obvious. For example, macro-invertebrate diversity found in a riffle upstream of a sewage treatment plant will probably be greater than that in a riffle downstream.

Where there are no riffles you can choose either edgewater habitats or pools and sample organisms living in and around vegetation and/or edges of water bodies. Muddy bottom water bodies usually have fewer types of macro-invertebrates because the habitat is less suitable. The same type of habitat must be selected at different sites if you want to compare results.

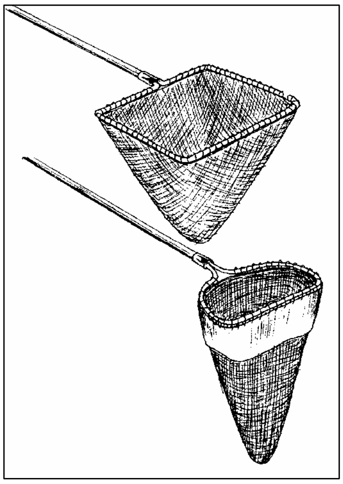
What Methods and Equipment can be Used?

To get a representative collection of macro-invertebrates in your waterway, there are three methods available, ie:

- kick sampling using nets;
- sweep sampling using nets; and
- artificial substrate sampling using man-made structures that are colonised by waterbugs.

Waterwatch recommends using nets for kick sampling in riffles where possible.

Nets



For groups mainly interested in awareness and education, the type of net is not critical. It can even be a kitchen sieve or made at home from a nylon stocking attached to a coat hanger and broom handle. Alternatively, you may choose to simply pick waterbugs from rocks or leaf debris as described in "Waterbug Awareness".

For kick and sweep sampling a long handled net is best. It should have a triangular or a D-frame with a 0.25mm or 0.3mm nylon mesh size. This mesh catches smaller waterbugs like midges but does not quickly plug up with sediment. A handle that extends to about two metres is useful.

Figure 17 Sampling nets (TVA 1995).

Kick sampling method for riffles

The best riffle habitats have the following characteristics:

- well scoured, mainly cobbles (rocks of tennis ball to soccer ball size, 6-25cm) with some gravel (4-16mm) bottoms;
- current velocity of 0.1 to 0.5 metres per second - fast water but not fast enough to knock you over; depth of 10 to 50cm, about knee deep.

In riffles, use a technique called kick sampling. Wearing rubber boots, stand in knee deep water facing downstream. Hold the net in front of you with the opening facing upstream. Disturb the rocks underfoot by vigorously shuffling and kicking. The current will sweep dislodged macro-invertebrates into the net. Move slowly upstream while you do this to sample a 10m length of the stream bed.

Sweep sampling method for edgewater and pool habitats

To sample edgewater or pool habitats, vigorously sweep your net against aquatic plants, roots, logs and the substrate at the water's edge to dislodge any attached animals. Use upward scooping movements to sweep any dislodged invertebrates into your net. Sample a 10 metre length of water's edge. Remember to keep up your momentum while sampling to stop macroinvertebrates from escaping.

Where are the Best Places to Locate Monitoring Sites?

Riffle sites are preferred for sampling, so locate and add these to your catchment map. Riffle sites for river baseline monitoring should represent the full range of conditions in the catchment. Sites should be chosen from:

- natural or least disturbed areas in the catchment (reference sites);
- streams of different sizes or with different catchment areas;
- areas near the headwaters and lowlands in the catchment;
- areas of differing land uses, eg: urban, agriculture, forestry;
- waterways receiving point source discharges, eg: wastewater treatment facilities, stormwater drains; and
- rivers receiving diffuse pollution, eg: irrigated land, logging areas, land treated with pesticides or fertilisers.

Results from reference sites located in the natural or least disturbed areas of your catchment can be compared with results from other sites. Reference sites need not be on your river, but the habitat should be similar. Consult with an experienced aquatic biologist who is familiar with the characteristics of rivers in your area.

When Should you Sample?

Ideally, macro-invertebrate sampling should occur twice a year. Dry Season samples will show the effects of lower flows and higher temperatures, when pollution inputs may have a greater impact. Sampling should occur no more than four times per year to minimise the physical damage to a site.

What Factors affect your Choice of Monitoring Methods?

The general approach taken to monitoring macro-invertebrates depends on your goals, skills of group members and resources available. See Table 9: Monitoring plan and macro-invertebrate sampling methods.

In particular, two important considerations will influence your choice of monitoring method:

1. The level of identification (gross body shape, order or family level classification) and skills of group members;
2. The ability of the method to detect differences in samples from site to site caused by human impact.

Level of Identification

The main choice you will need to make depends on the level to which you want to identify the animal - broad groups with similar overall body shape, or order or family. This in turn depends on the identification skills of group members.

Identification of overall body shape, eg: snail or worm. Identifying gross body shape can be done by anyone with little training (Waterbug Awareness Method).

Identification to order level, eg: stoneflies (Order Plecoptera). Identifying most macro-invertebrates to order level can be easily done by a trained non-biologist. It involves using diagrams included with this manual that show obvious body features. Identification is fairly simple. (Macro-invertebrate Rating Method).

Identification to family level, eg: families within Plecoptera such as Eustheniidae and Gripopterygidae). Identifying families involves patience, knowledge of some fairly subtle differences in body characteristics, and a good dissecting microscope, and requires the support of an aquatic biologist to check the identification.

Ability of the Method to Detect Differences in Macro-invertebrates Between Sites

Identification of macro-invertebrates according to overall body shape will only give an indication of the most heavily polluted sites. Order level identification will give more resolution but family level identification is the most sensitive method.

The sensitivity of the method refers to its ability to detect differences in the macro-invertebrate community from site to site. Sometimes these differences are subtle. For example, your sample may contain a number of mayflies belonging to the order Ephemeroptera, which is composed of nine families in Australia (Hawking and Smith 1997, Colour Guide to Invertebrates of Australian Inland Waters). Most mayfly families are sensitive to pollution, although a few of the families are fairly tolerant. You will need to identify which families make up your sample to be sure about the “message” that mayflies convey about the site.

For monitoring the impacts on waterways, it might be useful to think of identification to order level as a first step. This level will be sensitive to moderate to heavily pollution. If the pollution is more subtle and you suspect that there is a problem which does not show up from identifying to order level, you might want to go further and identify families.

Waterbug Awareness method

This survey is carried out entirely in the field. It involves collecting waterbugs using a variety of simple methods. An estimate of abundance (none, occasional or plentiful) of easily identified waterbugs can be recorded on result sheets. It is useful as a screening tool for identifying grossly polluted sites during your catchment survey (see Getting to Know Your Waterway and Catchment).

Waterwatch groups primarily concerned with awareness, education and community involvement should consider this method.

Macro-invertebrate rating method

This method is carried out entirely in the field. It involves collecting samples using a net, sorting and identifying major groups of aquatic macro-invertebrates (mostly orders). A 10 metre length of the edgewater, pool or riffle is sampled. The number of each group of macro-invertebrates present in the sample is recorded on data sheets, and animals returned to the water. Your *Waterwatch* coordinator will train participants in the field to sample and identify major groups of macro-invertebrates and sort them on the basis of sensitivity to pollution. Results indicate the condition of the site.

This method will suit *Waterwatch* groups with an interest in both education and assessing the general condition of sites.

Macro-invertebrate intensive survey

This survey is carried out in the field and completed in the lab. It produces a fairly sensitive assessment of conditions and allows site to site comparisons. It can detect shifts in families within major groups that might result from pollution or habitat alteration.

Participants work under the direction of professional aquatic ecologists to provide high quality data. Formal training and quality controlled sampling and analysis will be carried out. Participants will use microscopes to identify macro-invertebrates to family level. The data will be analysed and used to give a precise assessment of the condition of the site.

This method will produce high quality data suited to the needs of land managers from government agencies. However, it has yet to be adapted for community group use.

Table 11 Monitoring plan and macro-invertebrate sampling methods

Determine which method best meets your needs, by matching your monitoring plan and the suggested sampling method below.

Questions to be considered	Waterbug Awareness	Macro-invertebrate Rating	Macro-invertebrate Intensive Sampling
Why are you monitoring?	to educate / raise awareness to identify grossly polluted spots	to educate / raise awareness to identify the impact of pollution and pollution control activities and report to land managers to determine the general condition of the site	to educate / raise awareness to identify the impact of pollution and pollution control activities to determine the precise severity of pollution problems and rank sites on the waterway to identify whether waterways are meeting standards to support designated uses to identify water quality trends to select sites for remedial action to support government agency monitoring efforts
Who will use the data?	Teachers, students, group members.	Teachers, students, the general public, land owners, natural resource managers, catchment and rivercare groups.	Teachers, students, the general public, land owners, natural resource managers, catchment and rivercare groups.
How will the data be used?	to educate and raise awareness of students and group members to plan future monitoring efforts	to screen potential problem areas for possible future intensive studies to identify areas for possible corrective actions by local and state agencies	to assist government agencies in making management decisions about waterways in development of catchment management plans for state of environment reporting for selection of sites for remedial action
What will you monitor?	Presence of macro-invertebrates by gross body shape.	Abundance and diversity of macro-invertebrates to order level (and some families).	Abundance and diversity of macro-invertebrates to family level.
What data quality do you need?	As identification is based on gross body shape, data only provide very general indications. The activity of collecting data is more important than results.	The data are capable of indicating the general condition of the site on a four-point scale (excellent, good, fair or poor).	Quality controlled sampling and analysis ensures a high level of confidence in numerical data for decision making purposes.
What methods and equipment are	Pick macro-invertebrates from rocks, leaf packs or from	Standard sampling methods are used at all sites. Field	Standard sampling methods are used at all sites.

Questions to be considered	Waterbug Awareness	Macro-invertebrate Rating	Macro-invertebrate Intensive Sampling
used? What methods and equipment are used? cont	net samples. Equipment:: • sampling nets or kitchen sieve • shallow white tray or bucket • ice cube tray or ice-cream or yoghurt containers • plastic pipettes • small paintbrush • tweezers • plastic spoons	identification of macro-invertebrates. Equipment : • sampling nets (or artificial substrates) • shallow white tray • ice cube trays • plastic pipettes • small paintbrush • forceps • plastic spoons	Sampling and preservation of fauna in alcohol for laboratory identification to family level. Equipment includes laboratory and preserving equipment in addition to sampling and sorting implements.
Where will you monitor?	As determined by your goals, eg: to educate students, sites must be accessible, safe and close to the school.	Choose sites as required by the question you want to answer, eg: if point source pollution impact is being assessed, then riffles at reference, impact and recovery sites bracketing the impact are best.	Choose sites as required by the question you want to answer, eg: baseline monitoring sites will be located in representative areas of the catchment.
When and how often will you monitor?	Timing depends on the education/awareness needs of the group, eg: field days, school projects, on-ground catchment survey. (not designed as a monitoring tool).	Twice yearly. Maximum is four times per year to avoid depleting populations.	Twice yearly. Maximum is four times per year to avoid depleting populations.
Who will be involved and how?	Suitable for all - new groups, schools, etc. Demonstration by *Waterwatch* coordinator.	Best suited for trained community members, secondary students and older. Training by Waterwatch coordinator.	Suitable for experienced groups willing to undertake the rigorous training required and work under the direction of aquatic ecologists.
How will the data be managed and presented?	Not essential to record data but generally helpful in preparing reports for presentations to sponsors, the community and officials.	Keep complete and accurate records of result sheets. Interpretation of results should be done in conjunction with habitat assessment and water quality results. Site ratings can be indicated on your catchment map using different colours.	Sites are compared with reference conditions to estimate level of impact. Site ratings can be indicated on your catchment map using different colours.
How will you ensure your data are credible?	No training is required but is strongly recommended. Data are not used for decision making by others.	Field training by *Waterwatch coordinators* ensures comparability and accurate identification. Replicate samples by sampling teams provide a check on representativeness. In addition to using diagrams with this manual, a comparison of macro-invertebrates with a verified reference collection is highly desirable for accuracy.	Formal field and laboratory training with aquatic ecologists. 10% of macro-invertebrate samples to be preserved for identification to the same taxonomic level by an aquatic ecologist. External field duplicate samples taken by ecologist to ensure data confidence.

Waterbug Awareness

Waterbugs (macro-invertebrates) are animals that lack a backbone and can be seen with the unaided eye.

The procedures described below are a general guide for finding and identifying waterbugs by their body shape. The bugs may tell an interesting story about the waterway. Waterbug Awareness is not designed for groups wishing to undertake regular monitoring, but is useful for one-off events such as catchment surveys, community field days or school projects.

Choosing your sites

Your choice of site will be determined more by convenience and ease of access than other factors, eg: close to school. You can choose to sample from a riffle (shallow broken water with rocks of about tennis ball to soccer ball size), edgewater (close to banks), or amongst water plants in pools.

At your site, there are likely to be many small animals which are not easily seen. Waterbugs can be found attached to rocks and plants, and hiding in leaf packs.

Equipment

- kitchen sieve eg chip bucket and other sieves as per video or made from poly pipe and mesh;
- net (home made, or commercially made D-frame net, 250 to 300μm mesh);
- three pronged rake hoe;
- 2 x White buckets;
- 2 x flat trays for holding samples during sorting;
- sorting implements to pick bugs from plants and rocks eg tweezers (forceps); plastic spoon for large bugs (with 2-3 very small holes); plastic squeeze pipette for small bugs (about 5mm diameter); fine paint brush for lifting small bugs (small artist type);
- several ice cube trays; and
- Waterwatch : '*An NT guide to macroinvertebrates'* work sheet (See end of this section or contact your local *Waterwatch* Coordinator).

Sampling method

See the method on the '*An NT Guide to Macro-invertebrates'* work sheet and observe the video 'Waterwatch NT Water Quality Sampling: Part 2: Macroinvertebrates'.

Table 12 Types of waterbugs and tolerance to pollution

Animal body shape	Tolerance to pollution
Worm-like animals, eg: worms and leeches. They stick to rocks or sticks, or crawl slowly.	They are generally **tolerant** of pollution.
Shelled animals, eg: snails and mussels.	They vary from **tolerant to intolerant** of pollution.
Crayfish like animals.	These are generally **intolerant** of pollution.
Insect-like animals. They include a wide range of animals that have distinct heads, legs, bodies and tails. They come in many sizes and shapes and often move quickly.	They are generally **intolerant** of pollution.

Interpretation of the Sample

Referring to the NT guide to Macroinvertebrates, fill out the table on page 2 to determine the quality of the sample collected. This together with other water quality and habitat observations at the site will give you an indication of the waterway health.

Final Checks

Return all the waterbugs, leaf matter and rocks to your waterway. Wash your hands to remove parasites. Before you leave the site, check the following:

- Is all the equipment cleaned?
- Is there any rubbish left behind?
- Has equipment in the kit been checked?
- Is any equipment broken or lost and if so needs to be replaced?
- Have all the results been recorded?

You may choose to pass your result sheet onto your *Waterwatch* coordinator. If so, please complete the first part - background information. Your coordinator can help you to fill out this information if required.

Contact your regional Waterwatch Coordinator for more information on the Macro-invertebrate Rating and Macro-invertebrate Intensive Sampling methods

See Activity 20 (p 120-122)

Algae

Algae are naturally occurring aquatic plants. Algae are an essential component of the aquatic environment. They are primary producers, forming an important part of aquatic food webs and are important photosynthetic producers of oxygen. There are many types of algae, some free floating and microscopic, some large and attached to rocks or other submerged objects. Algae are made up of two broad groups:

- large water plants (macrophytes) which are often attached to rocks and other surfaces and can be seen with the unaided eye; and
- microscopic algae (phytoplankton) which are suspended in the water column and require a microscope to be seen, unless present in large quantities.

Phytoplankton

Microscopic free-floating algae (phytoplankton) are simple plants that grow with light and nutrients and are natural to Australian waterways. Various types of algae are found in Australian waters including blue-green algae, green algae, flagellates and diatoms.

Blue-green algae

Blue-green algae (cyanobacteria have a similar appearance to algae but are closely allied to bacteria. There are a number of blue-green algae; the common ones are *Microcystis, Anabaena, Nodularia, Oscillatoria, Cylindrospermopsis* and *Aphanizomenon. Nodularia* tend to occur in more saline waters. Excessive growth of blue-green algae (bloom) can discolour the water and cause health problems for people and animals.

Green algae

Green algae are the characteristic "slime" we see growing on rocks or the side of aquariums. They are relatively large and can be seen under magnification of x40 to x300. Some green algae give a grassy taste and odour to water if present in large numbers. They can block water filters, sprinklers and other equipment.

Diatoms

Diatoms are extremely small algae. In estuarine waters, diatoms called *Gonyallax* have caused "red tides". Deaths have been recorded after people have eaten contaminated shellfish taken from waters with red tides.

Flagellates

Flagellates are algae with 'hairs' and 'tails' (flagella) to flick themselves along. They may also have a light sensitive eye spot and can produce taste and odour in water supplies. Common flagellates include *Synura* and *Dinobryon*

Algal Blooms

Some human activities contribute to the overgrowth of algae.

Causes of blue-green algae blooms

In undisturbed catchments and waters, the amount of blue-green algal growth is naturally controlled and large blooms are rare. For example, blue-green algal growth is limited by the movement and mixing of water in flowing streams, low levels of nutrients particularly phosphorus, shade from riparian vegetation and high turbidity.

In disturbed catchments and waters where high phosphorus levels and slow flows are common, these algal blooms can be more frequent and intense. Nutrients can enter these systems from run-off from agricultural soils, animal waste sources and fertilisers such as superphosphate. Treated sewage effluent, which is often pumped into waterways, contains high levels of nutrients. These sources all increase the nutrient load, which promotes the growth of aquatic plants and algae. When humans remove water from rivers or streams for agricultural, pastoral or domestic purposes, the flow of that water body decreases. Weirs in a river also slow the movement of water. Under low flow conditions, blue-green algae are more competitive than other algae and can migrate up and down the water column to find the best conditions for growth. Many other factors influence blue-green algal numbers including light, salinity, pH and generally, but not always, temperature.

Problems caused by blue-green algae

Blue-green algal blooms affect water supplies, human health, livestock, fish, aquatic plants, recreation and tourism. They may give off foul odours, give an earthy taste to water or produce surface scum, which make waterways unattractive. Decay of large algal blooms may lead to low oxygen levels and fish kills.

If there is excessive growth of blue-green algae, there is a risk that water may contain toxins that are lethal to mammals, fish and other aquatic animals. A bloom may change from a non-toxic state to a toxic state in a few days. Similarly, one part of the bloom may be toxic whilst another part may not. Toxins are contained within the cells and are released as the cells die.

Blue-green algal toxins are known to cause health problems, such as liver damage and gastro-enteritis in humans or other animals following ingestion of water heavily infested with blue-green algae.

What can be done about algal blooms?

Humans can reverse some of the causes of algal blooms once they understand what is contributing to its growth and how to monitor change in its growth. *Waterwatch* groups can make an important contribution towards managing the blue-green algae problem by monitoring local waterways.

See Activities 21 to 24 (p 123-132)

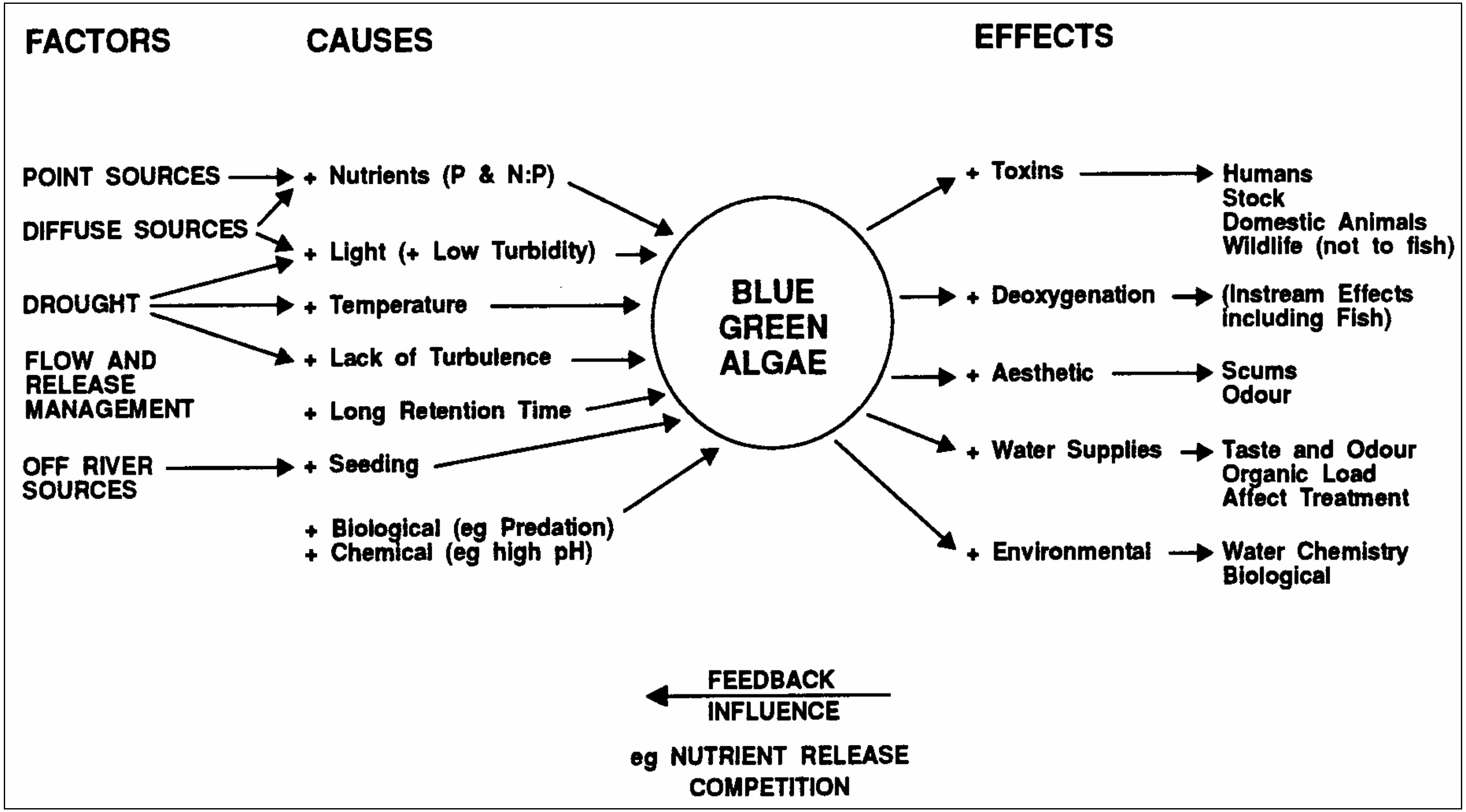


Figure 18 **Algae growth flow diagram**

Algae Testing

The following tests are covered in Table 13: Guidelines for algal monitoring.

- Test 1 shows how to monitor for weather conditions, which are favourable for developing blue-green algal blooms. This information will provide an early warning of potential blue-green algal blooms and allow more time to respond to potential threats.
- Test 2 will help you identify the most likely type of algae in a bloom and scum on the water surface.
- Test 3 will indicate the possible presence of one type of blue-green algae - *Anabaena* - based on its distinctive odour.
- Test 4 will indicate high concentrations of blue-green algae through formation of a surface scum.
- Test 5 involves field identification of algae with a microscope to show if the surface scum is caused by forms of algae other than blue-green.
- Test 6 shows how to estimate the number of algal cells per ml using a microscope, in order to assess the risk to human and animal use from drinking or skin contact.

Table 13 Guidelines for algae monitoring

Questions to be considered	Algae monitoring guidelines
Why are you monitoring?	To educate and raise awareness. Survey for conditions favourable to algal blooms. Detect and identify potentially significant concentrations of blue-green algae and other algal types. Report blue-green bloom outbreaks to government agencies.
Who will use the data?	Teachers, students, the general public, land owners, natural resource managers, catchment and rivercare groups.
How will the data be used?	Educate students and community. To alert water management agencies to a potential problem. Identify areas for possible corrective actions by local and state agencies.
What will you monitor?	Water and weather conditions favourable to blooms. Scums, water discolouration, algal types and density.
What data quality do you need?	Tests 2-6 detect the presence of blue-green algae and indicate whether the concentration of cells exceeds significant levels. The more tests that are positive, the more confident you can be about the presence of blue-green algae. Microscopic identification (Test 6) provides the best indication of blue-green algae.
What methods and equipment are used?	Test 1 - observation of conditions. Test 2 - record size and location of bloom. Test 3 - odour test method - glassware. Test 4 - scum formation - phytoplankton net, glassware. Test 5 - identification - microscope and algae counting cell. Test 6 - sample collection - sample bottles.
Where will you monitor?	Algal blooms most often occur in slow moving waters or lakes and dams. Look for presence on down- wind side of water bodies. For a large bloom, sample at 3 sites > 100m apart.
When and how often will you monitor?	Monitoring for outbreaks should be more frequent (7 to 14 days) during periods of low flow and still weather. Blooms may grow more quickly in higher temperatures.
Who will be involved and how?	All groups can be involved, however, microscope work demands care and skill.
How will the data be managed and presented?	Algal blooms as per pollution incident data should be reported to your *Waterwatch* coordinator as soon as discovered. Maintain a record of water and weather conditions and correlate with reported incidents of algal blooms. Take photos of blooms. Keep complete records of original result sheets.
How will you ensure your data are credible?	Follow standard procedures and instructions provided in this manual. Field training by *Waterwatch* coordinators ensures consistent and accurate sampling and testing techniques.

Faecal Bacteria

Faecal bacteria are common in the intestines and faeces of both warm and cold-blooded animals and their presence in water indicates possible sewage contamination. They are used to indicate the possible presence of disease-causing (pathogenic) bacteria, viruses, protozoa and other micro-organisms.

Monitoring water for the presence of pathogenic micro-organisms is difficult because so many different types exist and we risk exposure to them. Instead of testing for each type, we test for the presence of faecal bacteria, which are excreted with any pathogenic organisms in the faeces of animals (including humans). If faecal material gets into surface water and you come into contact with that water, you run the risk of getting sick. Many types of faecal streptococci are pathogenic.

Pathogens enter our body when we swallow contaminated water either by drinking it or accidentally when swimming, and through cuts. Testing the water for faecal indicator bacteria enables you to assess the risk of getting sick. Health risks associated with faeces-contaminated water include gastroenteritis, ear infections, typhoid fever, dysentery and hepatitis.

In addition to causing health risks, faecal material can cause a number of other impacts on waterways such as cloudy water, unpleasant odours and an increased biochemical oxygen demand (BOD). See Dissolved Oxygen Teacher note for more details about the impact of increased BOD.

What are the Types of Faecal Bacteria and What do They Indicate?

The most commonly tested faecal indicator bacteria are total coliforms, faecal coliforms and *Escherichia coli (E. coli).* See Figure 19 below.

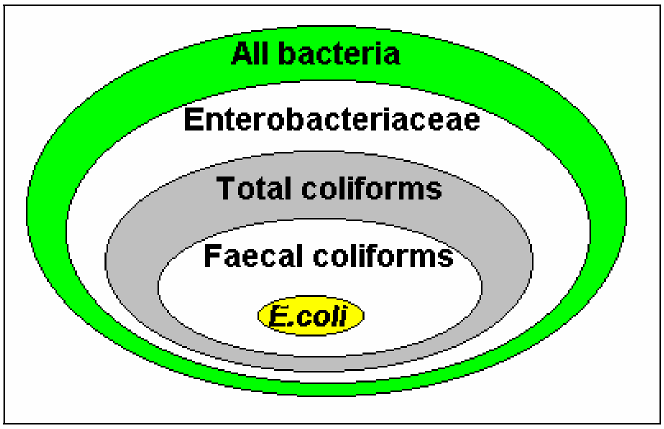


Figure 19 Faecal bacteria.

Total coliforms

This is a group of bacteria that includes faecal coliforms and non-faecal coliforms. Non-faecal coliforms are widespread in the environment, but some may also be found in animal manure, soil and submerged wood and in the intestines of warm-blooded animals, including humans. Faecal coliforms are found naturally only in the intestines of warm-blooded animals and humans. Thus, the usefulness of total coliforms as an indicator of sewage is limited.

Faecal Coliforms

This is a subgroup of total coliform bacteria more specific to faeces. However, it has one genus, *Klebsiella*, with species that are commonly associated with textile, pulp and paper mill wastes. Faecal coliforms are the main bacterial indicators for recreational waters.

Escherichia coli *(E. coli)*

This is species of faecal coliform bacteria that occurs in high numbers in faeces of humans and other warm-blooded animals. *E. coli* are mostly harmless, although one strain causes acute diarrhoea. It does not normally grow in the natural environment and has been used as an indicator of faecal contamination for many years.

What are the sources of faecal bacteria entering a water body?

Sources of faecal contamination of surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal faeces, and urban runoff. Faecal matter can enter the river system directly from pipes and from excretion from animals, or is carried by surface runoff after rain.

Sewage treatment plants may sometimes fail, and septic systems that are not properly maintained discharge sewage into our waterways. Some sewage treatment plants also carry stormwater runoff from streets, yards, and parking areas, and heavy rain can overload the plant forcing both the sewage and the rain water to be diverted directly into the river without treatment. A number of cities and towns have separated the stormwater and sewage water drain lines to avoid this problem. Another source of sewage to water is leaking pipes and pipes that are not hooked into the system correctly.

As bacteria cannot be seen, they must be encouraged to multiply and grow into visible colonies using one of several techniques. The method you choose depends on your purpose for monitoring, required accuracy, skills of your group and available funds to buy equipment. Seek advise from your local Waterwatch Coordinator before undertaking these tests.

Presence/absence methods

If you are interested in raising awareness of bacteria in water and monitoring for the presence of coliform bacteria, then choose from several easy to use presence/absence methods.

Most probable number method and Coliscan Easygel®

Both methods will show up sites that fail to meet standards deemed safe for secondary and primary skin contact, eg: swimming (less than 150 faecal coliform bacteria/100ml), but will not show if water is safe for drinking (zero required). Both methods are more precise than presence/absence tests. You can use the results to alert government agencies of a potential problem.

The most probable number method is a complex procedure. It involves adding specified quantities of the water sample to a number of tubes containing a nutrient broth, incubating the tubes at a specified temperature for a specified time period, and then looking for the development of colour change and/or gas that faecal bacteria produce. The colour change and presence of gas in each tube is used to calculate the most probable number of faecal bacteria per 100ml. The resolution of this method depends on the number of tubes innoculated with the water sample.

An alternative method (Coliscan Easygel®) involves much less preparation and is based on the presence of certain dyes in the media. *E. coli* activate two dyes (blue and red) in the nutrient media to form purple, dark blue or blue-green colonies, which can be readily identified from other general coliform bacteria which activate only one dye (red) to form red or pink colonies. A small amount of the water sample is added to a Coliscan Easygel® liquid nutrient, stirred and poured into a pre-treated petri dish and kept warm. The faecal coliform and *E.coli* colonies can be identified by their different colours and counted to calculate the number per 100ml. The resolution of the Coliscan method is limited to 20 colonies /100ml.

Interpreting your results

Human health

Drinking water must be entirely free of faecal coliforms.

Primary contact: ie: swimming, water skiing and whole body contact, the faecal coliform counts should not exceed 150 colonies per 100ml. If collecting a number of samples, add up the total number of faecal coliform bacteria from four of any five samples; the total should be less than 600 faecal coliforms per 100ml. The median number of 150 colonies/100ml has been chosen as an acceptable level of risk to swimmers. However, your actual chances of getting sick depend on a host of factors, such as your resistance to illness.

Secondary contact: eg: recreation including sailing, fishing, etc, the median bacterial content should not exceed 1000 faecal coliforms/100ml. Take a minimum of five samples at regular intervals of less than a month apart; four out of five samples should total less than 4000 faecal coliforms/100ml (Source: ANZECC (1992) Australian Water Quality Guidelines For Fresh and Marine Waters).

Environmental impact: In general, consistently high bacteria counts during low-flow periods might indicate faecal pollution from a steady source, such as a failing sewage system. Confirm the location of the pollution by comparing data with results from upstream. High bacteria counts during high-flow periods might indicate diffuse source pollution (runoff from agriculture and urban areas).

See Activity 25 (p 133)

Steps to Undertake a Site Habitat Rating

The health of a riparian habitat can be graded on a scale of excellent, good, fair or poor, which complements the Site Description. A rating allows you to:

- assess the health of the site for aquatic organisms and its value for human uses;
- monitor the condition of the site over time;
- compare one site with another; and
- identify which areas need restoring or protecting.

To assess the health of the habitat, you will need to consider five features:

- quality of bank vegetation;
- quality of verge vegetation;
- extent of in-stream cover;
- degree of bank erosion and stability; and
- variety of riffles, pools and bends.

How to carry out the survey

See Activity 29 (page 166) for full details.

Assessment of Threats to Habitat and Water Quality

Background Investigation

To begin an assessment a once off background investigation of a stream and its catchment will yield valuable information about the cultural and natural history of the stream and the uses of the land surrounding it. To establish what information you feel is relevant to your waterway, you may need to research library and council records, examine maps, collect photographs, news stories, industrial discharge records and conduct oral histories, hold public workshops and talk to experts. The information you uncover will help prioritise the issues, clarify your goals and plan for monitoring and future activities.

Catchment Survey

Surveying the catchment and recording the condition of the stream and its surroundings provides a check on information gathered in the background investigation. It also helps to understand about issues and the processes that affect all parts of the catchment, and fosters a sense of ownership towards the environment.A catchment survey involves walking the stream or a drive through the catchment to see its condition first hand and check the accuracy of information uncovered during the background investigation.

How can you tell if a Wetland is Healthy?

The vegetation surrounding a healthy wetland will not show signs of stress. Healthy wetlands will often be surrounded by diverse and abundant communities of native plants, with very few weeds. The area of vegetation surrounding a wetland is sometimes termed the buffer zone. This is because the surrounding vegetation 'buffers' the wetland plant and animal communities from the adverse effects of land management activities within the catchment. The buffer zone does this by:

- reducing the volume of water runoff from surrounding land into the wetland community;
- filtering out sediments, contaminants and nutrients in this runoff;
- preventing invasion by exotic plants eg. *Mimosa* which unfavourably change living conditions for other plants and animals;
- protecting fauna and wetland flora from disturbance; and
- providing corridors for the movement of wildlife.

If your wetland is not surrounded by vegetation, it is likely to be under stress. Water quality will give a good indication of wetland health. Poor water quality in the wetland might arise from the poor quality of inflows or from local contamination.

One of the best ways to tell if a wetland is healthy is to sample for the presence of macro-invertebrates. If healthy, you can expect to find a diverse and abundant macro-invertebrate population. Conversely, expect low diversity and variable abundance in less healthy wetlands.

Undertaking the Catchment Survey

What to Survey

The main issues uncovered during the background investigation will guide your survey on the ground. You may decide to survey several things during the field day in addition to ground truthing your background investigation findings. For example, the issue could be the location of drains that are suspected of causing pollution or loss of riparian habitat, or the instability of the stream channel. Consider including in your survey a visit to activities carried out by other groups eg: rivercare works or wetland restoration projects.

Where to Survey

You should choose the largest area you feel comfortable assessing and ensure that it has easy, safe and legal access. The area should have clear boundaries that can be marked or found on road maps or topographic maps. This will help you easily locate sites and allow future *Waterwatch* members to continue the survey in later years.

It may be helpful to break the catchment up into a number of sub-catchments and go to representative sites within each sub-catchment. Record your findings for each on separate Catchment Survey Sheets and site information on Site Description Sheets. This will help you record your observations in an orderly way.

If investigating other aspects of the catchment eg: pipes and drains inventory, during your catchment tour, use the appropriate field data sheets to record your observations.

The survey will have most value if the same stream or part of the stream is visited each time. In this way, you will grow familiar with baseline conditions and will be better able to identify changes over time.

When to Survey

To look for seasonal variations, you might find it useful to drive through the catchment once a year at approximately the same time and to walk the problem sites in the chosen stream more frequently. Problem sites include construction sites, combined sewer stormwater outfall pipes, animal feedlots and bridge/highway crossings. If erosion, polluted run-off or failing septic systems are suspected, plan a survey during or after a heavy rainfall.

Things to Take

- a reference map such as road map or topographic map, to locate the stream and the area to be surveyed;
- a photocopy of your base map to record observations during the walk or drive;
- relevant information from background investigation (eg: location of sewage outfalls, farms, abandoned mines, etc.);
- copies of the Catchment Survey Sheets :a copy of quick identification guides for flora and fauna;
- note paper, pens pencils; and
- a camera and film.

Writing a Summary of your Findings

The last step of the catchment survey is to write a summary of your findings and to add any further important information to your base map. In most cases you will find that you have put together a very interesting picture of your stream. You will be able to update and add to your background information.

A summary of your findings could include the following information:

- a description of the geography of the area including how the river character changes downstream, location of towns and population size of the catchment;
- a map showing the catchment and sub-catchment boundaries, location of the stream and its tributaries and major land forms;
- a map showing the land uses in your catchment, main soil types, vegetation cover, rainfall data, location of sewage treatment plants, bridges, weirs and dams;
- a map showing colour coded habitat ratings (if surveyed) for each site;
- a list of uses, protected environmental values, positive aspects and threats identified by members of your community;
- a description of the issues facing your waterway, eg: the uses or values of part(s) of the waterway which are threatened and what if anything, is being done about the threats;
- a list of the information or description of the advice you will need to fully understand the problem or the effectiveness of solutions to the problem;
- a list of the questions you will try to answer through further surveys and/or monitoring the waterway.

This picture might prompt additional monitoring or community action to restore the waterway, or you may decide to inform catchment committees, councils or government agencies about potential problems.

Your catchment survey data and base map will be a very valuable resource to your group as well as the local council, catchment committee and agencies. It can become a historical base map for recording future changes and is vital for planning effective long term community actions to protect and restore your waterway.

See Activities 26 to 30 (p 134-161)

Water : Who Needs It? **B1-B3**

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 1

Curriculum Links:
Science Concepts and Contexts / Natural and Processed Materials CC 2.1

Focus Question:

- **What is meant by water quality?**

Aims:

1. To develop student's understanding of the many ways people, plants and animals rely on standards of water quality.

Main Idea:

- We rely on our healthy waterways and so do many plants and animals.
- The quality of the water is an important component of catchment health. Many animals and plants are sensitive to even small changes in a particular water quality parameter (eg: pH, dissolved oxygen).

Need:

Water Quality Standards Table (1 per group). Student Sheet 5.1 (below). 4 containers for each group. Distilled water (approx. 4 litres). Table salt. Laboratory scales. Small cups (one per student). A Waterwatch Coordinator will be required for the second part.

Advance preparation:

Prepare the simulated 'water' using distilled water.

Container 1 place 0.1 grams salt per litre distilled water (simulated fresh water).

Container 2 place 1 gram salt per litre (marginal water).

Container 3 place 3 grams salt per litre (brackish water).

Container 4 place 35 grams salt per litre (seawater).

Divide the class into small groups and provide each group with 4 jugs of the prepared solutions, cups and a copy of the Student Sheet 'Water who needs it?'.

Consider:

Explain that one way to measure water quality is to measure how much salt is in it. We can taste salt in water and once it becomes too salty, it is not fit for us to drink and cannot be used by livestock, agriculture or industry.

Salinity levels can be measured with a portable instrument that reads the electroconductivity of the water. These probes provide readings in 'EC' units. The more salty the water, the higher the EC reading. In the past the most common way salinity was measured was by evaporating a given amount of the solution and weighing the remaining salt. The units were milligrams per litre (mg/L) of solution or total dissolved salts).

Water has a range of dissolved natural salts including sodium, calcium and bicarbonates. These all contribute to the salinity of the water. Salt concentration varies naturally with the geology of the surrounding area that the surface water and groundwater flowed through. For example, an area which was an inland sea in the geological past would naturally have high levels of salt in it.

Ask each student to taste water from container 1.

Explain this is water of Excellent quality. It will not taste salty because it has very little salt in it.

Repeat for the remaining containers, in the sequence from container 2 to 4.

Students have now tasted water rated from Excellent, Good, Fair, Poor to Very Poor Quality for salt levels.

These categories also roughly relate to freshwater (excellent to good), brackish (fair), and seawater levels (poor to very poor).

(Explain that the fair to very poor quality water was made by adding table salt to it – a sip of it is not harmful to their health.)

Each group brainstorms to develop a list of ways fresh water (not seawater) is used by people in the Northern Territory.

As a class, develop a short list of some of the Northern Territory's aquatic plants and animals.

Each group brainstorms to develop a list of ways these animals and plants use fresh water.

Analysis:

As a class, use the Water Quality Standards Table to allocate a water quality standard needed for each use by people, plants and animals.

Many uses require Excellent to Good quality water. Fewer uses can be made of Poor and Very Poor quality water.

Fewer aquatic plants and animals can survive in Poor and Very Poor water quality.

For health reasons, human consumption (drinking) and contact (swimming) need Excellent or Good quality water.

Each student to write a sentence or two to summarise their conclusions about the varying water quality needs of plants, animals and people?

Extension

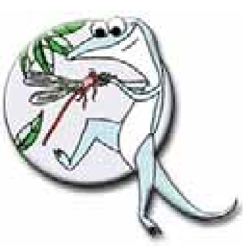
Determine salinity levels of some local waterways using an EC or TDS Meter (contact you local Waterwatch Coordinator to arrange to borrow one if necessary).Apply the information learned from this activity. Based on the salinity of the water samples, what potential does it have for human and animal use?

Complete Student Sheet 5.2 Groundwater Quality for Domestic Use. Groundwater information is covered in Part 1 of this education kit.

Reflection:

Suppose you would like to speak to someone interstate about what the water quality is like in their catchment.

How would you both understand what the other is describing without using a standard like the National Water Quality Guidelines?



Student Sheet 5.1
Water - Who Needs It? -

One way to measure water quality is to measure the salinity level in the water. Salinity levels can be measured with a portable instrument which reads the electro-conductivity of the water, which measures ‘EC’ units. The more salty the water, the higher the EC reading. Salinity can also be measured by evaporating a given amount of the water and weighing the remaining salt. The units are milligrams per litre (mg/L) of solution or total dissolved salts.

Use the Water Quality Standards table to complete the Salinity Tolerance Table.

Table 14 Water Quality Standards Table

Rating	EC	mg/L
Excellent	0-799 EC	0-479 mg/L
Good	800-1,699 EC	480-1019 mg/L
Fair	1,700 – 2,499 EC	1020-1,499 mg/L
Poor	2,500 – 9,999 EC	1,500-5,999 mg/L
Very Poor	Over 10,000 EC	Over 6,000 mg/L

Conversions
From EC to mg/L multiply by 0.6
From mg/L to EC divide by 0.6

Table 15 Salinity Tolerance Table (Dept. Industry, Technology & Resources 1987).

Upper salinity limits for some water uses		Water quality required
Domestic		Excellent (preferred) to Good
Industry	1,667 EC	
Paper	250 EC	
Petroleum	583 EC	
Irrigation		
Tobacco	83 EC	
Lucerne, cotton	4,167 EC	
Livestock		
Poultry	5,833 EC	
Pigs	7,500 EC	
Horses		
Beef cattle	18,333 EC	
Dry sheep	25,000EC	

Student Sheet 5.2
Groundwater Quality for Domestic Use

Use a groundwater test strip kit (available through your Waterwatch Coordinator) see how your groundwater sample compares to what it is being used for. Is it suitable for the purposes it is being used? Your Waterwatch Coordinator will assist you in providing instructions on how to use the test strips, where to take the sample from and how to safely extract the groundwater sample.

What do the results of your water sample mean?

All groundwater contains various kinds of dissolved salts (minerals). Small quantities of many of these are essential to good health. Excessive concentrations however, can limit the uses of the water. When a bore is drilled, a water analysis is normally carried out to determine if any of the salts exceed guideline values. This sheet provides some information to help interpret the water analyses.

Source of dissolved salts
The salts originate from minute quantities dissolved in rainwater and from the chemical breakdown of rocks. Nitrate is also produced in the soil by natural biological activity. Over long periods of time, evaporation concentrates them to varying degrees.

Guideline values
The maximum recommended values listed beside each salt are guidelines rather than strict limits. The reason for this is because there are often many factors governing how a particular salt affects the user. These can include a person’s age and the total volume of water consumed. The guidelines given below are conservatively chosen in order to cover most situations.

Nitrate 50mg/litre
Based on health organisations a limit of 50mg/litre is recommended for babies less than three months old and 100mg/litre for older children and adults. Nitrate levels can be reduced if necessary with the ion exchange process.

Fluoride 1.5mg/litre
This limit is based on health considerations. Excess fluoride can be removed by treating water with aluminium sulphate or bone char.

Iron 0.3mg/litre
Above this limit, taste may be unacceptable but it does not pose a health problem. High iron concentrations give water a rust brown appearance resulting in staining of laundry, pipe encrustation and odour problems. A common way to remove iron is to aerate the water by cascading it into a tank and allowing the iron floc to settle.

Hardness 200mg/litre
Hardness is a measure of the amount of calcium and magnesium in the water. Hard waters can cause the build up of scale in hot water pipes and fittings. They also require more soap to obtain a lather. It can be reduced by softening the water.

pH 6.5 – 8.5
This is a measure of acidity or alkalinity. Values less than 6.5 indicate acidic water and can result in corrosion of pipes and fittings. When pH is more than 7.5, the water is alkaline and encrustation of pipes with calcium can occur. pH can be adjusted to a more desirable level with the addition or either an appropriate acid or alkali.

Introducing Water Quality

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 2

Curriculum Links:
SOSE Environments / Natural Systems Env 2.3

Focus Question:

- **What is meant by water quality?**

Aims

1. To highlight to students that we rely on good quality water coming from our taps.
2. To make connections between drinking water and waterways.
3. To illustrate that water quality can be affected by inputs.

Main Idea:

- The quality of the water is an important component of catchment health. Many animal and plants are sensitive to even small changes in a particular water quality parameter (eg: pH, dissolved oxygen).

Need:

Per group:
2 clear containers. 1 glass or container per ingredient. 2L tap. 0.5L creek. Texta and masking tape to label. Ingredients to represent pollutants (eg: soil, fertiliser, salt, cooking oil, laundry powder, ammonia, rubber bands, vinegar), Student Sheet 5.3 (below).

Consider:

Fill 1 clear container with tap water, 1 with creek water. Ask which they would rather drink?

Taste, appearance and health are important for drinking quality water. Both jugs may have clear water but tap water is treated therefore we know it is high quality water that is safe to drink. Creek water may not be as clear; it may even have some more obvious pollutants in it.

Explain that our tap water has come from a river somewhere, usually one in the catchment. Water is collected from a river, carried in underground pipes to our schools, homes and workplaces. So river water becomes our drinking water.

Explain the historical context: For Aborigines, drinking water usually came directly from a river and was good quality. Early settlers also obtained their water directly from rivers and creeks but waterways became polluted as the population increased. Today it is generally not considered safe to drink water directly from most waterways. As part of this unit students will investigate why water has become polluted since European settlement.

Add 1 teaspoon of each ingredient to a new glass of tap water and label it. Discuss what each ingredient represents in terms of pollution.

(Eg: soil, fertiliser, salt can represent pollutants from farms and gardens. Laundry powder and ammonia can represent household pollutants.)

Oil, vinegar, plastic bag, rubber bands can represent industrial pollutants. Rubber bands might be rubber tyres, oil might be motor oil washed down stormwater drains, food colouring might represent chemicals spills, vinegar might represent acid mine drainage from a mine.

Analysis:

Can students see any differences in the water after the ingredient has been added?

Write up a class list describing the effect of each pollutant on the visual appearance of water. Identify that while water may still look clear it may be polluted (eg: ammonia).

Put the jars on a sunny windowsill and record observations on a daily basis for 5 days.

Summarise conclusions.

Conclusions:

We prefer to drink clear rather than cloudy water. A range of pollutants can get into water. Not all pollutants are visible in water.

> **Note**: The water in some rivers looks brown because it is coloured by naturally occurring tannins. This water is not necessarily unhealthy but people want to drink clear water. Some Water Authorities have therefore installed expensive equipment to remove this colouring from their reticulated water supplies. (Adapted from Non point Source Pollution Prevention. Air and Waste Management Association. USA. 1993.)

Reflection:

What inputs might your family/school be adding to water downstream?

Student Sheet 5.3
Introducing Water Quality

Materials

Per group: 1 clear container per ingredient, you will be testing tap water, texta, masking tape, teaspoon(s). Ingredients: (choose from soil, fertiliser, salt, cooking oil, laundry powder, ammonia, rubber bands, food colouring, vinegar.)

Activity instructions

Pour the water into your container and label your 'mini-pond' with your names and the date. Add 1 teaspoon of one of the ingredients to your 'mini-pond' and add a label to it to record the ingredient added. Mix the ingredient in to simulate natural currents. Can you see any differences in the water after the ingredient has been added? Do you think this ingredient will affect water quality? Repeat this for another ingredient if you have time. Put the uncovered 'mini-ponds' on a sunny window sill. Record your observations for your 'mini-pond' and four others. In the first column write down what each 'mini-pond' contains.

Observations

'Pollutant'	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Your mini-pond' contains ___________					
'mini-pond 2' contains ___________					
'mini-pond 3' contains ___________					
'mini-pond 4' contains ___________					
'mini-pond 5' contains ___________					

Introducing Water Quality

Describe what happened over the 5 days when soil was added to the water? (How did the water look when you first added the soil? What happened to the soil over time?)

Describe what happened over the 5 days when oil was added to the water?

Describe what happened over the 5 days when ammonia was added to the water?

After listening to the results from all the teams, list which ingredients dissolved or disappeared when added to the water [i.e. you could not see a difference in the water].

Dissolved or disappeared in the water	No difference in the water

List all the ‘ingredients’ that polluted the water in the ‘mini-ponds’.

In the space below, write the name of pollutants which may have been represented by an ingredient added to the ‘mini-ponds’. Draw or explain how this pollutant might get into a real-life lake or river.

Monitoring Water Quality

B1-B3

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 3

Curriculum Links:

Science Working Scientifically / Investigating WS 2.2, WS 3.2

SOSE Environments / Environmental Awareness and Care Env 2.2

Focus Question:

- **How is water quality measured?**

Aims:

1. Students will be able to identify which tests are used to measure water quality.
2. To be familiar with community based water quality testing methods and equipment.
3. To understand the importance of water quality testing and the status of the water quality of your region.

Main Ideas:

- The quality of the water is an important component of catchment health. Many animal and plants are sensitive to, even small changes in a particular water quality parameter (eg: pH, dissolved oxygen).

Location:

School laboratory or local waterway.

Assistance:

Regional Waterwatch Coordinator required.

Need:

Access to a laboratory or a stream within walking distance.

Consider:

Teacher to explain to the class that they are going to measure the water quality of a Waterwatch site (in your local area).

Waterwatch Coordinator to briefly discuss the importance of water for the survival of living things. Students are asked about what they know about water uses in their area.

Waterwatch Coordinator explains pollution types and sources and that even water that appears clear may be polluted.

Water can be collected from a nearby water body by the Waterwatch Coordinator and brought into the lab OR the class can walk to a nearby water body to do the tests on site.

Explain to the class what they will be studying and why. That is the existing water quality of this waterway to monitor changes over time. Note that monitoring enables early detection of problems so appropriate action can be taken.

Waterwatch Coordinator Instructions:

The Waterwatch Coordinator explains that:

- The class is going to monitor the water quality at the site as part of the Australia-wide Waterwatch Monitoring Program, so it is important that the tests are done correctly;
- Quality assurance and quality control is an important aspect of taking water quality measurements;
- What parameters to measure for baseline studies;
- The water quality data collected should become part of a monitoring plan;

- Broad catchment assessment assists in predicting what issues may be important for a particular location. Information gathered also assists in deciding where to monitor and how often to monitor;
- The Education Kit being used represents only one method of undertaking water quality tests; and
- A number of water quality parameters can *only be monitored* by sending water samples into a special laboratory.

The Waterwatch Coordinator then:

- Holds up parts of the kit and describes each part and its use, eg: pH probe; and
- Assigns group and distributes tasks to each appropriate equipment, instructions and record sheets.

Note: Teachers are required to assist in supervision and behaviour management. It is best to have a ratio of 1: 5 adult to students, so landcare group members or parents may be interested in being involved.

Analysis:

If on site begin with the site description for the area recording rainfall and land use details.

Students follow written instructions for an initial set of tests and make records on the data sheets provided.

Supervise each group in their use of equipment and recording of results. Rotate groups so all students get a chance to use all the equipment.

Groups come back as a class at the end of the activity and discuss what the results mean and the future of the students' involvement in Waterwatch. National Water Quality Management Guidelines are used to interpret the results. Students are guided through the interpretation of the test results.

Reflection:

How does repetition of the same test on the same water sample assist data quality control?

Extension:

The Regional Coordinator may talk about comparisons with other Waterwatch data taken at different times or locations within the catchment.

The Regional Coordinator discusses the need to be careful when making comparisons for the purpose of drawing conclusions about the health of the water body.

Further information:

Department of Infrastructure, Planning and Environment Waterwatch website http://www.lpe.nt.gov.au/waterwatch/

Measuring Water Quality

B3-B5

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 4

Curriculum Links:

Science Working Scientifically / Investigating WS 3.2, WS 4.2 / Evaluating WS 3.3, WS 4.3

Focus Question:

How is water quality measured?

Aims:

1. To be able to identify which tests are used to measure water quality.
2. To become familiar with the water testing equipment before conducting the tests at a field monitoring site.

Main Idea:

See relevant tests in the resource section of this booklet.

Need:

WATERWATCH
Northern Territory
A Federal - Territory Partnership

Regional Coordinator assistance initially. Student Sheet: Measuring Water Quality (copied onto card, cut out and shuffle - 1 set per group). Waterwatch monitoring equipment kit and data record sheets.

Consider:

Water can become polluted if it has too much sediment, salt, nutrients, pollutants or lowered amounts of dissolved oxygen. Items that don't decompose are more obvious (eg: plastic/oil). Pollutants such as toxins often can't be seen.

Explain that the class is going to monitor the water quality as part of the Australia-wide Waterwatch monitoring program.

Explain the following:

Water quality scientists measure / record:

- Physical features of water (flow, temperature, turbidity).
- Chemical features of water (pH, phosphorus and nitrogen levels, dissolved oxygen levels, conductivity).
- Biological features of water (types and abundance of macro-invertebrates).
- Streamside habitat (the condition and type of streamside vegetation).

Show students the water testing equipment in the Waterwatch kit, naming each piece as you hold it up.

Analysis:

Assign groups and distribute card sets. Students work in teams to match the right water quality tests with what they measure, then they identify the correct piece of equipment used to make this test.

Once all the groups have finished, ask a student from each group to name one of the water quality tests they chose. Explain what it measures and how that parameter affects aquatic life. Complete Student Sheet 5.4: Measuring Water Quality.

Reflection:

This exercise considers chemical and physical measures of water quality. What is the third group of measures that is required for full interpretation of results? (biological)

Student Sheet 5.4
Measuring Water Quality

Test	What it measures	How to measure it
Turbidity	Clarity of the water (level of suspended particles in the water)	A Turbidity Tube
Water temperature	The temperature of the water	A temperature meter or probe
Water flow	The volume and speed of the water flow	Measure a length along the creek bank; time how long an object takes to float over this set distance, then calculate the flow rate
pH	Acidity of alkalinity level of the water	A pH meter
Conductivity	Salinity level of the water	TD Scan 4 probe or meter
Dissolved oxygen	Oxygen concentration in the water	Phosphorus chemical test kit
Phosphorus	Nutrient level in the water	Phosphorus chemical test kit
Water depth	Depth of the water	A metre ruler
Stream habitat	State of the vegetation; bank erosion; diversity of water habitats	Stream Habitat Record Sheet
Macro-invertebrates	Presence of water quality sensitive species	Dip nets, plastic trays and Macro-invertebrate Record Sheet

Measuring Water Quality

Water quality can sometimes be judged by looking at it, but for accurate testing and monitoring we need to measure water quality with special equipment and always take measurements in the same way. Imagine you are water quality scientists. You need to know what to test in the water and what equipment to use to measure it.

The physical features of the water:

___ ___ ___W
T ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
T ___ ___ ___ ___ ___ ___ ___ ___ ___

The chemical features of the water:

P ___
P ___ ___ ___ ___ ___ ___ ___ ___
D ___ ___ ___ ___ ___ ___ ___ ___ O ___ ___ ___ ___ ___
C ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Match the cards.

Select the rights tests for measuring water quality.

Match each water quality test with what it measures.

Circle the correct words (there may be more than one) in each sentence.

Water is polluted if we can see (oil, froth, water boats).

Even though it looks clear, water could be polluted by high levels of (sunlight, nutrients, salt).

High levels of (sediment, oxygen, sunlight) reduces water quality.

Unjumble these letters.

River water becomes polluted if there is too much:

aslt ___ ___ ___ ___;

mistedin ___ ___ ___ ___ ___ ___ ___ ___; and/or

sitrunnet ___ ___ ___ ___ ___ ___ ___ ___ ___

Water becomes polluted if there is not enough:

goyenx ___ ___ ___ ___ ___ ___

Measuring Water Quality

List the different kinds of tests we can use to measure water quality.

Test	What it measures

Determining Stream Surface Velocity

B3-B5

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 5

Curriculum Links:

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Science Concepts and Contexts / Life and Living CC 3.2

SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- What are water quality parameters and how do they assist in assessing the health of our waterways?
- What is flow and why is it important?

Aims:

Students will be able to relate velocity to real life situations such as stream flow.

Main Idea:

- The Waterwatch Program can provide support to community groups who wish to be involved in measuring these parameters in their local water bodies.
- This activity measures the *velocity* of the water flowing on the surface of the stream (ie: speed and direction). Further activities are required to calculate the stream *flow* taking into account the cross section of the stream.
- See Test 1, Page 9.

Need:

Access to a flowing creek, tennis ball, net on a pole, 10 meters of tape or rope, stopwatch or watch with second hand.

Consider:

Follow the procedure outlined in Test1: Investigating Stream Velocity in Part 5: Monitoring Catchment Health.

Analysis:

Determine velocity. Example on calculation method is given below.

Distance travelled =		10meters
Average time taken =		18 seconds
Correction Factor =		0.9
Stream Velocity =		<u>10m x 0.9</u>
18 seconds	=	0.5 m/second

Ask the students to explain how the ball moved along the stream and to consider where all the water has come from.

Reflection:

Ask students to think what factors might influence surface flow in a creek. How can this data be used? Does more information need to be collected to draw any conclusions? Do further measurements need to be taken at different times at the same site? Why might this be necessary? Evaluate the outcomes of the experiments.

Turbidity Study

B3

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 6

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- What is turbidity and what causes it?

Aim:

Students will understand the term ‘turbidity’.

Main Idea:

- Turbidity is a measure of water clarity. Particles such as clay, silt, sand, algae, plankton and other substances suspended in the water, scatter the passage of light through water. To the naked eye, turbidity appears as cloudy or muddy water.
- Sources of turbidity include soil erosion; waste discharge; urban runoff; eroding river banks; excessive algal growth; disturbances to a waterway channel or banks.
- Suspended particles absorb more heat, so high turbidity can raise the water temperature.
- High turbidity reduces the amount of light passing through water from the surface and lowers photosynthesis.
- Suspended materials can clog fish gills, reducing resistance to disease, lowering growth rates, and affecting egg and larval development. As suspended particles settle in slow flowing waters, fish eggs may be smothered
- See Test 3, Page 17.

Need:

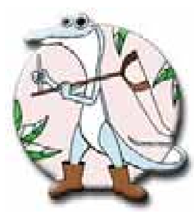
Student Sheet: Turbidity

Consider Analysis:

Student Sheet: Turbidity.

Reflection:

How might the levels or frequency of turbidity be reduced?



Student Sheet 5.5
Turbidity

Turbidity is the name for the clarity or 'clearness' of a waterway. Rivers usually turn brown after heavy rain. This is because the rainwater picks up soil particles when it flows over exposed soil and carries it to waterways. Any human activity that increases erosion on land, especially land close to waterways and wetlands can lead to increased turbidity (Green 1992).Turbidity can also be caused by millions of tiny floating algae and high levels of salt. High turbidity usually means water quality is poor (Green 1992).

How does turbidity affect water quality?

The suspended soil particles or algae cloud the water and reduce light penetration into the water. Soil particles suspended in the water absorb heat from the sun and raise the water's temperature. This lowers the oxygen levels in the water (because warm water holds less oxygen than cold water).

Floating particles can clog the gills of insects and fish, making it hard for these animals to breathe (Green 1992).

When the floating particles sink, they can smother and kill the eggs of aquatic insects and fish that have been laid on the bottom of the waterway. This sediment can also remove habitat. It can fill in the small holes and cover rocks on the lake or riverbed that are used by small animals.

Plant growth is reduced because less sunlight is able to reach the leaves of aquatic plants growing on the lake or riverbed. This vegetation is very important food and habitat for many aquatic animals (Green 1992).

Activities

Some causes of Turbidity are:

List some of the impacts of turbidity on aquatic living things.

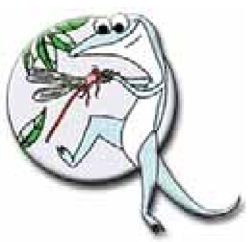
Complete these sentences

If the water is muddy it is because ______________________ particles from erosion are present.

If the water looks green it is because of ______________________ .

Turbidity in water makes it harder for insects and fish to survive because there is less ______________________ in muddy water.

In general, high turbidity means *good / poor* quality water. (Cross out the wrong word.)



Choking our Waterways

B3

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 7

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **Why is it important to monitor and control sedimentation?**

Aims:

1. To understand how sediment enters water.
2. To understand the impacts of sediment on waterways.

Main Idea:

- This activity involves making up 2 identical jars to represent an aquatic environment. Soil is added to one of the model 'lakes' to see what effect sediment can have on waterways.
- See Test 3, Page 20.

Need:

Student Sheet: Choking our Waterways.

For each group: 2 large clear jars of the same size, one with a lid. 2 plastic aquarium plants or 2 pieces of a weed.

Several large dried beans, macaroni noodles, white rice (about 10-15 grains) styrofoam (reuse food trays), plasticine (enough for 6 small lumps), scissors, string, paper clips, hole punch, soil (about half a cup), texta.

Consider:

Make sure students know these words before they undertake the activity.

sediment – soil or dirt.

smother – to suffocate or prevent from getting air.

spawning – the process of laying eggs by fish and frogs.

submerge – to sink beneath the surface of the water.

suspended solids – soil suspended in water).

Organise student groups and distribute materials. To make the 'lakes', Follow the instructions on the student sheet. Explain that the dried beans, white rice and macaroni noodles are to represent aquatic animals. Once model 'lakes' have been made add soil to one, and observe the result.

Analysis:

Explain that this is a representation of what happens on in lakes, creeks and rivers that are polluted by excessive erosion. Discuss a local example.

Note: If the water is brown but clear this indicates there are tannins in the water rather than suspended solids. Tannins are dissolved chemicals which come from the native vegetation around the waterway. Tannins make the water look like weak black tea and are not harmful to aquatic life.

Student Sheet 5.6
Choking our Waterways

To make the model 'lakes':

- Use lumps of plasticine to anchor the plant, beans and rice to the bottom of the jar. These represent an aquatic plant, benthic (bottom) dwelling aquatic animals such as mussels and frog eggs respectively
- The macaroni should be added without being attached. These represent free-swimming macro-invertebrates.
- Tie a loop of string around each jar from top to bottom, placing it so the string loops over the top of the jar. By connecting several paper clips and a hole punch, suspend fish shaped pieces of styrofoam from the top of the jar.
- Once both jars have been set up, add water. Label one jar 'Plus Sediment'.

To test the model lakes

Draw a diagram for each of your model 'lakes'. Label the organisms you are representing in each of the jars. Describe how the water differs in the 'lakes'.

Jar 1 Jar 2

Add the soil to the 'Plus Sediment' jar. Put the lid on firmly and shake the jar. How does the water in each 'lake' look now? Draw the 2 jars as a record.

Jar 1 Jar 2

Through which jar could sunlight pass most easily? To which organism(s) in your 'lake' is sunlight important and why?

Read the Turbidity information sheet. After 5 minutes observe the 2 jars again. What happened to the suspended soil in the water? Draw and label a diagram.

Jar 1 Jar 2

Write a sentence to summarise your conclusions from this experiment.

Summarise how sediment affects each type of aquatic life represented in your jar. Does the sediment affect the organism when the sediment is suspended in the water or when it settles, or both?

Waterwatch Data: Temperature Comparisons

B3

Activity 8

Curriculum Links

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **What factors influence temperature in a water body?**

Aim:

Students determine what factors might influence temperature readings of aquatic water bodies.

Main Ideas:

- Water temperature is affected by a number of factors that include the temperature of the air, groundwater inflows to the river, temperature of stormwater runoff, turbidity, shade, and warm or cold water discharges.
- See Test 4, Part 24.

Need:

Slide projector, Waterwatch data, Student Sheet: Temperature.

Consider:

Students read the Student Sheet: Temperature. Invite your local Regional Waterwatch Coordinator to bring along their water temperature, depth and turbidity data. Ask them to also bring along photos/slides of the sites that the temperature data is associated with and maps of where the sites are located.

Regional Coordinator then demonstrates data collected against various sites, showing the site and pointing out site features.

Analysis:

Students identify what site features may be contributing to the temperature data collected for each site.
The focus is likely to be on: time of year and day, presence of shade, depth of water and turbidity levels.
Students may like to clump sites with similar reasons for temperature changes identified and then consider where these sites are in relation to each other on the ground.
Complete Student Sheet: Temperature.

Reflection:

Are there aquatic sites near your school that could benefit from more shade? Bank stabilisation to reduce local turbidity levels?

Who could you speak to about revegetation using native species? Consider Government and Non Government organisations such as Landcare and Greening Australia.

Student Sheet 5.7
Temperature

The temperature of the water affects the amount of dissolved oxygen in the water, the rate of photosynthesis and animal survival

Cold water can hold more oxygen than warm water.

As the temperature rises, so too does the rate at which plants photosynthesis resulting in increased plant growth – more plant growth means more plants die. When plants die, decomposers eat them and use up oxygen. When the rate of photosynthesis increases this leads to a need for oxygen by more aquatic organisms.

Many aquatic animals can only survive within certain water temperature ranges. As water temperatures increase dissolved oxygen levels will fall and plants, used for food and shelter will die. Some aquatic animals such as fish only breed in certain temperature ranges.

Human increases in waterway temperatures can be attributed to:

Runoff: Bitumen and concrete roads, paths and parking lots are heated by the sun, rain is heated as it falls on these surfaces before it runs into waterways.

Thermal pollution: Water is used by some factories and power stations to cool production processes. Heated water may be disposed of into waterways.

Removal of riverine vegetation: Removes shade, which results in the sun directly hitting the water surface and warming it. Cutting down trees also leads to erosion, causing soil to wash into the water. Muddy (turbid) water is darker and so absorbs more heat from the sun than clear water.

Illustrate human influences on water temperature

Draw a river scene with a factory and nearby roads, paths, car park and very little riverbank vegetation. Draw arrows and write labels on your river scene to show how the river's temperature may be increased. Discuss how humans altered the temperature of waterways in urban and rural area through various land uses?

Cross out the incorrect word to complete these sentences:

As temperatures rise, the amount of dissolved oxygen in the water *decreases / increases.*

As water temperature rises, animals' need for oxygen in the water *increases / decreases.*

Clearing trees from the riverbank can *increase / decrease* the temperature of the water.

Oxygen and Water Quality

B3

Activity 9

Curriculum Links:

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Science Concepts and Contexts / Life and Living CC 3.2

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **What is dissolved oxygen and why is it important?**

Aims:

1. To demonstrate the effects of organic wastes on dissolved oxygen levels in water.
2. To provide practice in (or demonstrate) testing dissolved oxygen levels in water.
3. To draw conclusions about the relationship between dissolved oxygen levels and water quality.

Main Idea:

- Oxygen is necessary for all living things and for many of the chemical processes that take place in water.
- Most aquatic animals respire the oxygen dissolved in water.
- Waters with consistently high dissolved oxygen levels are capable of supporting many different kinds of aquatic animals.
- See Test 5, page 30

Need:

Waterwatch Regional Coordinator assistance required (at least the first time).

2 one litre glass jars or clear containers for each group (or if a demonstration use 2 two litre containers and double the quantity of fertiliser), 2 teaspoons (15ml) of fertiliser, Creek water (2 litres per group), D.O. testing equipment (**Waterwatch equipment kit)**, thermometer, Student Sheets: Dissolved Oxygen and Effects of Nutrients on the River.

Consider:

Conduct this experiment as a demonstration or organise students into small groups.

Advanced preparation:

Organise small groups and distribute materials OR conduct as a demonstration experiment.

Analysis:

Student Sheet 5.8: Dissolved Oxygen (p.98).

Reflection:

What might be achieved by appropriate waste management, ie ensuring wastes do not find their way into waterways?

What community projects are happening/could happen in your area to protect waterways from raw wastes?

Human Activity and Dissolved Oxygen B3

Activity 10

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- What factors influence variations in dissolved oxygen levels?
- What is biochemical oxygen demand and why is it important?

Aim:

To demonstrate the effects of organic wastes on dissolved oxygen levels in water.

Main Idea:

- Oxygen is necessary for all living things and for many of the chemical processes that take place in water. Most aquatic animals respire the oxygen dissolved in water.
- Waters with consistently high dissolved oxygen levels are capable of supporting many different kinds of aquatic animals.
- See Test 5, page 27.

Need/Consider:

Student Sheets: Dissolved oxygen 1 and 2 (below).

(*Solution to Q2* - Sewage treatment plants sewage waste water, animal feedlots; animal manure, food processing plants, food wastes. Failing septic systems; sewage waste water, urban streets; stormwater containing food and leaf materials, farmland; animal manure.)

Reflection:

What actions could we all take to reduce the pollution of stormwater and therefore prevent this being a source of reduced oxygen levels for aquatic plants and animals?

Note: Students may like to take this home and discuss it with their family using the brochure: “stormwater-keep it clean”.

Student Sheet 5.8
Dissolved Oxygen 1

Most aquatic animals respire or breathe the oxygen dissolved in water. Waters with high dissolved oxygen levels are capable of supporting many different kinds of aquatic animals.

Oxygen is both added and removed from water. Water gains oxygen from the atmosphere and from plants as a result of photosynthesis. In addition, the churning of running water helps add dissolved oxygen. Respiration (breathing) by aquatic animals, decomposition, and various chemical reactions, consume oxygen from the water body. If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken or die.

Activity Instructions:

1. First label the 2 jars as ‘Control’ and ‘Organic Waste’.
2. Add 1 litre of river water to each jar. Explain that we need to use creek water because tap water contains chlorine which would kill organisms.
3. Add organic waste (2 tablespoons fertiliser) to the jar labelled Organic Waste and stir in until it is dissolved.
4. Record the DO level, colour, odour and temperature of the jars in the table provided. Draw a line on the jar to mark the water level. Put the uncovered jars on a windowsill for one week.
5. Keep the remainder of the creek water in a separate jar and use it to top up the experiment jars if water evaporates.
6. Students or teams inspect the jars after 5 days and again record DO reading, colour, odour, and temperature.
7. Summarise the results from the experiment and draw conclusions.

Record table

	Observations	**Jar 1 (Control)**	**Jar 2 (Organic Waste)**
Day 1	DO (% saturation) colour odour temperature		
Day 5	DO (% saturation) colour odour temperature		

Explain your results

How did the level of dissolved oxygen change over the time of your experiment?

Explain the differences in oxygen levels in the 2 jars over this time.

How did the colour, odour and temperature of the water changed over time?

Student Sheet 5.9
Dissolved Oxygen 2

Clean, healthy water has plenty of dissolved oxygen (100% is excellent). If the level of dissolved oxygen drops or increases too much, the quality of the water drops. Dissolved oxygen comes from the atmosphere: Waves, wind, waterfalls and riffles trap oxygen and mix it into the water. Aquatic plants produce dissolved oxygen through photosynthesis.

Organic Waste

Decomposers, such as bacteria break down organic waste, using up oxygen in the process. If there is a large amount of organic waste in the water, dissolved oxygen levels may fall dramatically. Organic wastes such as sewage, animal manure and food wastes can originate from sewage treatment plants, failing septic systems; animal feedlots and stormwater runoff.

Nutrients

Nutrients such as nitrate and phosphate enter the water as fertilisers or sewage. These nutrients stimulate the growth of algae and other aquatic plants. Initially increased growth increases dissolved oxygen levels due to the increase in photosynthesis, however, when these plants die and are decomposed by bacteria oxygen levels fall.

Flow

Too much dissolved oxygen can also be a problem. Below some dams, highly turbulent waters passing through turbines and spillways can create supersaturated conditions that are dangerous to fish. Supersaturated conditions do not last long as excess dissolved oxygen diffuses into the air.

Water Temperature

Lowered discharge rates, which may result from dams and irrigation, and the removal of riparian vegetation result in higher water temperatures and associated lower dissolved oxygen levels. Thermal pollution also occurs from the release of water used to cool industrial processes and power plants. Some chemicals like those in some industrial wastes react with oxygen and decrease dissolved oxygen levels.

Questions

Name five human activities that cause changes in dissolved oxygen.

What role do bacteria play in reducing dissolved oxygen?

In the following 2 lists draw a line to match the organic waste on the left to its source on the right:

sewage treatment plants	animal manure
animal feedlots	animal manure
failing septic systems	sewage waste water
urban streets	sewage waste water
farmland	food wastes
food processing plants	stormwater containing food and leaf material

What is Acidity?

B3-B5

Activity 11

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3,

Focus Question:

- **What is pH and why is it important?**

Aim:

To understand the concept of pH, acid and alkaline.

Main Idea:

- pH is a measure of acidity of water and varies on a scale from 0 to 14 units. The acidity of water increases as the pH gets lower.
- All animals and plants are adapted to a certain pH range but most prefer 6.5-8.0. An increase or decrease in pH outside the normal range of a water body will cause a loss of species depending on their sensitivity.
- Extremely high or low pH values will lead to the death of all aquatic life.
- See Test 6, page 34.

Need:

27 cups (or 9 per group)**,** lemon, tomato, apple and orange juice, vinegar, milk, distilled water, water with baking soda in it and water with detergent mixed in. pH test strips.

Student Sheet: Factors that affect the pH of a waterway.

Consider:

Divide the class into three groups. Each group receives 9 cups and a portion of each of the liquids. Students then use the pH test strips to determine each liquid's pH. Record the measurements. The class then collates all the results and calculates an average measurement for each liquid.

Analysis:

What do the results mean? Which liquids were the most acidic and which were the most alkaline?

Given the types of liquids used in this experiment, what does this say about our ability to digest liquids of varying pH value?

Now dilute each of the liquids by half (50:50 water and liquid) and repeat the above steps. Does this have an effect on pH?

Consider water's ability to act as a 'buffer' ie water's ability to resist a change in pH when an acidic or alkaline solution is added.

Complete Student Sheet 5.10 Factors that affect the pH of a waterway (below).

Reflection:

What might be some liquids that are discharged into our natural waterways that could effect its pH? Where might these discharges originate from?

Are there any human activities in your area that may effect the pH water bodies in your region? If so what management is being undertaken to ensure that these actions are not having a detrimental impact on the environment?

Student Sheet 5.10
Factors that Affect the pH of a Waterway

Respiration and Photosynthesis

The respiration and photosynthetic activities of aquatic plants and algae cause changes in pH. As you know people breathe out carbon dioxide (CO_2). Similarly CO_2 is produced during the respiration of aquatic plants and animals. The CO_2 produced results in an increase in hydrogen ions (H^+) present in the water, which results in a lowered pH (higher acidity).

Some of the CO_2 being produced is used by plants for photosynthesis during daylight hours. The removal in CO_2 means less hydrogen ions (H^+) and a higher pH (lower acidity). A cyclic pattern of addition and removal of carbon dioxide takes place over each 24 hour period. The highest pH values usually occur at mid-afternoon.

Table 16 Respiration and Photosynthesis

	Uses	Produces	H^+ Ions	pH	Acidity
Respiration	Oxygen (O_2)	Carbon dioxide (CO_2)	↑	↓	↑
Photosynthesis	Carbon dioxide (CO_2)	Oxygen (O_2)	↓	↑	↓

Buffering capacity

The buffering capacity of a water body refers to its ability to cope with the addition of an acid or a base without significant changes to pH. Water containing low concentrations of ions, eg: Calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+) and chloride (Cl^-) tend to be poorly buffered. In contrast, when higher concentrations of these ions are present, the water body is better able to deal with acidic or alkaline inputs. This is because the various ions bind with the added hydrogen ions (H^+) of an acid or hydroxide ions (OH^-) of a base to neutralise their effects. In general, small streams in pristine areas tend to be poorly buffered, whilst larger lowland rivers are well buffered.

Catchment geology

The pH of natural waters is largely determined by the geology and soils of the catchment. For example water running off limestone areas would have relatively high pH levels, while waterways in coastal dune areas may have very low pH values (sometimes less than 5) due to the presence of humic acids. These cause the brown ti-tree colour in water.

Increasing salinity causes an increase in pH. In a typical estuary, pH would rise from values of 6.5 to 7.5 in the upstream fresh water reaches, to between 8 and 8.5 in the downstream coastal areas.

Human caused changes in pH

The most common cause of unnatural pH changes occur follow disturbance of acid sulphate soils. Disturbance, resulting from mining and other development, exposes these soils to oxygen in the air, causing acids to be formed. During rain events, these acids are washed into streams where they cause short-lived, but sometimes quite large, reductions in pH. Some industrial wastes have pH values outside the normal range and thus have the potential to affect pH in receiving waters. Changes in pH can also be caused by atmospheric deposition (acid rain, dry particle deposition) and from the burning of fossil fuels by cars, factories, and smelters.

Factors that Affect the pH of a Waterway

Questions

What are the four major categories that influence the pH of water?

____

Aquatic plant respiration makes the pH of water more: acid / alkaline. Aquatic plant photosynthesis makes the pH of water more *acid / alkaline*. (Circle correct word).

Is it a good thing that water has buffering capacity? Explain your answer.

____

What is in the water that makes it have good buffering capacity?

____

Which of the following is most likely to be able to tolerate the addition of a strong acid or alkaline? A *small upland stream / a large lowland river*?

The pH of _ _ _ _ _ _ _ waters is largely determined by the geology and soils of the catchment. Water running off limestone areas would, for example, have relatively _ _ _ _ pH levels. On the other hand, streams and lakes in coastal dune areas may have very _ _ _ pH values. Increasing salinity causes an _ _ _ _ _ _ _ _ in pH.

List four human activities that, if poorly managed, can cause a change in the pH of water.____

Factors Influencing Conductivity

B3-B5

Activity 12

> ***Curriculum Links:***
>
> **Science** Concepts and Contexts / Life and Living CC 3.2
>
> **Science** Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3
>
> **SOSE** Environments / Natural Systems Env 3.3,

Focus Question:

- **What affects conductivity of a water body?**

Aim:

To increase understanding about conductivity in waterways.

Main Ideas:

- Electrical conductivity can be measured in terms of the ability of water to pass an electrical current.
- This ability depends on the presence of salts and hence conductivity is used as a measure of salinity.
- See Test 7, page 37.

Need/Consider:

Student Sheet 5.11 Factors influencing conductivity.

Reflection:

Imagine the complexity of analysing why a stream of waterhole has become more saline, what other factors could you observe to determine the primary cause(s)?

Solutions: warmer; granite; clay soils; lowest; increases; droughts; groundwater, river; sewerage, oil spills; heavy metals; salt and fresh.

Student Sheet 5.11
Factors Influencing Conductivity of Water

Conductivity in waterways is affected primarily by the geology. Waterways that run through areas with granite bedrock tend to have lower conductivity because granite is composed of materials that do not dissolve to form ions (ionise). Rivers that run through areas with clay soils tend to have higher conductivity levels due to the presence of materials that ionise when they come into contact with water. Groundwater inflows can have the same effects depending on the bedrock they flow through.

Conductivity is affected by temperature, increasing 2% for every 1°C rise in temperature. The warmer the water, the higher the conductivity. Monitoring results are reported as conductivity at 25°C.

Conductivity varies with flow. Levels are generally lowest during high flows because of the high proportion of surface runoff water to base flow. Conductivity increases as the river returns to normal flow, with extreme levels occurring during droughts.

Human-caused changes to catchments can affect the conductivity of run-off water. Changes can occur with extensive agricultural activity, as a result of vegetation clearing and irrigation, affecting groundwater levels and natural water balances. The serious problems that occur in the Murray-Darling Basin are caused by removal of vegetation, application of irrigation water and the subsequent rise in water tables, bringing salt to the surface. The salt affects crops and is eventually flushed into the river causing salinity problems.

In the Top End region, there is an additional impact namely, saltwater intrusion. Saltwater intrusion is where land that once separated the tidal waters from the freshwaters have been breached so that the tidal salt water now extends inland further than it did originally effecting the once freshwater habitats.

Discharges to rivers can influence conductivity depending on their make-up. A failing sewage system raises the conductivity because of its chloride, phosphate, and nitrate content, but an oil spill would lower the conductivity. The discharge of heavy metals into a river ecosystem could raise the conductivity as metallic ions are introduced into the river. Water used for irrigation can pick up salts in the soil, raising conductivity when returning to the river.

Factors Influencing Conductivity of Water

Activities

Unscramble the following words and determine where they best fit into the spaces in the following sentences:

wmearr; irangte; lacy ilsos; welost; ieasncres; dugrohts; atgdonuwrer, verir; sweagere, lio llips; vayhe maetsl; lsat; shfre.

Conductivity is affected by temperature, the _ _ _ _ _ _ the water, the higher the conductivity.

Conductivity in rivers is affected primarily by the geology of the area that rivers flow through. Rivers that run through areas with _ _ _ _ _ _ _ bedrock tend to have lower conductivity. On the other hand, rivers that run through areas with _ _ _ _ _ _ _ _ _ tend to have higher conductivity.

Conductivity varies with flow. Levels are generally _ _ _ _ _ _ during high flows because of the high proportion of surface runoff water to base flow. Conductivity _ _ _ _ _ _ _ _ _ as the river returns to normal flow, with extreme levels occurring during _ _ _ _ _ _ _ _.

Large changes in conductivity can occur where changes to vegetation or agricultural activity, particularly irrigation, affect _ _ _ _ _ _ _ _ _ _ _ levels and natural water balances.

The salt affects crops and is eventually flushed into the _ _ _ _ _ causing salinity problems.

Discharges to rivers can change the conductivity depending on their make-up. A failing _ _ _ _ _ _ system raises the conductivity because of its chloride, phosphate, and nitrate content, but an _ _ _ _ _ _ _ _ would lower the conductivity.

The discharge of _ _ _ _ _ _ _ _ _ _ _ into a river ecosystem could raise the conductivity as metallic ions are introduced into the river.

Salt water intrusion is where land that once separated the _ _ _ _ _ waters from the freshwaters have been breached so that the tidal salt water now extends inland further than it did originally therefore effecting the once _ _ _ _ _water habitats

.

Saltwater Intrusion - Mary River Catchment

B3

Activity 13

Curriculum Links:
Science Concepts and Contexts / Life and Living CC 3.2
Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3
SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **What affects conductivity of a water body?**

Aim:

To understand the reasons for saltwater intrusion and the impact that this has on freshwater habitats.

Main Idea:

- Electrical conductivity can be measured in terms of the ability of water to pass an electrical current.
- This ability depends on the presence of salts and hence conductivity is used as a measure of salinity.
- See Test 7, page 40.

Need:

Student Sheet 5.12, Saltwater Intrusion in the Mary River Catchment.

Analysis:

What is believed to have caused the saltwater intrusion in the Mary River?

What area do you expect to start to improve now that the 1996 barrages have been in place for some time?

What are some of the impacts of salt water intrusion in the Mary River region?

What are some of the *economic* impacts of saltwater intrusion in the Mary River region?

How have remedial actions taken into account the need to allow local fish migration to continue?

Who has paid for the remedial actions undertaken?

Who else do you think could assist in funding this work?

Reflection:

What could the impact be if global climate change resulted in a rise in sea level?

Student Sheet 5.12
Saltwater Intrusion in the Mary River Catchment

(Extract from the Mary River Integrated Catchment Management Plan 1998 DLPE)

The Issue

Saltwater intrusion occurs where freshwater environments become saline through the incursion of tidal waters. Since the 1940's, the breakdown of coastal cheniers (remnant coastal dunes) and development of tidal channels has linked saltwater to freshwater over much of the Mary River floodplains. The process has greatly changed the environmental values of affected wetlands and reduced the land use options they normally offer. Such intrusion must be controlled in order to prevent further damage.

Current Situation

Over 240 km2 of freshwater wetlands in the Mary River catchment have been destroyed by the intrusion of saltwater within the last 50 years. This process was initiated primarily through the impact of large populations of feral buffalo, although other natural processes helped predispose the wetlands to saltwater intrusion. The breakdown of coastal cheniers and the formation of swim channels between previously freshwater areas and tidal, saltwater areas began the process which has now become internally driven through the daily tidal cycle. This cycle now causes channel expansion and elongation and the extremely low elevation of much of the floodplains makes them highly susceptible to further tidal intrusion.

One third of the area already affected by saltwater intrusion lies within the Mary River Conservation Reserve. The remaining two thirds lies within crown leases used for pastoral purposes. These wetlands previously supported large Melaleuca forests, magpie geese and saltwater crocodile habitats and other flora and fauna dependent on a freshwater environment. A total of 1 000 km2 of wetlands both within the Mary River Conservation Reserve and upstream of the Shady Camp barrage is under immediate threat of intrusion if this process continues. This would mean additional losses to important wildlife habitats and to the pastoral and tourism industries, which rely on those wetlands.

The fisheries value of these wetlands is also dependent on the maintenance of both the highly productive freshwater floodplains as well as tidal flats which act as nurseries for fingerlings. For many species, most notably the barramundi, fish breeding and growth cycles depend on an ability to move between saltwater and freshwater at various times of the year. Efforts to control saltwater intrusion must not hinder normal fish migration. There is no suggestion from population modelling that barramundi numbers have declined significantly as a result of the past eight years of saltwater intrusion control and rehabilitation works.

Only a preliminary cost benefit analysis has been conducted on this issue. However in terms of their value as a grazing resource to the pastoral industry, the area destroyed could be valued at $1million - $500 000 per annum. This is based on the carrying capacity of this land, live weight gain for stock and the value of stock that could have been turned off these pastures if they had not been destroyed. The real value of this land lost would of course be much higher; wildlife habitat, tourism and recreational fishing values are not yet able to be quantified.

From 1988 to 1997, about $1,000,000 has been expended in the battle to control saltwater intrusion. Much of this work has been undertaken by government to rehabilitate or prevent further loss of valuable conservation land and reserves. Over 25 km2 of degraded floodplain within the Mary River Conservation Reserve has been rehabilitated. Landholders have spent about 20%-of the total in undertaking works on their own properties to prevent further loss of their productive floodplains. Many of the control works have been the simple Earthen barrages to block small tidal gutters. Some structures have included stabilised spillways to allow wet season flow over the structure and provide for fish migration. The largest barrage has been constructed across Shady Camp billabong to prevent the intrusion of saltwater further south. The cost of fully addressing the problem cannot be determined precisely, but the best estimates indicate the cost of remediation may amount to $5-6 million.

The Response

Finding the means for long term control of saltwater intrusion is strategically the most important issue for the Mary River catchment. It is also one of the most difficult as there are no 'off the shelf engineering solutions available. At this stage and based on a number of comprehensive studies involving the best available expertise, the primary target is to reduce tidal entry into Tommycut Creek and Sampan Creek. An attempt to block Tommycut Creek late in 1995 was unsuccessful, due primarily to failure in the embankment foundation, which was compromised by early wet season flood flow.

Lessons learned from this initial attempt are being considered in the detailed investigations currently underway to determine the feasibility of a range of options for both creeks. Attention is focussed on solutions at the mouths of each creek since the coastline may offer both the first and last lines of defence against the tide. Control works further inland will not diminish the continuing loss of downstream floodplain areas and also suffer the ever present risk that existing and new tidal channels will side-step and render ineffective those works.

It is most likely that control works on Tommycut Creek and Sampan Creek will depend on staged construction over several years. This will require interim measures for tidal control at key locations off stream from both creeks. In recognition of *this,* prior to the onset of the 96/97 wet season, works were undertaken to block a major tidal channel threatening to circumvent Shady Camp Barrage and to block some 30 tidal tributaries of Tommycut Creek (Figure 6). These works were intended to enhance protection already in place for the Mary River Conservation Reserve. Based on the success of this work, and the outcome of the strategic investigations into coastal controls, other key areas may be similarly tackled in the short term future. Following the record wet season of 1996/97, many of the works on upstream tributaries installed in late 1996 failed. The strategy for addressing saltwater intrusion in the short term will be re-evaluated in 1997.

Smaller scale works to protect areas of lesser importance and involving simpler construction methods that are well proven on the floodplain will also remain necessary as interim measures until feasible solutions are established and implemented for Tommycut and Sampan Creeks.

All control works on the floodplain, both major and minor, carry a continuing requirement for checking and maintenance at cycles dictated by wet season flood impacts and continuous daily tidal interactions.

Phosphorous and Water Quality B3-B5

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 14

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- **What is phosphorus?**
- **How do phosphates influence water quality?**

Aim:

Students will understand the sources of phosphorous and its effect on water quality.

Main Idea:

- Phosphorus is a mineral which exists naturally in rocks, soil and animal wastes. It is also found in man made substances such as fertilisers and detergents
- When too much phosphorus enters a river, lake or wetland, it makes the plants in the water grow more quickly, especially algae. Algal blooms can result.
- Algal blooms can result in lowered dissolved oxygen levels in the water as well as reduction in the variety of aquatic plants.
- See Test 8, page 41.

Need/Analysis:

Student Sheet 5.13, Phosphorous.

Reflection:

What actions could we all take to reduce the phosphate pollution of stormwater.

Note: Students may like to take this home and discuss it with their family using the brochure: “stormwater-keep it clean” included in this Education Kit

Student Sheet 5.13
Phosphorus

What is phosphorus and where is it found?

Phosphorus is a mineral found in rocks and soil. In Australian soils it is found in low levels. Phosphorus is absorbed by plant roots. When people buy fertiliser for their farms or gardens, it contains nutrients such as phosphorus to help plants grow. Introduced plants generally need more phosphorus than native plants. Some types of phosphorus are used for other purposes. Phosphorus is sometimes put into laundry detergent to clean clothes.

What effect does phosphorus have on waterways and wetlands?

When too much phosphorus enters a river, lake or wetland, it makes the plants in the water grow more quickly, especially the microscopic algae. The tiny algae multiply quickly, this making the water green and cloudy (the green colour comes from the very large numbers of these tiny floating plants). As older algae die, they sink to the bottom but new algae keep growing. Bacteria decompose the dead plants that sink to the bottom. These decomposers use up most of the oxygen in the water. They actually use more oxygen than the amount added by the extra plants through photosynthesis. Too much phosphorus leads to too many algae, which leads to less oxygen in the water.

The phosphorous cycle

1. Phosphorus enters the water.
2. Plants, including algae, take up the phosphorus and grow too well.
3. Algae reproduce quickly and create an algal ‘bloom’.
4. The algal bloom shades out the submerged vegetation.
5. The algae soon die and sink to the bottom.
6. Bacteria decompose these plants, using up oxygen.
7. Oxygen levels drop, killing fish or aquatic insects.
8. Phosphorus continues to enter the water and the cycle continues.

Where does phosphorus come from?

- Human and animal wastes carried into waterways from poorly treated sewage, broken pipes or run-off
- Some industrial sites
- Soil carried into waterways from eroding areas
- Over-fertilised lawns, gardens and farms from which fertiliser is carried away when it rains
- Animal wastes (eg:droppings) that are carried into waterways by stormwater.

Phosphorus

Questions

List four sources of phosphorous:

1.
2.
3.
4.
5.

What happens when too much phosphorous enters the water?

Complete these sentences and number them in the right order:

Smaller plants (algae) ____________________________ and ____________________________.

Phosphorus enters the ____________________________.

Bacteria ____________________________ these plants, using up ____________________________.

P____________________________ take up the phosphorus and ____________________________.

O____________________________ levels drop.

Fish and aquatic insects ____________________________.

Please Don't Feed the River B3-B5

(Activity adapted from the Waterwatch Education Kit 1997, Waterwatch Victoria and Barwon Water)

Activity 15

Curriculum Links

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **What is phosphorus and why is it important?**

Aims:

1. To understand the sources of phosphorus and nitrogen.
2. To observe the effects of fertiliser on water quality.

Main Ideas:

- Higher than natural levels of nutrients (including phosphorus, nitrogen) are entering our waterways from urban stormwater and agricultural use of fertilisers. Nutrients are absorbed by soil particles and carried by run-off into waterways.
- Excess nutrients increase aquatic plant growth, including algae, this potentially leading to the eutrophication of lakes and wetlands. Algae may become toxic.
- See Test 8, page 41.

Need:

Per group: 2 one litre glass jars or clear containers of the same size, 2 teaspoons of fertiliser. 3 litres of pond or creek water.

Per student: Student Sheet 5.14, Effects of nutrients on waterways.

* Plan this activity for a Monday so that you have 5 days to record the results.

Consider:

As a class, discuss and list how fertilisers are used in the community.

Organise student groups for the experiment.

Explain that tap water contains chlorine to kill organisms so we need to use untreated water. Additionally describe why a control is necessary in a scientific experiment.

Follow the instructions given on the Student Sheet: Effects of nutrients on rivers.

Extension:

Draw a lake scene with a factory, house and lawn, farm and eroding site. Draw arrows and write labels to show how phosphorus can get into the lake.

Draw 2 lake scenes - before and after too much phosphorus has entered its water.

Conduct the experiment to compare the effects of manufactured fertiliser and cow manure. Manufactured fertiliser is more concentrated and so will have more impact.

Conduct the experiment to compare the control with tap water and distilled water.

(Distilled water has no impurities and tap water is treated so both will show limited changes.)

Note: Algae can sometimes take 10 to 20 days to grow, extend experiment duration if necessary.

Student Sheet: 5.14
Effects of Nutrients on Waterways

Higher than natural levels of nutrients (including phosphorus, nitrogen) are entering our waterways from urban stormwater and agricultural use of fertilisers. Nutrients are absorbed by soil particles and are carried by run-off into waterways.

These higher levels increase aquatic plant growth, especially of algae, potentially leading to the eutrophication of lakes and wetlands. In some cases these algae are toxic to aquatic and land animals such as fish and cattle, and can be a health risk to people.

High levels of phosphorus occur naturally in some waterways because of the types of rocks and hence the soil that occurs in the catchments. In these areas the plants and animals have evolved to live in conditions of high phosphorus. Problems only occur if additional phosphorus enter the river from non-natural sources. Nitrogen can also affect groundwater quality.

Consider/Analysis:

1. Label the jars as 1.Control and 2.Fertilised. Add 1 litre of creek or pond water to each jar.
2. Add 2 teaspoons of fertiliser or 2 tablespoons of manure to the jar labelled ‘Fertilised’ and stir in until it is dissolved.
3. Draw a line on the jar to mark the water level.
4. Let the fertiliser settle then record your observation for Day 1.
5. Put the uncovered jars on a sunny windowsill for one week. Inspect your jars each day for the next 5-10 days. Record colour and odour in the results table below. Add more creek water if the level falls below the line as water evaporates.

Observations	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Jar 1 (Control)					
Jar 2 (Fertilised)					

Explain your results.

List some ways that nutrients can get into waterways.

Identifying Sources of Phosphorous in Your Area

B3-B5

Activity 16

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **What are sources of phosphate?**

Aim:

To observe sources of phosphate in the local environment and determine implications on water quality.

Main Idea:

- Phosphorus is a mineral that exists naturally in rocks, soil and animal wastes. It is also found in man made substances such as fertilisers and detergents.
- When too much phosphorus enters a river, lake or wetland, it makes the plants in the water grow more quickly, especially algae. Algal blooms can result.
- Algal blooms can result in lowered dissolved oxygen levels in the water as well as reduction in the variety of aquatic plants.
- See Test 8, page 41.

Need:

Student Sheet 5.15, Sources of phosphate (below).

Consider:

Ask students to brainstorm and list on paper at least three potential sources of phosphorous in their area.

Analysis:

Discuss as a class.

Determine which are the most significant sources of phosphorous in your area. Which are the less significant?

What might the cumulative effect be of small sources that occur frequently throughout the catchment?

You may like to contact a scientific officer from the Dept. of Infrastructure, Planning and Environment to accurately identify phosphorus sources in your local area. Contact numbers are provided below:

Darwin:

Environment Division (08) 8924 4139

Alice Springs:

Environment Division: (08) 8951 8632

Advisory Services: (08) 8999 3678

Water Monitoring: (08) 8999 3413

OR for other regions: Contact Your Regional Waterwatch Coordinator.

Reflection:

Why is it important to understand the cumulative effects of nutrient sources?

What other parameters might you chose to monitor that can influence phosphate in the water? (pH, temperature or dissolved oxygen).

Student Sheet 5.15
Sources of Phosphate

The large number of sources and variety of routes that phosphorous takes to a river make it difficult to pinpoint and correct sources of phosphate enrichment.

Animal Wastes

Organic phosphate from animal wastes can enter the river system in runoff from manure storage areas, feedlots and farm yards.

Human Wastes

The main sources of organic phosphate in human waste are from faulty septic systems and sewage treatment facilities. Unless sewage treatment plants are specifically designed to remove phosphate, only a portion of the phosphate entering them is removed. Many sewage treatment plants have a limit on how much phosphate can be discharged. When the storm sewers are connected to the sewage treatment plant, storms can overload the treatment plant, dumping raw sewage directly into the river.

Fertilisers

Phosphate rich fertilisers enter our waterways through runoff from fertilised lawns and cropland.

Detergents

Most detergents and commercial cleaning preparations contain phosphates. Condensed phosphates are mostly human made for use in laundry detergents, commercial cleaning preparations, water supply and boiler water treatment. In time these condensed phosphates break down to orthophosphates. They enter the river with the wastewater from the sewage treatment facility or a failing septic system. There are an increasing number of detergents that have a reduced phosphate content. These have 0% to 10% phosphorus by weight so read the labels to find a detergent with no phosphate.

Disturbed Land

Phosphate occurs naturally in the soil in dissolved and suspended forms bound to soil particles. Soil erosion from disturbed land introduces the phosphate to the water when the soil enters the river. Wetlands that are drained for development, release phosphate that has accumulated in the sediments over time.

Other

Urban and suburban runoff contains phosphate from a variety of sources that can enter waterways through the storm sewage systems.

Sources of Phosphate

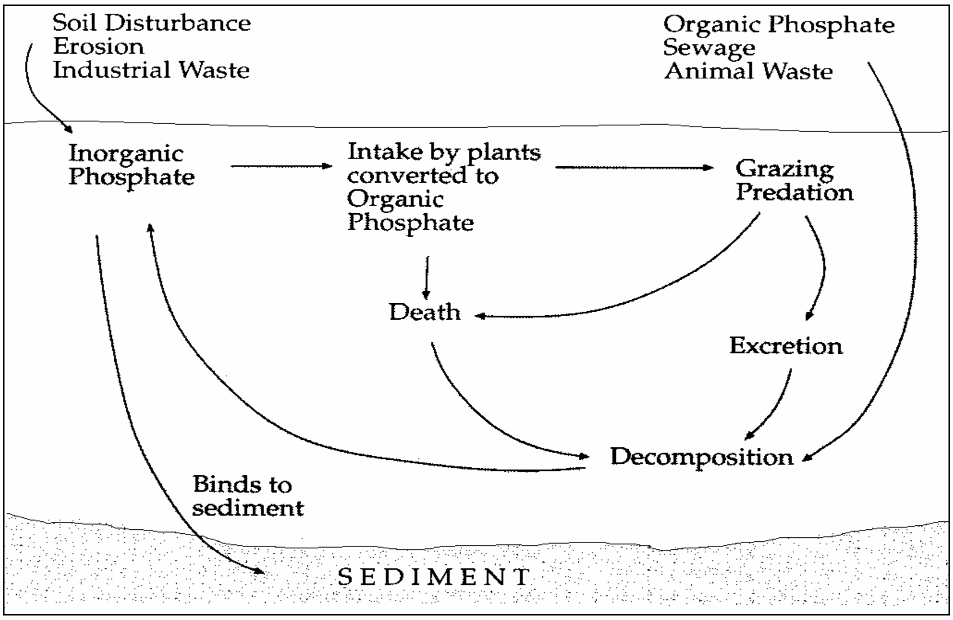


Figure 20 The Phosphorous Cycle

What role do the various segments of the phosphorous cycle play?

Sediment?

Decomposers?

Plants?

Aquatic Herbivores?

Water?

Review of the Nitrogen Cycle

B3-B5

Activity 17

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- **What is nitrate?**
- **How do nitrates, nitrites, and ammonium affect water quality and human health?**

Aim:

To understand the nitrogen cycle and why it is important to water quality.

Main Ideas:

- Nitrate is one form of nitrogen. Nitrogen is found in several different forms in terrestrial and aquatic ecosystems, including ammonium ions (NH_4), ammonia (NH_3), nitrate (NO_3), and nitrite ($N0_2$).
- High nitrate levels can upset the delicate balance of an aquatic ecosystem and pose a threat to human health in drinking water.
- For more information on the fixation of nitrogen by marine blue green algae (which occurs off the NT coastline) Link to http://www.lpe.nt.gov.au/enviro/Fact/faq6.htm.
- See Test 9, page 44.

Need:

Student Sheet 5.16, The nitrogen cycle (see below).

Consider:

Session 1:

Teacher introduces the topic. Together with students, the teacher pieces together the nitrogen cycle onto the blackboard until the diagram is complete.

Session 2:

Students are asked to revise what was done in the previous session by filling in the missing words on the nitrogen cycle diagram and completing the questions.

Analysis:

See Student Sheet 5.16.

Reflection:

What other parameters might you chose to monitor that can influence nitrogen in the water? (pH, temperature or dissolved oxygen.)

Student Sheet 5.16
The Nitrogen Cycle

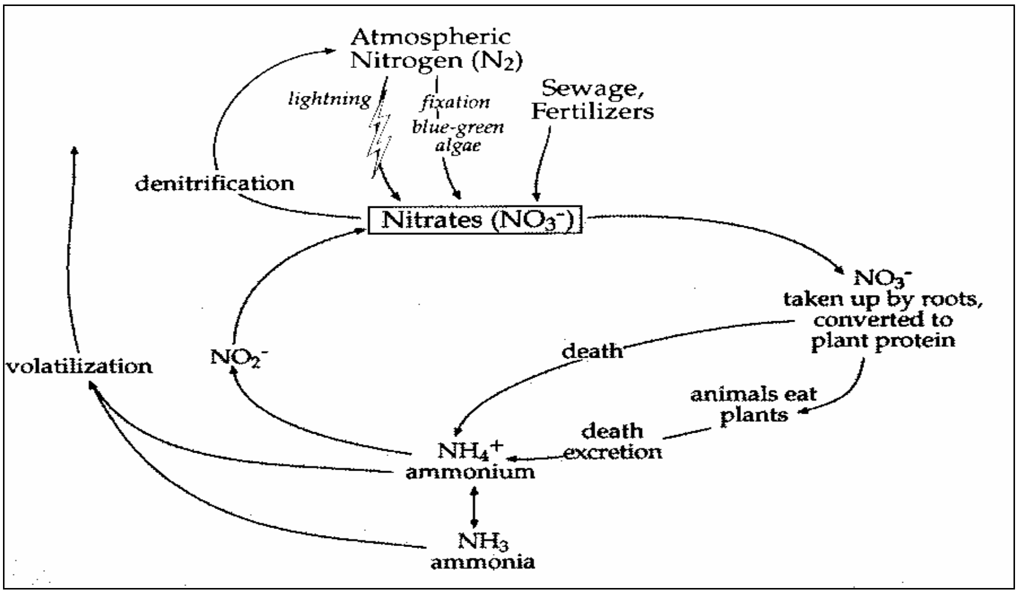


Figure 21 The Nitrogen Cycle

What role do the various segments of the nitrogen cycle play?

The atmosphere?

Sediment?

Decomposers?

Aquatic Plants?

Algae?

Aquatic Herbivores?

Water?

Class Investigation into Sources of Pesticides

B3-B5

Activity 18

Curriculum Links:
Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3
Science Concepts and Context / Life and Living CC 3.2

Focus Questions:

- **What are pesticides and why are they important?**
- **What are sources of pesticides?**

Aim:

To gain a greater understanding about pesticides sources entering our waterways.

Main Idea:

- Pesticides are chemical substances (or mixtures of substances) used to control the growth of insects (insecticides), fungi (fungicides) and weeds (herbicides)
- Pesticides get into water from direct use in the waterway, eg: to control mosquitoes or from land-based applications, aerial drift, or in runoff waters.

Need:

Web access, possibly display materials.

Consider:

Divide the class into several groups. Each group undertakes a separate line of inquiry:

Which industries produce which pesticides and the effect that each one has on living things?

Who uses the pesticides produced and who uses the end products from these industries?

Interview

Relevant staff from either DBIRD, DIPE Suitable people may include water quality or waste management staff.

A staff member from a water quality laboratory regarding how pesticides in water samples are tested.

Staff from the NT National Pollution Inventory regarding levels of pesticides detected in the NT so far. Web site: http://www.lpe.nt.gov.au/enviro/poldoc/npi/default.htm

Analysis:

Students write a brief report on the research findings and present their findings to the whole class. The report needs to be done on computer to allow for compilation of the whole classes findings.

The whole class then collates a report on all their findings. The information gained could then be summarised and either adapted into a display for the school to use or put onto a web site?

Reflection:

How well did the questions chosen for the interviews meet the objectives of the investigation?

Library Internet Search on Heavy Metals

B3-B5

Activity 19

Curriculum Links:

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

SOSE Environments / Environmental Awareness and Care Env 3.2

Focus Question:

- **What are heavy metals and why are they important?**

Aim:

To gain a greater understanding about sources of heavy metals entering our waterways.

Main Idea:

- Heavy metals are a group of metals which are often associated with pollution and toxicity.
- Heavy metals are found naturally in many aquatic environments. Many heavy metals are very toxic to aquatic animals. Even those, essential for growth can have adverse effects at only slightly higher than normal concentrations.
- Industrial and mining activities are the major sources of heavy metal contamination in Australian waters.

Need:

Access to research resource materials/ Internet.

Consider:

Students choose a heavy metal to research and present their findings.

Analysis:

Questions that could be investigated:

1. Where does the metal occur naturally in the NT?
2. Does the metal have any industrial use?
3. How are wastes containing the metal disposed of?
4. What concentrations of the metal in the water are considered toxic?
5. Are there any animals effected by the abnormally high concentration of the metal?

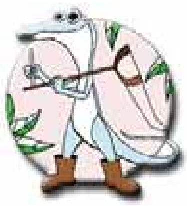
Reflection:

What role does each individual in society play in the discharge of heavy metals into waterways as a result of human related activities?

Extension

Staff from the NT National Pollution Inventory regarding levels of heavy metals detected in the NT so far. Web site: http://www.lpe.nt.gov.au/enviro/poldoc/npi/default.htm

Students write a brief report on the research findings and present their findings to the whole class. The report needs to be done on computer to allow for compilation of the whole classes findings.



Aquatic Macroinvertebrate Investigation

B1-B3

(Adapated from Swan River Education Kit 1999 Water and Rivers Commission WA)

Activity 20

Curriculum Links:

Science Working Scientifically / Investigating WS 2.2 / Evaluating WS 2.3

SOSE Environments / Environmental Awareness and Care Env 2.2

Focus Question:

- What are aquatic macroinvertebrates and why are they important?

Aims:

To investigate aquatic macro-invertebrates in their local environment

To collect and identify macro-invertebrates.

To clarify relationships between the diversity and abundance of macroinvertebrates and the condition of their non-living environment.

To clarify relationships between aquatic macroinvertebrates, their aquatic habitats and the streamline vegetation.

To relate the diversity and abundance of macroinvertebrates found to the health of the ecological system.

To explain why a range of macroinvertebrates is necessary for the ecological balance of river systems.

Main Ideas:

- Aquatic macroinvertebrates can be used to rate the health of a stream. The animals reflect the conditions in which they live: a full suite of macroinvertebrates indicates clean, healthy water.
- This activity could be used as a preliminary investigation of the diversity, form, habits, adaptations and habitats of freshwater macro-invertebrates.

Need:

WATERWATCH Northern Territory A Federal - Territory Partnership

Technical video – macroinvertebrates monitoring (P2) available in this Education Kit. An NT Guide to Macroinvertebrates (available in this Education Kit).

Consider:

Choose appropriate sampling sites.

Discuss the aims of the excursion activity with students.

Discuss guidelines for collecting and preserving macroinvertebrates in the field.

Prepare macroinvertebrate collecting equipment and discuss how to use it.

At the site:

Collect macroinvertebrates by using a long-handled dip net, rake and hoe. Students should demonstrate responsible behaviour by minimising environmental disturbance and returning aquatic life to the water as soon as possible.

Analysis:

Identify collected macroinvertebrates according to their appearance and behaviour. Record details of the presence (and absence) of macroinvertebrates of various types on the 'An NT Guide to Macroinvertebrates' pamphlet. Calculate the water quality rating based on sample results (as described in pamphlet).

Having calculated the macroinvertebrate water condition index for the site(s), decide whether it has a poor, fair, good or excellent stream quality rating. If more than one site was tested, site ratings can be compared and explanations for variations suggested.

Make sure that macroinvertebrates are returned to the water.

Further Investigation:

Focus on biological studies of macroinvertebrates:

Use the fieldwork as a basis for further studies of the natural history and ecology of macroinvertebrate life-cycles, adaptation, habitat, community and taxonomy.

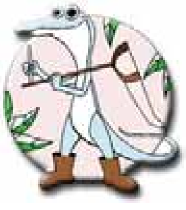
Think about another stream or river with which students are familiar and predict its stream quality rating. As a follow-up to this, students can plan an investigation to compare the ratings of different sites.

Using the pamphlet research different macroinvertebrates and suggest reasons for their varying tolerances to water quality. Discuss the idea of particular species acting as indicators for specific forms of pollution. Try to explain why some macroinvertebrates were missing from the sampling site.

Using reference books or information from the teacher notes and handout, students can classify the macroinvertebrates into the functional feeding groups of: predators, collectors, filter feeders, shredders and scrapers. Investigate how each group obtains its food. Predict how each group would be affected by changes in water conditions such as higher temperatures, increased sedimentation and excessive algal growth. Check that the sampling results verify predictions.

Consider seasonal changes in the physical and chemical properties of the water and how these would affect aquatic organisms. If possible, visit the sites to determine if differences exist.

Graph the diversity and abundance of macroinvertebrate data from all sampling sites and compare the results. Graph diversity and/or abundance against certain physical or chemical conditions present. Interpret graphs by deciding which non-living factors have the most significant influence on macroinvertebrate diversity and/or abundance.



Focus on the links between macroinvertebrates and vegetation:

Relate the abundance and diversity of macroinvertebrates found at the site(s) to the quality of water that was determined by conducting Streamline Vegetation Survey, at different sites. Display results graphically. Describe the ideal streamline vegetation structure for aquatic macroinvertebrates.

Using reference materials, find out more about the habitats that different types of macroinvertebrates prefer. Determine if this is reflected in the students' results.

Focus on ecosystems:

Write a short paper to explain why macroinvertebrates might give a better indication of the status of an ecological system than physical or chemical tests.

Algae Introduction

B3-B5

Activity 21

Curriculum Links:

Science Working Scientifically / Investigating WS 3.2

Science Concepts and Contexts / Life and Living CC 3.2

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **What are algae and why are they important?**

Main Idea:

- Algae are naturally occurring aquatic plants. Algae are an essential component of the aquatic environment.
- They are primary producers, forming an important part of aquatic food webs and are important photosynthetic producers of oxygen.
- There are many types of algae, some free floating and microscopic, some large and attached to rocks or other submerged objects.
- Excess nutrients increase aquatic plant growth, including algae, this potentially leading to the eutrophication of lakes and wetlands. In some cases these algae become toxic.

Need:

Transport. Poster: "What Scum is that”? Waterwatch Regional Coordinator assistance.

Consider:

Visit a local waterway with the local Waterwatch Regional Coordinator

Review the site for the presence of algae on the surface or beneath the water. What does the water’s surface look and smell like?

Analysis:

Looking at the poster, can you identify the algae (if any)?

What might be influencing the algae growth at the site?

Reflection:

What did your results tell you about the health of the waterway?

What other observations might you need to take to determine how natural the algae formation is (if any).

EXCURSION

Algae Awareness

B3

Activity 22

Curriculum Links:

SOSE Environment / Natural Systems Env 3.3

Science Concepts and Context / Life and Living CC 3.2

Focus Question:

- What are algae and why are they important?

Aim:

To learn about the different types of algae that exist and what features are used to identify them.

Main Idea:

- Algae are naturally occurring aquatic plants, which are an essential part of the aquatic environment.
- They are primary producers, forming an important part of aquatic food webs and are important photosynthetic producers of oxygen.
- There are many types of algae, some free floating and microscopic, some large and attached to rocks or other submerged objects.
- Excess nutrients increase aquatic plant growth, including algae, which can lead to the eutrophication of wetlands. Alga blooms can become toxic.

Need:

'What Scum is that?' poster.

Consider:

Consider the 'What scum is that?' poster. Work through the key on the left-hand side with the students so they understand how it works.

Teachers may need to explain the botanical terms used in the key, eg: whorls, radially symmetrical, filaments, globular: Whorl: a ring of 3 or more organs (eg: leaves) arising from the same axis on a stem, like spokes on a old cart wheel) Filament: thread like Globular: spherical.

Analysis:

Divide the students into groups, each choosing one type of algae from the poster.

Students then make up a poster that lists and illustrates each of the algae's features (from the poster).

What do algae require to survive and what factors might cause a bloom?

How can a reduction in water flow influence algal growth?

What things can you and I do to prevent algal blooms?

Should people swim in or drink water that is clearly affected by algae blooms?

Who could people report algal blooms to?

Reflection:

Algae are naturally occurring in aquatic ecosystems. When are they considered harmful to the environment?

Extension Activities:

Try growing algae in an aquarium in the class – see what impact changes to temperature and duration of light exposure and adding fertiliser have on its growth rates.

Write a story/poem/play of the monster algae that takes over the waterway and engulfs the other species living there and how the people came to the rescue to keep the monster algae from spreading any further.

How are Algae Identified? Shape Sorting

B3

Activity 23

Curriculum Links:

Science Concepts and Context / Natural and Processed Materials CC 3.1

Science Working Scientifically / Investigating WS 3.2

Focus Question

- **How are algae identified?**

Aim:

1. To learn to identify and sort different shapes beyond the basic geometrical ones.
2. To learn about algae as a plant that naturally occurs in waterways.

Main Ideas:

- There are many types of algae including free floating and microscopic, and large and attached to rocks or submerged.
- Shape and form are used to assist scientists to identify the different species of algae.

Need:

Attached algae illustrations.

Consider:

Teacher duplicates and distributes the diagrams, explaining the actual size of these organisms that live in water.

Students are asked to cut out the various shapes.

Analysis:

Students are then asked to sort them into groups, eg: circular, star shaped, symmetrical and non symmetrical, clusters, spirals or chains, those with hairs or tails.

Reflection:

To explain the actual size of the algae, explain that although as a group you can see these with the naked eye, individually, they are smaller than a pin prick or pen tip dot.

Extension:

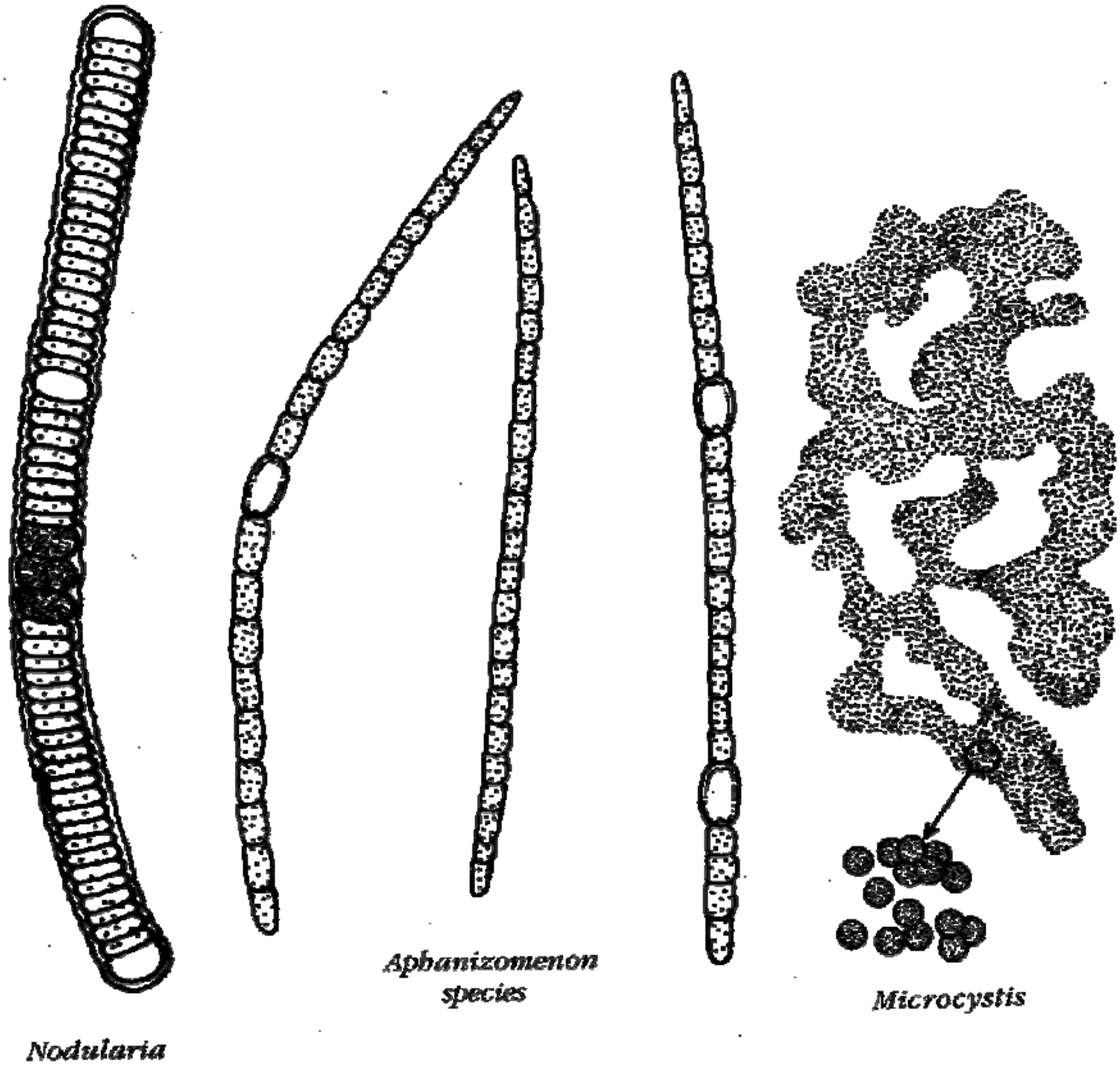
Use the algae shapes in maths:

Use a combination of standard geometric shapes, eg: rectangle, diamond, square and circle, triangle or semicircle to create a jigsaw puzzle for a specific algae example.

Use the algae shapes in art:

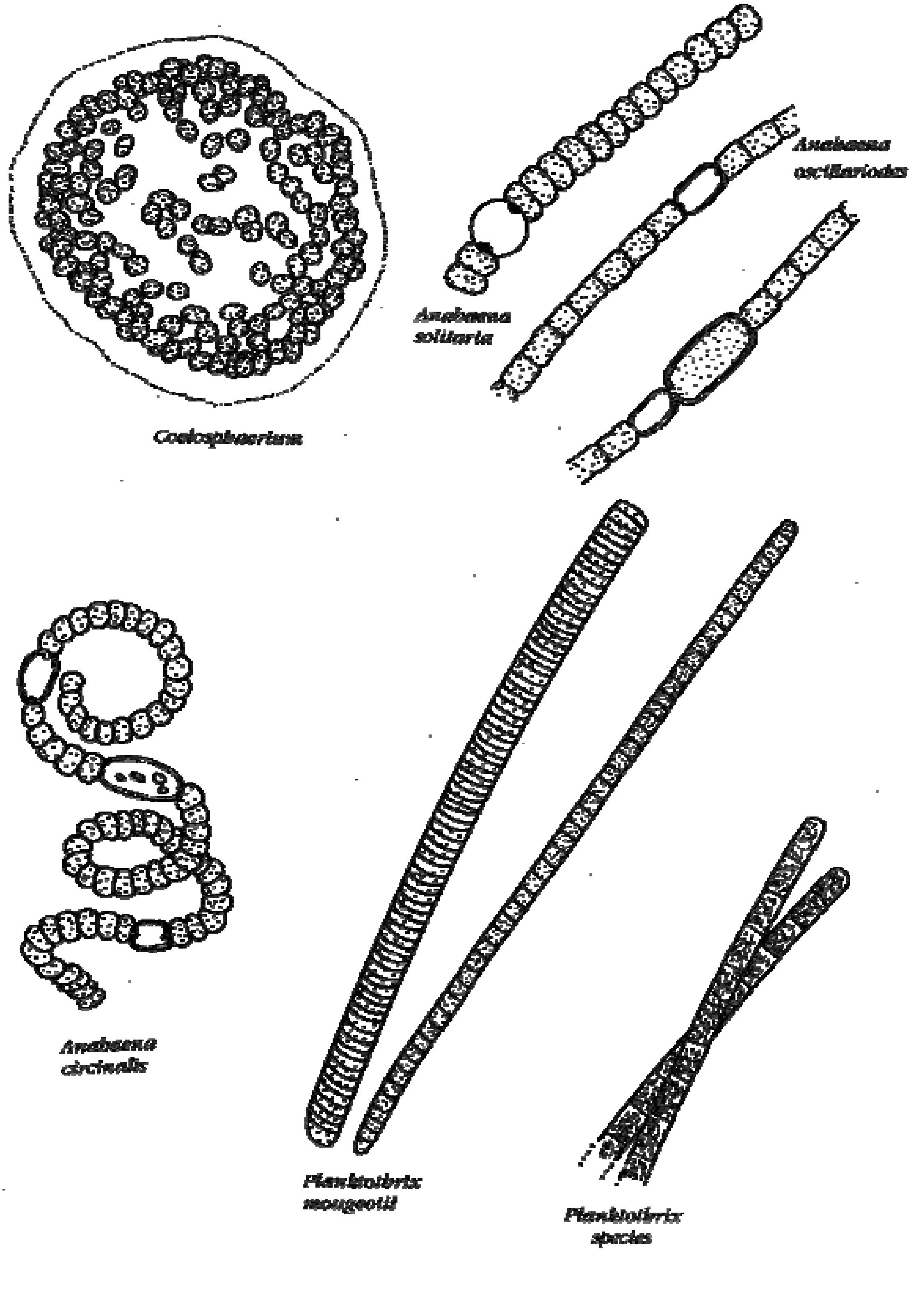
- Trace the shapes.
- Colour the shapes different types of green and some red.
- Cut the shapes.
- Hang the shapes as a mobile individually or as a class.
- Make the shapes part of a bigger aquatic mural/hanging diagram.
- Discuss what primary colours are dominant in making the greens the different colours that they are.

Algae



* Varying magnifications

Algae



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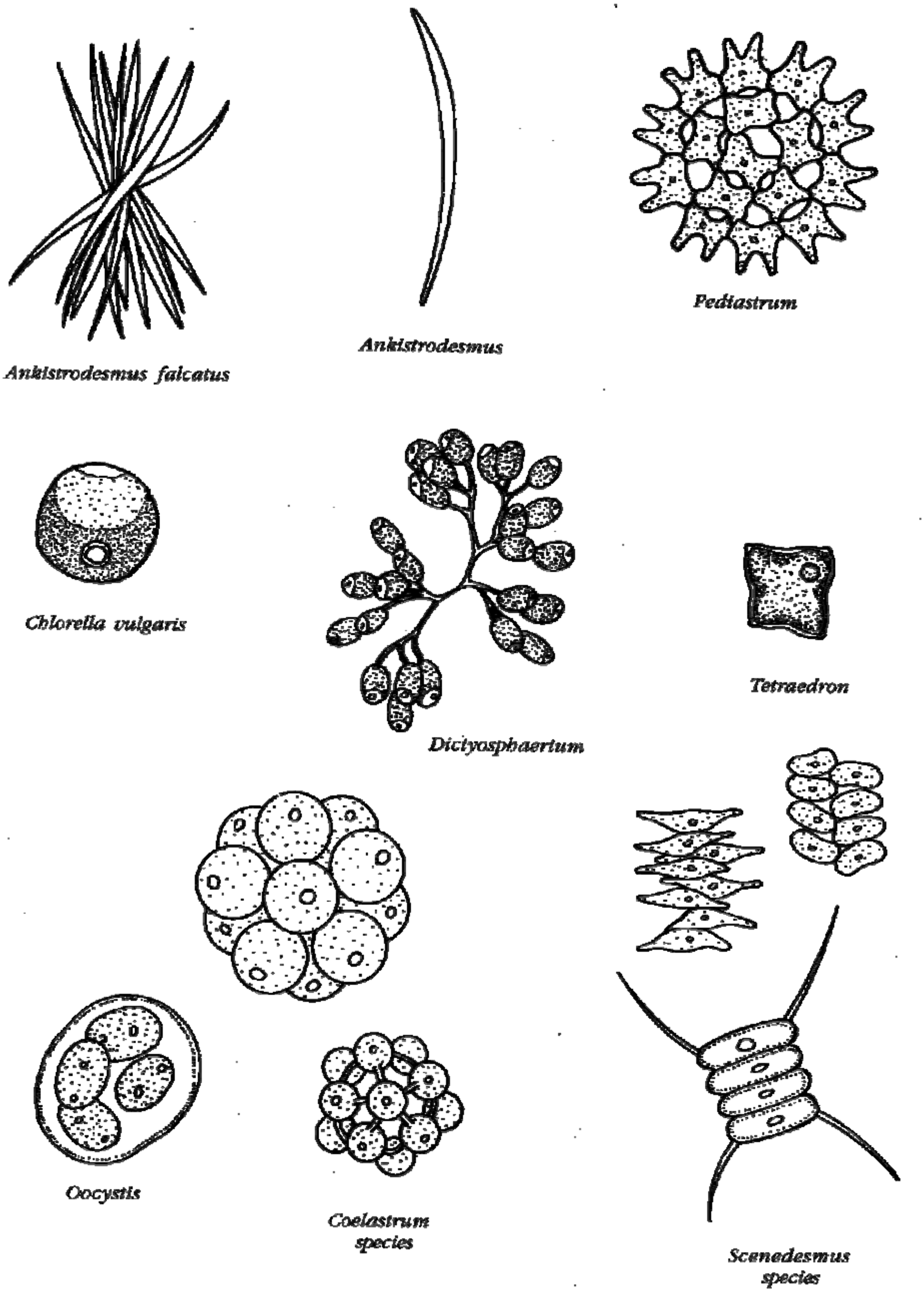

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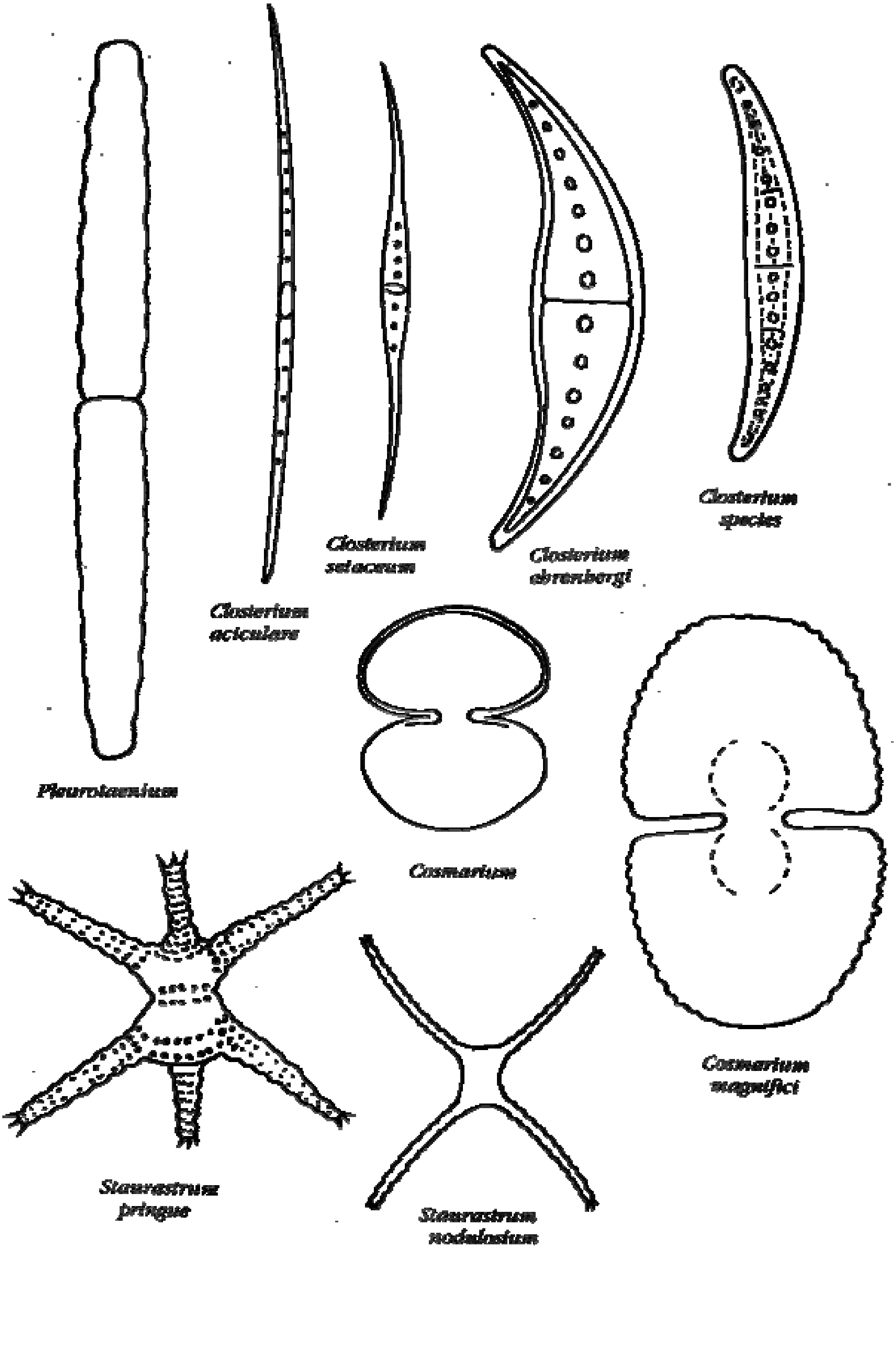

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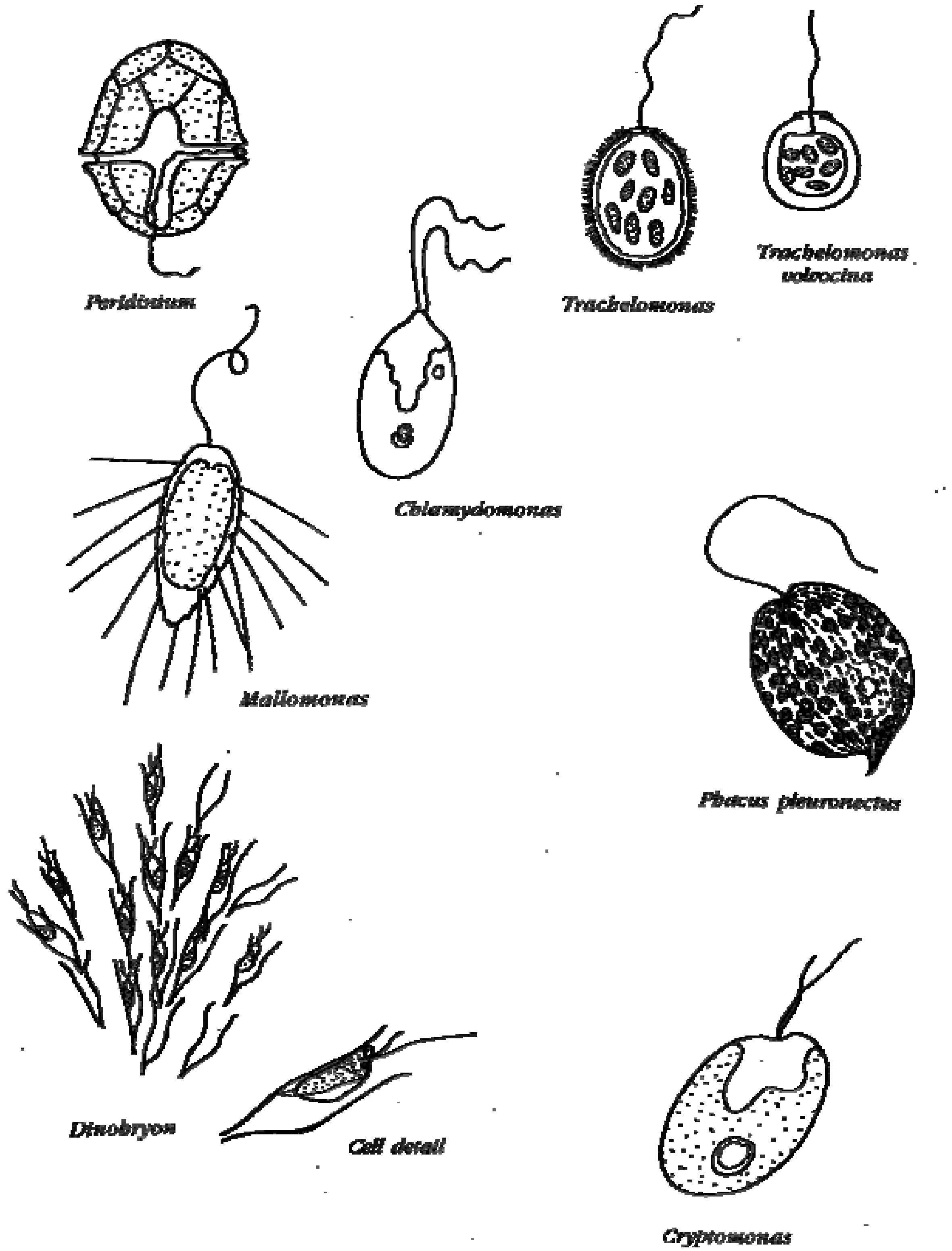
Algae



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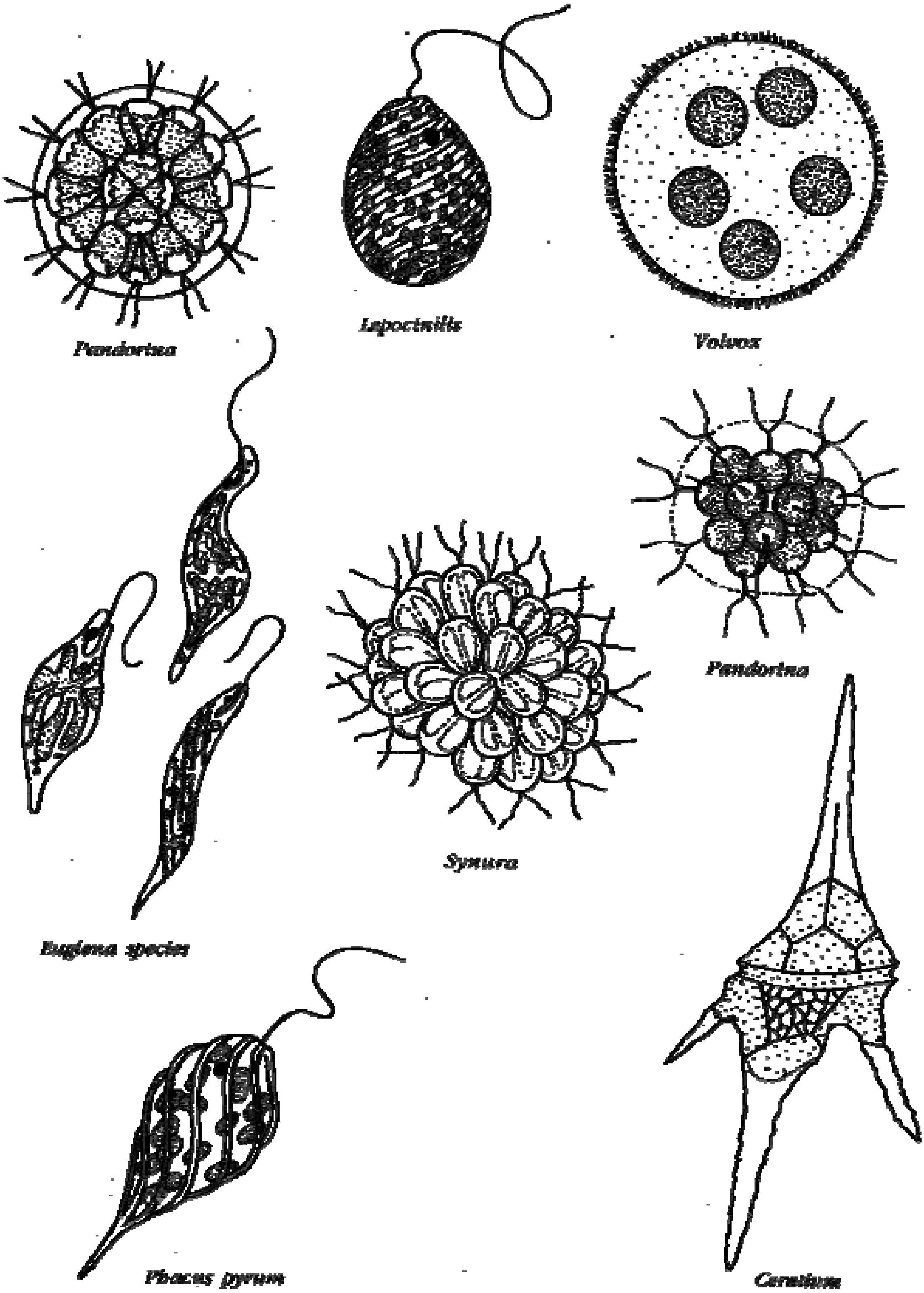
Algae



* Varying magnifications

Growing Algae

B3

Activity 24

Curriculum Link:

Science Working Scientifically / Investigating WS 3.2

Focus Question:

- **What are algae and why are algae important?**

Aim:

To test the hypothesis that algal growth rates are influenced by the light, nutrient availability and temperature.

Main Ideas:

- There are many types of algae, some free floating and microscopic, some large and attached to rocks or others submerged objects.
- Algal growth is influenced by temperature variations and light and nutrient availability.

Need:

At least 4 clear containers or aquarium style containers, local creek/pond water, fertiliser, portable light source and possibly a heat flat bed source, thermometer, and whiteboard marker.

Consider:

Set up aquariums/buckets with different amounts of light nutrients and temperatures to see how fast the algae grow compared to a control aquarium/bucket over a few weeks. The control needs to be plain water, set under normal light and temperature conditions (in the warmer months of the year).

Analysis:

Students should:

Observe and record the area and density of algal growth over sides of the containers, this may be marked with a whiteboard pen on the outside every 3-5 days.

Calculate the growth (cm^2).

Graph the growth rates for the different growth conditions

What influence does the high nutrient have on the growth of algae compared to the control?

What influence does extended hours of light have on the growth of the algae compared to the control (normal daylight hours)?

What influence does the maintenance of higher temperatures have on the growth of the algae compared to the control (normal room temperature)?

Reflection:

Where does the source of algae come from?

Local Investigation of Faecal Bacteria

B3-B5

Activity 25

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2

SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- **What are faecal bacteria and what do they indicate?**

Aim:

To understand what might contribute to the presence of faecal bacteria in local waterways, who is responsible for monitoring this and how can it be monitored.

Main Idea:

- Faecal bacteria are common in the intestines and faeces of both warm and cold-blooded animals
- The presence of faecal bacteria in water indicates possible sewage contamination.
- Faecal bacteria can indicate the possible presence of disease-causing bacteria, viruses, protozoa and other micro-organisms.

Need:

Assistance: relevant staff required, eg: Environmental Health Officers or Waterwatch Regional Coordinator.

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Consider:

Teacher introduces the subject and asks students to consider the question: Where might sources of faecal bacteria come from in our local environment?

Students decide who might be able to confirm their thoughts on the question (eg: Waterwatch Coordinator or Environmental Health Officer). Ask these staff what simple tests used to identify the presence of faecal coliforms in the water?

Analysis:

Students are asked to discuss:

Where do faecal coliforms naturally occur?

What is the normal role of faecal coliforms?

What happens when faecal coliforms are allowed to build up in waterways?

Should camping activities be allowed to occur next to waterways?

If so what management should be taken to protect the waterway?

Reflection:

Has anybody in the class noticed a problem with the presence of nappies along a waterway or the water's smell, taste or odour?

Would you still swim in or drink the water from a waterway which appeared to be polluted?

Who might you report pollution occurrences to?

Riverine Vegetation Survey

B3-B5

(Adapted from the Swan River Education Kit 1999, Water and Rivers Commission WA)

Activity 26

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3, Env 4.3
Science Concepts and Context / Life and Living CC 3.2
Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Focus Question:

- **How are changes in aquatic habitats assessed?**

* Conducted in conjunction with the Living Streams Survey (Activity 27).

Aims:

1. To distinguish weeds from indigenous vegetation (assistance required).
2. To determine the health of a waterway or wetland by assessing the vegetation structure and habitat varieties present.
3. To draw conclusions about the various functions of riparian vegetation

Main Ideas:

- Functions of riverine vegetation include filtering nutrients, trapping sediments, stabilising banks and providing productivity and habitats.
- The condition of a section of river foreshore can be determined by assessment of the vegetation lining the river. Degradation occurs as remnant vegetation declines, weed infestation increases and banks become unstable.
- The assessment system used for this survey consists of grades of riparian vegetation degradation, ranging from A (pristine) to D (compete degradation). Each grade has three sub-levels.

Need:

Student Sheet 5.17 Grading Descriptions (see below).

Consider:

Familiarise students with the waterway terminology and the concepts outlined on the Work sheet.

Assist students to identify the layers that make up the vegetation structure of a riparian environment and ensure that they can determine whether regrowth is occurring (ie: recruitment of native species).

Make sure that students can distinguish weeds from native vegetation. Weeds posters and information are available from DIPE.

Select the study site for the streamline vegetation survey.

Explain the procedure for conducting the survey:

a) Rate the streamline site as A,B,C or D using the criteria on the Student Resource Sheet Grading Descriptions.

b) Examine the vegetation more closely and assess the vegetation condition as 1, 2 or 3, using the resource and work sheets.

Analysis:

- Determine the area of the stream to be assessed.
- Conduct the survey.
- Discuss and justify assessments, and ensure that consensus has been reached.

The surveys could be a starting point for an examination of strategies for eradicating weeds and rehabilitating streamline vegetation.

EXCURSION

Student Sheet 5.17
Grading Descriptions

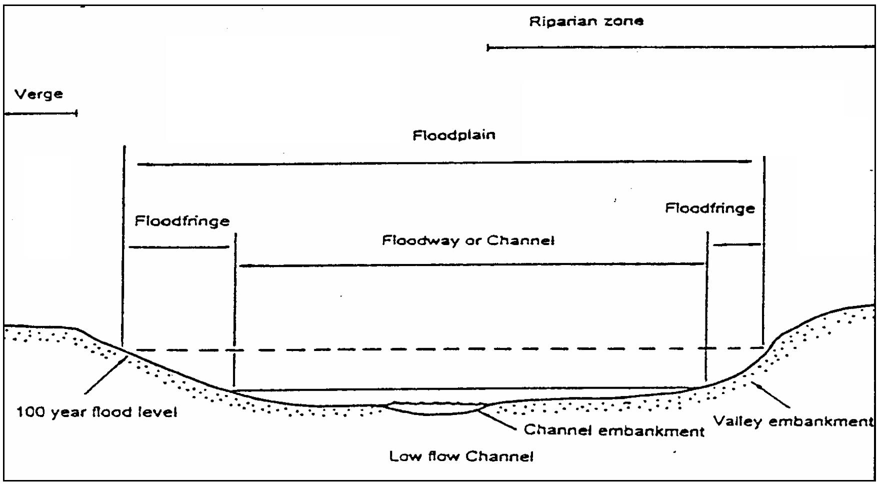

Table 17 Grading Descriptions

A Grade Foreshore:	**A.1** **Pristine**	The river embankments and floodway are entirely vegetated with native species, and there is no evidence of human presence or livestock damage.
	A.2 **Near Pristine**	Native vegetation dominates. Some introduced weeds may be present in the understorey, but not to the extent that they displace native species. Otherwise, there is no human impact.
	A.3 **Slightly Disturbed**	Native plants dominate, but there are some areas of human disturbance where soil may be exposed and weeds are relatively dense (such as along tracks). The native vegetation would quickly recolonise the disturbed areas if human activity declined.
B Grade Foreshore:	**B.1** **Weed Infested**	Weeds have become a significant component of the understorey vegetation. Although native species are dominant, a few have been replaced or are being replaced by weeds.
	B.2 **Heavily Weed Infested**	In the understorey, weeds are about as abundant as native species. The regeneration of some types of trees and large shrubs may have declined.
	B.3 **Degraded and Weed-Dominated**	Weeds dominate the understorey, but many native species remain. Some trees and large shrub species may be less numerous or have disappeared altogether.
C Grade Foreshore	**C.1** **Erosion Prone**	Trees remain, and possibly some large shrubs or grass trees, but the understorey consists entirely of weeds, mainly annual grasses. The trees are generally resilient or long-lived species, but there is little or no evidence of young trees or tree seedlings. The shallow-rooted weedy understorey provides no support to the soil, and only a small increase in physical disturbance will expose the soil and make the river embankments and floodway vulnerable to erosion.
	C.2 **Soil Exposed**	Older trees remain, but the ground is virtually bare. Annual grasses and other weeds have been removed by livestock trampling or grazing the area, or through overuse by humans. Low-level soil erosion caused by wind or water has begun.
	C.3 **Eroded**	Soil is washed away from between tree roots, trees are being undermined, and unsupported embankments are subsiding into the river valley.
D Grade Foreshore	**D.1** **Eroding Ditch**	There is not enough fringing vegetation to control erosion. Some trees and shrubs remain and retard erosion in certain spots, but are doomed to be undermined eventually.
	D.2 **Freely Eroding Ditch**	No significant fringing vegetation remains and erosion is completely out of control. Undermined and subsided embankments are common, and large sediment plumes are visible along the river channel.
	D.3 **Weed Dominated Drain**	The highly eroded river valley has been fenced off, preventing control of weeds by stock. Perennial (long-lived) weeds have become established. The river has become a simple drain, similar or identical to a typical major urban drain.

Living Streams Survey

B3-B5

(Adapted from Swan River Education Kit 1999, Water and Rivers Commission WA)

Activity 27

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Science Concepts and Context / Life and Living CC 3.2

Focus Question:

- **How are changes in aquatic habitats assessed?**

This excursion can be conducted in conjunction with the previous activity, Streamline Vegetation Survey. The living streams survey provides an indication of stream health based on an assessment of the quality and diversity of habitats. Each parameter is scored and, from the total, an overall stream health assessment is made.

Aims:

Students will be able to:

1. Recognise vegetation as a guide to stream health.
2. Distinguish weeds from native vegetation.
3. Determine the health of a section of the stream by assessing the quality of the vegetation structure and the varieties of habitat present.
4. Discuss the importance of vegetation in the riverine ecosystem.

Main Idea:

- The condition of a section of river foreshore can be determined by an assessment of the vegetation lining the river. Degradation occurs as remnant vegetation declines, weeds infest the area and banks become unstable and begin to erode.

Need:

Student Sheets: Living streams and Explanation of assessment parameters, transport and excursion materials.

Consider:

Select the study site

Explain the purpose of the survey.

Students assess and rate each of the different assessment parameters: bank and floodway vegetation, verge vegetation, stream cover, bank stability and erosion, and habitat diversity, in order to produce an overall stream health rating.

They also examine and assess the surrounding land use as an additional factor affecting the quality and diversity of habitats.

Familiarise students with the parameters to be assessed and with the explanations in the Student Sheet: Living streams survey.

Analysis & Investigation:

Determine the area to be surveyed. For each factor examined, survey a distance of about 100m along both banks of the stream.

Using the resource and work sheets, students identify and assess the different habitat types at the site, and select the rating they consider most appropriate.

Add the scores to obtain an overall environmental river health rating for the site. A separate rating survey sheet is needed for each site surveyed.

Students then identify the major land use in the area and apply the appropriate rating. They add this to the score for other parameters. Note that, if one side of the stream differs greatly from the other in some way, students should evaluate each side separately, add the scores and divide the sum by two to determine the average condition.

Students discuss each assessment within their groups and, when each is confirmed, add the scores to determine the overall health score. Then they apply the appropriate stream health assessment.

Analysis:

Focus on vegetation:

- Write a general description of the vegetation at each site and illustrate it with a diagram based upon information from the 'Streamline Vegetation Assessment' sheet (previous activity)
- Investigate different types of plants associated with waterways. Research their requirements in terms of abiotic and biotic environments, reproduction and their tolerance for habitat disturbance.

Focus on the links between vegetation and water quality:

Compare water quality and vegetation data for the sites that were visited. Respond to the following questions:

- Does better vegetation correspond to better water quality?
- How does vegetation help in maintaining water quality?
- What is the link between vegetation and water temperature? How does vegetation reduce the turbidity of the water?
- How does vegetation prevent excess nutrients from entering the water?
- How does vegetation contribute to oxygen levels in the water?
- Focus on the relationship between vegetation health and macroinvertebrates.
- Relate the diversity and abundance of macroinvertebrates found in the macroinvertebrate study to the stream health rating. Investigate the habitat needs of each of the macroinvertebrates and see if they are adequately represented at the site. Decide if the site provides adequate habitat for stable, long-term macroinvertebrate communities.
- List all animals (including larger organisms) observed at the fieldwork site and determine if the vegetation is adequate for the habitat needs of large animals and smaller animals.

Relate the condition of the vegetation to the surrounding land-use activities in the area.

If the vegetation was found to be in poor condition, consider whether it is because of grazing by stock, over clearing of vegetation or other factors. If the vegetation is in good condition, is it because of fencing or protection by a conservation zone etcetera?

Write a report on the role of vegetation in riparian ecology, focusing on links between vegetation and land use.

Students should consider questions such as:

- Does the vegetation have a role in reducing the impact of land uses on the water?
- Does the vegetation seem to be acting as a sediment trap?
- Is it contributing to bank stability by reducing erosion?

Compare the impacts of rural and urban land uses on streamline vegetation.

Reflection:

Consider what impacts would occur if there was no riparian vegetation or if the riparian vegetation became all weeds. Impact of this on wildlife ecology?

TOTAL SCORE	*ASSESSMENT*
40 - 53	EXCELLENT
30 - 39	GOOD
20 - 29	MODERATE
10 - 19	POOR
0 - 9	VERY POOR

Student Sheet 5.18

Living streams survey *(Swan River Education Kit. 1999 Water & Rivers Commission WA)*

Table 18 Assessment Parameters

	Bank & floodway vegetation	Verge vegetation	Stream cover	Bank stability & erosion	Habitat diversity	Surrounding land-use
EXCELLENT	• Healthy undisturbed native vegetation. • No weeds. **15**	• Healthy undisturbed native vegetation. • Verges more than 20m wide. **8**	• Abundant cover: shade, overhanging vegetation. • Snags, leaf litter, rocks and/or aquatic vegetation in the stream. **8**	• No erosion, subsidence or sediment deposits. • Dense vegetation cover on banks and verge. • No disturbance. **8**	• Three or more habitat zones. • Some permanent water. **6**	• Conservation reserve such as a National Park. **8**
GOOD	• Mainly healthy undisturbed native vegetation. • Some weeds. • No recent disturbances. **12**	• Mainly healthy undisturbed native vegetation. • Verges less than 20m wide. **6**	• Abundant shade and overhanging vegetation. • Some cover in the stream. **6**	• No significant erosion, subsidence or sediment deposits in floodway or on lower banks. • May be some soil exposure and vegetation thinning on upper bank and verge **6**	• Two habitat zones. • Some permanent water. **4**	• Remnant bush – healthy natural vegetation with little sign of disturbance. **6**
MODERATE	• Good vegetation cover, but a mixture of native and exotic species. • Localised clearing. • Little recent disturbance. **6**	• Good vegetation cover, but mixture of native and exotic species. • Verges 20m wide or more. **4**	• Some permanent shade and overhanging vegetation. • Some instream cover. **4**	• Good vegetation cover. • Only localised erosion, bank collapse and sediment heaps. • Verges may have sparse vegetation cover. **4**	• Mainly one habitat type with permanent water, or range of habitats with no permanent water. **2**	• Rural. • Agricultural with stream buffer zone. • Urban with stream buffer zone. **4**
POOR	• Mainly exotic ground cover. • Obvious site disturbance. **3**	• Narrow verges only • (<20m wide). • Mainly exotic vegetation. **2**	• Channel mainly clear. • Little permanent shade or instream cover. **2**	• Extensive active erosion and sediment heaps. • Bare banks and verges common. • Banks may be collapsing. **2**	• Mainly one habitat type with no permanent water. **1**	• Agricultural with no stream buffer zone. • Urban with no stream buffer zone. **2**
VERY POOR	• **Mostly bare ground or exotic ground covers (ie. pasture, gardens or weeds but no trees).** **0**	• Mostly bare ground or exotic ground covers (ie. pastures, gardens or weeds but no trees). **0**	• Virtually no shade or instream cover. **0**	• Almost continuous erosion. • >50% of banks collapsing. • Sediment heaps line or fill much of the floodway. Little or no vegetation cover. **0**	• Stream channelised. • No pools, riffles, or meanders. • The stream forms a continuous channel. **0**	• Commercial. • Industrial. **1**

Student Sheet 5.19
Explanation of Assessment Parameters

Bank and Floodway Vegetation
This vegetation grows in the floodway or on the banks and is the major source of energy, nutrients and carbon for the stream ecosystem. The canopy is the tree cover that overhangs the stream. Plant roots stabilise the floodway and banks against erosion and bank collapse. Stems and foliage dissipate the energy of floodwaters, reducing erosion and promoting sedimentation.

Verge Vegetation
The stream verge, which extends from the top of the embankment to a paddock fence, backyard fence or road, the verge may be part of streamside parkland. Verge vegetation provides habitat next to the water, increases the value of the riparian zone as an ecological corridor and stabilises the stream banks by anchoring them with tree roots.

Stream Cover
Fish and other aquatic organisms require logs, snags, leaf litter, rocks and aquatic plants to provide shelter from predators. Aquatic plants influence the amount of oxygen available in the water, which in turn affects the type of fish and other animals found. Protruding snags and rocks provide roosting and preening sites for birds and help to mix and oxygenate water in the faster flowing sections of the stream. Overhanging and emergent vegetation provides shade. Insects blown from flowers and leaves are an important source of food for fish and other animals.

Bank Stability and Erosion
Streams sometimes naturally erode on bends. However, when vegetation is cleared for development banks can become unstable, resulting in more severe erosion and a build-up of sediment that is then washed downstream. Erosion and bank collapse can also be caused by increased runoff from hard surfaces (eg. car parks), from pipes and drains, and by straightening or channelling the stream.

Habitat Diversity
Different habitat types in streams include cascades, rapids, riffles, waterfalls, runs, meanders, pools and floodplains. Stream sections that have a range of habitat types can support a greater variety of species. Rapids occur when rocks and snags protrude through rapidly flowing water. Areas where water flows quickly over stones and rocks or between tree stems are known as riffles, while areas where the water surface is essentially flat are known as a runs. Rapids and riffles aerate water and provide habitat for invertebrates.

Usually the stream floodway, including rapids and riffles, is heavily vegetated. The vegetated floodways are usually broken by deep pools that provide habitat for fish, turtles and other animals. Pools are often the only part of the stream to retain water over the Dry, providing drought refuge.

Long, broad sections of vegetated or clear floodway are typical of the lower reaches of our larger rivers. They provide different types of habitats because the cutting action of water at bends creates deeper areas and variable water speed. Seasonal floodwaters next to the stream may provide important breeding and feeding habitat for aquatic life.

Surrounding Land Use
Land use activities contribute greatly to the ecological value of the stream. A stream in an agricultural setting may have higher sediment and nutrient levels, while a stream in an urban or industrial area will be more vulnerable to weed invasion and pollution.

Site Description

B3-B5

(From the Swan River Education Kit 1999 Waters and Rivers Commission WA)

Activity 28

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3

Science Concepts and Context / Life and Living CC 3.2

Science/ Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Focus Question:

- **How are changes in aquatic habitats assessed?**

Aims:

Students will be able to:

1. Recognise vegetation as a guide to stream health.
2. Distinguish weeds from native vegetation.
3. Determine the health of a section of the stream by assessing the quality of the vegetation structure and the varieties of habitat present.

Main Idea:

- Industrial discharges contain many substances that can be toxic to the environment.

Need:

Transport, drawing and writing materials, including clip board, detailed topographic map of the area, assistance from your Regional Waterwatch Coordinator.
Analysis:

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Step 1. Taking a walk

Determine the area to be described. Walk the 100m area along the stream bank and become familiar with the features of the site and surrounding land. Choose a reference point such as a prominent tree or rock so that you can accurately locate the site on future visits.

Step 2. Fill in the top portion of the Site Description Record Sheets

Complete a Site Description Record Sheet p? for each one of your sites. Each time you visit your waterway you will need to take a copy of the Site Description Record Sheet completed on the last visit to look for any changes in or around the site and to help assess the health of the site.

Name of the waterbody: Give a name to the waterway, preferably as it appears on the map. If it is a stream but does not have a name then record which water body it flows into.

Type of waterbody: Indicate the type of water body, eg: pond, wetland, lake, dam, creek, river, irrigation channel, spring, bore, drain, estuary, ocean inlet or bay.

Site code: The site code has three letters and three numbers. The Regional Waterwatch Coordinator will provide the three letters to your group coordinator, who will add three numbers to produce a unique code for each site. The letters correspond to the stream name, and numbers to the relative position of sites in the waterway. Sites with small numbers are found towards the headwaters.

Map name, number and scale: You can get this information from the map.

Eastings and Northings: These are the coordinates from the universal grid that tell us the exact location of your site on the map.

Position in the catchment or sub catchment: Get this information from the maps.

EXCURSION

Site name: Record the property name and then select a site name

Land title numbers of adjacent properties: These are available from the map.

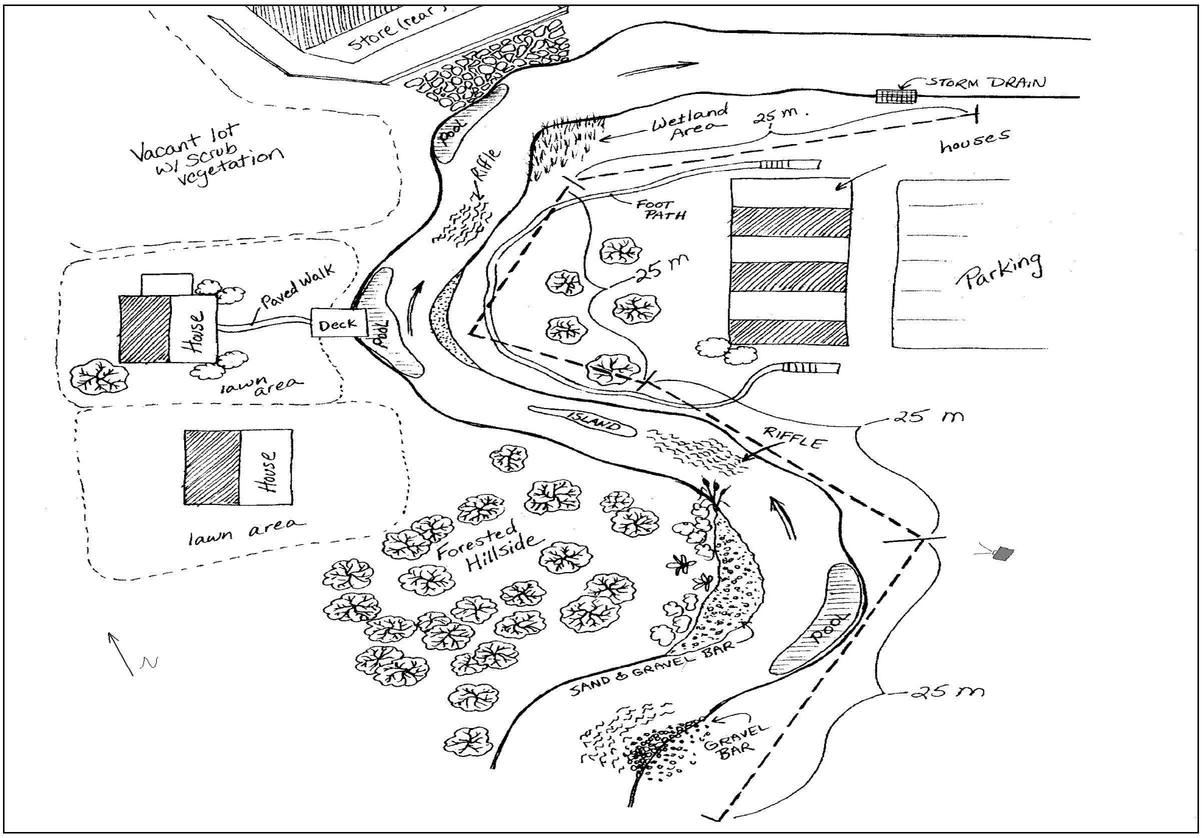
Brief description of how to get to the site: This should include precise details of roads and nearest access. Remember that you or other *Waterwatchers* will be returning to the same spot at some time in the future.

Step 3. Make a sketch

Make a sketch of the area on your Site Description Record Sheet. Drawing the site will serve as a useful record. Draw a 'bird's eye' view of 100m of your waterway. Note on the sketch features such as:

- tributaries, dams;
- roads and access points;
- fences and buildings;
- direction of true north;
- direction of water flow;
- riffles pools and bends;
- levees, wetlands, billabongs, lateral stream channels;
- logs and large woody debris over 30cm in diameter;
- riparian vegetation and physical features;
- photo sites and direction of photo;
- type of substrate (sand, mud, gravel, cobble, bedrock);
- property boundaries/names and tenure; and
- any important features outside of the 100m area which may affect the site, eg: a recently burnt area, bridges, etc.

Note: that left and right banks are those when looking downstream.



Example of a bird's eye view of a site *(Adapted from Tennessee Valley Authority1995).*

Step 4. Take photographs

Photographs are an excellent record of habitat condition. "Before" and "after" pictures are very valuable in showing changes to your site. Take care to ensure that you choose a representative portion of the waterway for your photographs. Suggested things to photograph are:

- the bank looking upstream and downstream;
- streamside vegetation, woody debris in the stream, erosion, stock in water;
- a bend in the stream; and
- an overview from a distance, overlooking the creek and surrounding areas, choose an elevated position, if possible.

Step 5. Fill out the details of your Site Description Record Sheets

The following numbered instructions correspond with the numbers on the Site Description Record Sheets.

1. Landscape features surrounding the site

These can include flood plains, ponds, wetlands, billabongs, lateral stream channels.

2. Stream channel and banks

a) and b) A comparison of the width of the wetted part of the stream with the width of the channel (from base of woody roots on left bank to base of woody roots on right bank) indicates the amount of water flowing relative to flood level.

c) A variety of depths in a stream provides habitat for different species. Estimate the average depth of riffles at your site.

d) The size of the dominant material on the stream bed provides clues about the velocity of the stream and its erosive power. Note whether your site is mainly boulder, cobble, gravel, sand or silt.

e) The average height of the banks indicates potential erosion problems. Record the average height of each bank.

f) The slope of stream banks can indicate likely problems such as erosion.

- *Vertical or undercut:* this may indicate stable banks.
- *Steeply sloping:* a bank that slopes at more than a 30 degree angle.
- *Gradual or little slope:* a bank that has a slope of 30 degrees or less.
- *Variable slope.*
- *Artificial changes to banks:* include the use of wood, concrete or rock, eg: riprap or retaining walls.

g) Note the soil type on the river banks and its erosion potential (if known).

3. Description of the water

a) Pay particular attention to the appearance of the water as this can indicate pollution, eg:

- *Froth:* may be natural or due to pollutants such as detergents;
- *oily sheen:* a multicoloured film on water surface might indicate oil or an algal bloom;
- *dark brown colour:* due to natural tannic acid from plants;
- *turbid brown:* cloudiness due to suspended silt;
- *reddish:* may be acid seepage;
- *milky or grey:* may be natural or due to pollutants;
- *green:* may indicate an algal bloom from excessive nutrients;
- *brown scum:* may be due to brown algae floating on water surface; and
- *brown layer smothering bottom:* may be brown algae or growth of iron-loving bacteria which indicates possible pollution.

b) Smell can indicate pollution, eg:

- *fishy:* suggests excessive algal growth and/or dead fish;
- *rotten eggs:* suggests rotting organic matter such as sewage or dead algae;
- *chlorine:* may indicate presence of chlorinated discharges from, eg: swimming pools, or sewage treatment plants;
- *sewage:* from human or animal wastes, c) Fast flowing water aerates the water and dilutes pollutants. Note whether the average velocity is high, moderate or low.

4. Plant material in the water

a) Snags or woody debris in the water are often seen as a source of problems in a river, but they are vital for healthy ecosystems. Logs slow the flow of water and reduce erosion (unless they form a log jam), and provide habitat and a source of food. Note the quantity of logs greater than 10cm in diameter (none, occasional, plentiful) at the site.

b) Large aquatic plants provide food and shelter (cover) for aquatic organisms. They may be attached to the bottom or floating on the water surface. Note that aquatic plants cannot take root in fast flowing water. Abundant exotic aquatic plants indicate a degraded waterway. A proliferation of native or exotic aquatic plants suggests over-enrichment with nutrients but an absence may indicate extreme acidity or toxic pollutants. Describe whether they are present or absent, attached or free floating.

c) Algae in the waterway are normally green or brown and grow on rocks, twigs, etc. or float on the water surface. Excessive algal growths may indicate high nutrient levels in the stream but may also occur in warm calm conditions when there is low rainfall or little flow due to extraction of water for irrigation. Note the amount - none, occasional, plentiful and describe the colour (green or brown).

5. Riparian vegetation

a) The width of vegetation in the riparian zone affects the ecological health of the site. Streamside vegetation up to 40m away from the banks helps to reduce the pollution entering the stream from overland runoff. Estimate the average width of vegetation on each bank of your 100m site.

b) Shaded areas are valuable habitats for many species. Estimate the length of riverbank with vegetation overhanging the water.

c) Major weed infestations have an adverse effect on the health of the site. These weeds include coffee bush, *Mimosa* and candle bush. Record the total length of each bank infested with weeds.

d) Native vegetation is important for healthy aquatic ecosystems and as a source of seed for revegetation works. Native vegetation may vary from intact to fragmented or sparse depending on the amount of disturbance to the site. Estimate the total length of each bank lined with native vegetation.

6. Animals and birds

Native animals and birds in or around your waterway suggest that the environment is relatively healthy. Note if present.

7. General conditions affecting the stream

Many human activities at a site can have adverse effects on ecological health. Note if they appear to affect the waterway.

- *Pavement, structures:* any man made structures or paved areas including paths, roads, bridges, houses etc.
- *Dead trees:* are important habitat but may indicate pollution or dieback.

- *Stock erosion paths*: stock having free access to the stream can foul the water and create pathways which erode and reduce water quality for downstream users.
- *Mud in or entering the stream*: muddy water may be a normal condition of your stream but in clear streams it can indicate poorly controlled construction works, street runoff, forestry activities or agriculture. Excessive mud can blanket plants and animals on the stream bottom.
- *Rubbish in stream*: note the presence of rubbish, car tyres, shopping trolleys, etc.
- *Pipes and drains:* may well be dumping fluids or water into the stream. Note these even though you may not be able to tell where they are coming from. See the Pipe and Drain Inventory.
- *Dams or weirs:* across the stream can lead to the decline in populations of native fish. Many native species need to migrate at some time in their life and barriers can prevent them from moving freely upstream or downstream. Dams and weirs can also change the pattern of flow in the stream and affect the whole aquatic ecosystem.

8. Land uses around the site

The way in which land is used and managed can have a major effect on health of the waterway. Describe land uses up to 400m away and whether they are clearly affecting the stream.

9. Changes since the last visit

Take a copy of the Site Description Record Sheets from the last visit and compare with your observations this time. Note any significant changes and possible reasons for the changes.

10. Ideas for action

When you are making observations you may think of ways of improving the habitat or maintaining the quality of the site. Note your ideas on the Site Description Record Sheets.

11. Drain and pipe inventory

You may find one or more pipes or drains that affect the waterway particularly if the site is in an urban area. The Pipe and Drain Inventory will help you record their location, type, size, nature of the discharge, and condition of the stream downstream. Make a photocopy of the Inventory for each pipe or drain that you are likely to find.

Things to do before leaving the site

Make sure that you have completed all parts of your Site Description Record Sheets. If you cannot answer a question on the sheets, then write "unable to answer" or " does not apply". Give a copy of your Site Description Record Sheets to your *Waterwatch* Coordinator. You may want to use your site description to track changes at the site over time.

Note: If you have found evidence of serious pollution, eg: fish kills, leaking drums of chemicals, or foul odours, immediately contact your Coordinator and/or local council.

Student Sheet 5.20: Site Description Record Sheets

Complete a Site Description Record Sheet for each one of your sites. Each time you visit your site, take a copy of the Site Description Record Sheet completed on the last visit to look for any changes. A site is a 100m length of the waterway. Face downstream when describing the left and right banks.

BACKGROUND INFORMATION

Date: .... Time: .... Name of group: ....

Name of investigators: ....

Name of water body: .... Site code: ☐☐☐☐☐☐ Map Name:

Type of Water body

(pond, wetland, lake, dam, bore, piezometer, drain, estuary, ocean, bay, creek, river, irrigation channel, spring) ..

Site name ....

Land title numbers of adjacent properties ....

Easting (6 numbers): .... Northing (7 numbers): ....

Position in the catchment**:** (upper, middle, lower) ....

Estimated elevation: ....Name of suburb, nearest town or settlement: ....

Brief description of access to site: ....

....

Describe the weather both now and in the past 24 hours.

	Clear/sunny	Overcast	Showers	Rain (steady)	Rain (heavy)
Weather now	θ	θ	θ	θ	θ
Past 24 hours	θ	θ	θ	θ	θ

GENERAL FEATURES OF YOUR SITE

Birds eye view of the site

Sketch a bird's eye view (a view looking down from above) of your stream site, showing curves in the stream, adjacent land on both sides etc. Mark areas of vegetation, eroded banks, fences, roads, drains, etc. Try to draw about 100 metres of stream length. Remember, it is only a rough sketch. Label the sketch. Mark and number any photo sites and draw an arrow to show the direction from which each photograph was taken. Show the direction of stream flow and the scale of your sketch.

Describe the location of photo sites

....
....
....
....

1. Landscape features surrounding the site

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....
....

2. Stream channel and banks

a) Average width of wetted part of stream.. (metres)
b) Average width of channel, eg: to base of roots of woody plants.. (metres)
c) Average depth of riffles at the site.. (metres)
d) Dominant size of bed material (boulder, cobble, gravel, sand or silt)..
e) Evidence of erosion (head cuts, undercutting banks, incised bed) ....

	Left bank	Right bank
f) Average height of the banks		
g) Levee banks present or absent		
h) Typical bank slope over 100m of stream, (vertical or undercut, gradual or little slope, variable, artificial banks).		
i) Soil type and erosion potential		

3. Description of the water

a) Appearance of water - clear, oily sheen, foamy, frothy, milky, muddy, coloured brown, green, reddish or other (describe).

....
b) Smell of water - none, sewage, fish, chlorine, rotten eggs, other (describe). ....
c) Average water velocity - high, medium, low ....

4. Plant material in the water

a) Presence of logs greater than 10cm in diameter in the water - none, occasional, plentiful ....
b) Large aquatic plants - present / absent, attached or free floating?...
c) Algae in the waterway

i) Algae growing on submerged stones, twigs, etc.
None, occasional, plentiful. Colour (green or brown)...
ii) String like algae (filamentous)
None, occasional, plentiful. Colour (green or brown)...
iii) Detached ‘clumps” or “mats” of floating algae.
None, occasional, plentiful. Colour (green or brown)...

5. Riparian Vegetation

	Left bank	Right bank
a) Average width of stream side vegetation		
b) Length of riverbank with vegetation overhanging the water		
c) Total length of riverbank with weed infestation		
d). Total length of each bank lined with native vegetation.		

6. Evidence of animals and birds

Birds (describe/name)..

Animals (describe/name)...

7. General conditions affecting the stream

Note the general conditions around the site that might be affecting your stream.

These conditions may include dead trees, degraded vegetation on bank, banks collapsed, eroded, stock erosion paths, mud in or entering stream, litter, rubbish in or next to stream, actively discharging pipes, other pipes, drains entering, dams, weirs across stream.

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8. Land uses near the site

The way the land is used and managed can have a severe effect on the health of the waterway. Look at the surrounding land uses for a distance of up to 400m away from the site. Add comments if a land use or management practice appears to be causing problems.

Land use area as a percentage of total		**Comments**
Agriculture....................................	%	....
Built environment.............................	%	....
Construction....................................	%	....
Recreation	%	....
Bush, forests, nature reserves	%	....
Other land uses	%	....

9. Significant changes to the site since your last visit

Compare conditions at the site with those recorded on your Site Description Sheets from the last visit.

....

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10. Ideas for action

While describing the site, you may think of some actions that could be taken to improve the habitat in and around your stream. Write them down here for reference.

....

....

11. Pipe and drain inventory

Record observations on each pipe and drainage ditch found on the banks or in the stream. Photocopy additional sheets sufficient for each pipe or drain that you are likely to find. Pipes or drains can be abandoned or active.

a) This information applies to a: ☐ pipe ☐ drain ☐ other (name)

b) Location of pipe/drain ☐ in-stream ☐ in bank ☐ near stream

Describe location for purpose of adding to your base map...

....

....

c) Type of pipe and diameter

		Diameter (m)			Diameter (m)
Industrial outfall	θ		Agricultural field drain	θ	
Sewage treatment plant outfall	θ		Settlement pond drain	θ	
Storm drain	θ		Parking area drain	θ	
Combined sewer overflow	θ		Bridge culvert	θ	
Other (name)	θ		Unknown	θ	

d) Discharge flow

Rate of flow	None θ	Trickle θ	Heavy θ	Intermittent θ	Steady θ
Appearance	Clear θ	Foamy θ	Turbid θ	Oily sheen θ	Coloured θ (name)
Odour	None θ	Sewage θ	Fishy θ	Chemical θ	Chlorine θ

Other observations

e) Condition of the stream bank below the pipe or drain

No problem evident θ Sewage litter, eg: toilet paper θ Rubbish, eg: cans, paper θ

Eroded θ Lots of algae θ

f) Additional comments

Use this space to expand or explain on information provided above. For example, you may want to add notes on the condition of the stream below the discharge.

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Habitat Rating

B3-B5

Activity 29

Curriculum Links:
SOSE Environments / Natural Systems Env 3.3
Science Concepts and Context / Life and Living CC 3.2
Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3

Focus Question:

- **How are changes in aquatic habitats assessed?**

Aim:

To determine the health of a section of habitat by assessing various components according to predetermined ratings.

Main Ideas:

- This activity describes how you can rate the health of the habitat on a scale of excellent, good, fair or poor.
- The rating allows you to assess the health of the site for aquatic organisms and its value for human uses, monitor the condition of the site over time, compare one site with another; and identify which areas need restoring or protecting.

Need:

Student Sheets:
Explanation of Assessment Parameters (5.21)
Habitat Descriptions and Ratings (5.22)
Habitat Rating Record Sheet (5.23)
Habitat Survey Field Guide Ratings (5.24)
Stream Habitat Record Sheet (5.25)
plus transport, exercise materials

Consider:

To assess the health of the habitat around the stream you are monitoring, you will need to consider five features:

- quality of verge vegetation;
- quality of bank vegetation;
- extent of in-stream cover;
- degree of bank erosion and stability; and
- variety of riffles, pools and bends.

Analysis:

How to carry out the Survey

1. Survey both sides of the stream for approximately 100m and extending out from the water by 40m for a medium/large size waterway or 10-20m for a small stream.
2. For each feature in Table 4 Habitat Descriptions and Ratings, select a category (excellent, good, fair or poor) that is most like your habitat. If the description in the table does not match, try another category.
3. Record the score for each feature on the Stream Habitat Rating Sheet.
4. For an overall assessment of the site, add up the scores to obtain a total.

Bank and verge vegetation and in-stream cover are more important in determining the health of the habitat than either bank erosion and stability or riffles, pools and bends.

Quality Control:

The main quality control challenge for the Habitat Rating is to ensure consistent evaluation of features of the habitat. The easiest way to accomplish this is to have one team whose job is to carry out the habitat assessment throughout the catchment. From time to time the evaluation of habitats by field teams should be compared with that of your Waterwatch Coordinator.

EXCURSION

Student Sheet 5.21
Explanation of Assessment Parameters

Bank Vegetation

Bank vegetation refers to trees, shrubs, grasses etc. actually growing on the bank. This vegetation provides food and shelter for aquatic animals in the form of fallen leaves, twigs and branches, etc.

Verge vegetation

Verge vegetation is considered to be stream side vegetation up to 40m from the bank of wide rivers or 10-20m from the bank of small streams. The verge vegetation can be quite extensive but many streams in urban areas have almost no verge vegetation at all. The condition and type of vegetation around a waterbody gives a good indication of the quality of the aquatic environment. It helps to explain physical and chemical changes and the macro-invertebrates found in the water.

In-stream cover

In-stream cover refers to the diversity of living places available to aquatic life and includes aquatic vegetation, woody debris, snags, fallen trees, logs and rocks. Streams with a rich diversity of in-stream cover allow fish and macro-invertebrates to shelter from the current, feed and reproduce. Aquatic plants supply food and oxygen, and protruding snags form roosting and preening sites for birds.

Bank erosion and stability

Streams naturally erode, usually on the bends of meanders. However changes in adjacent land use can cause streams to become unstable, resulting in continuous erosion along its channel. Such changes include increased runoff from impervious surfaces and piped tributaries, stock access, or direct interference such as straightening or channelling the stream. If it has been stabilised with concrete banks, the stream will be stable but should not be ranked highly as it is not ecologically healthy.

Riffles pools and bends

The variety of habitats found in riffles pools and bends helps to support a variety of living things. Before you consider assessing this part of the habitat, make sure that riffles, pools and bends are a natural part of the catchment being studied. For example, large slow flowing rivers may not have riffles but the bends provide different habitats because of the cutting action of water at bends provides deeper areas.

Student Sheet 5.22
Habitat Descriptions and Ratings

Table 19 Habitat Description and Ratings

Habitat Features	Score	Excellent 4	Good 3	Fair 2	Poor 1
Bank vegetation (Examine the bank over a length of 100m)		Mainly undisturbed native plants on both banks. Introduced species are absent or present at very low levels.	Native vegetation on both sides of river in generally good condition. Some intrusion of introduced species.	Mixture of native and exotic species on both banks, OR one side may be cleared and the other side undisturbed native plants, Other impacts may be present, eg: fire, stock grazing.	Any native vegetation present is severely modified on both sides by grazing or human access, OR cleared land both sides (eg agriculture, housing), OR species present are virtually all exotics (eg: *Mimosa*, coffee bush, candle bush). OR site has a concrete lined channel.
Verge vegetation (Examine the verge over a length of 100m and 40m back from the bank of wide rivers or 10-20m for a small stream.)		Mainly undisturbed native plants on both sides of river with intact canopy to 40m (10-20m) from water. Introduced species are absent or present at very low levels.	Native vegetation on both sides of river in generally good condition. Some intrusion of introduced species. Riparian zone less than 40m (10-20m) but still wide.	Mixture of native and exotic species on both banks, OR one side may be cleared and the other side undisturbed native plants, OR narrow corridor of native plants on both sides. Other impacts may be present, eg: fire, stock grazing in riparian zone.	Any native vegetation present is severely modified on both sides by grazing or human access, OR cleared land both sides (eg agriculture, housing), OR species present are virtually all exotics (eg: *Mimosa*, coffee bush candle bush).
In-stream cover (aquatic plants, snags, logs, rocks, bank overhangs and overhanging vegetation.)		High cover on banks. Abundant in-stream, and overhanging vegetation. Abundant snags and logs or boulders. Bank overhangs present.	Good cover on the banks, moderate areas of in-stream and overhanging vegetation. Some snags, logs or boulders.	Some cover. Some areas of in-stream or overhanging vegetation. Invasion of bank vegetation by terrestrial grasses. Few snags, logs or boulders.	Little or no cover. No overhanging vegetation or in-stream plants. Stream is largely cleared with few or no snags, logs. Boulders present are submerged. Site may have rock or concrete lining.
Bank erosion & stability (roots, bare soil, slumping, erosion, fall-ins, cracking of bank.)		Stable. No erosion or deposition evident. No slumping of banks. Lower banks completely covered with root mat, grasses, reeds or shrubs.	Very occasional and very localised erosion. Little slumping or undercutting of bank. No significant damage to bank. Good vegetation covers.	Some erosion evident but localised. No continuous damage to bank structure. Moderate vegetation cover.	Extensive areas of erosion. Unstable, extensive areas of bare ground, bank failure such as cracks and fall-ins. Little vegetation cover.
Riffles, pools & bends (Before you consider assessing this part of the habitat, make sure that riffles, pools and bends are a natural part of the catchment being studied. If not, then ignore this part.)		Wide variety of habitats. Riffles and pools of varying depths present. Bends present.	Good variety of habitat, eg: riffles and pools or bends and pools. Variations in depth of riffles and pools.	Some variety of habitats, eg: occasional riffle or bend. Some variation in depth.	Uniform or only slight variety of habitat. All riffles or pools with uniform or only slight variation in depth, eg: channelled stream.

Student Sheet 5.23: Habitat Rating Record Sheet

BACKGROUND INFORMATION

Date: .... Time: .... Name of group: ....

Name of investigators: ....

Name of water body: .... Site code: ☐☐☐☐☐☐ Map Name:

Type of Water body

(pond, wetland, lake, dam, bore, piezometer, drain, estuary, ocean, bay, creek, river, irrigation channel, spring) ....

Site name ....

Land title numbers of adjacent properties ....

Easting (6 numbers): .... Northing (7 numbers): ....

Position in the catchment**:** (upper, middle, lower) ....

Estimated elevation: ....Name of suburb, nearest town or settlement: ....

Brief description of access to site: ....

....

Describe the weather both now and in the past 24 hours.

	Clear/sunny	Overcast	Showers	Rain (steady)	Rain (heavy)
Weather now	θ	θ	θ	θ	θ
Past 24 hours	θ	θ	θ	θ	θ

HABITAT RATING

Rating the habitat**.** Circle your rating score for each part of the habitat below:

Habitat rating	Bank vegetation	Verge vegetation	In-stream cover	Erosion & stability	Pools, riffles and bends
Excellent	4	4	4	4	4
Good	3	3	3	3	3
Fair	2	2	2	2	2
Poor	1	1	1	1	1

If you wish to get a general rating for the site then add up all the numbers you circled for a total score. The minimum total is 5 and maximum 20.

Total Score	Stream Habitat Rating:

Habitat rating	Overall condition of the habitat	Colour code for map
Excellent 18-20	Site in natural or virtually natural condition; excellent habitat condition.	Blue
Good 13-17	Some alteration from natural state; good habitat conditions.	Green
Fair 8-12	Significant alterations from the natural state but still offering moderate habitat; stable.	Yellow
Poor 5-7	Significant alterations from the natural state to very degraded. May have moderate to severe erosion or sedimentation problems.	Red

Student Sheet 5.24: Habitat Survey Field Guide Ratings

(Source: Catchment Education Resource Book, Vic)

Excellent	Good	Fair	Poor	Very Poor
Bank vegetation				
(10)	(8)	(6)	(4)	(2)
Mainly undisturbed native vegetation. No signs of site alteration.	Mainly native vegetation. Little disturbance or no signs of recent site disturbance.	Medium cover, mixed native/introduced. Or one side cleared, the other undisturbed.	Introduced ground cover, little native understorey or overstorey, predominantly introduced vegetation.	Introduced ground cover with lots of bare ground, occasional trees. Also includes sites with concrete-lined channels.
Verge vegetation				
(10)	(8)	(6)	(4)	(2)
Mainly undisturbed native vegetation on both sides of stream. Verge more than 30m wide.	Well-vegetated wide verge corridor. Mainly undisturbed native vegetation on both sides of stream; some introduced or reduced cover of native vegetation.	Wide corridor of mixed native and exotics, or one side cleared, an other wide corridor of native vegetation	Very narrow corridor or native or introduced vegetation.	Bare cover or introduced grass cover such as pasture land.
In-stream cover				
(10)	(8)	(6)	(4)	(2)
Abundant cover. Frequent snags, legs or boulders with extensive areas of in-stream, aquatic vegetation and overhanging bank.	A good cover of snags, logs or boulders, with considerable areas of in-stream and overhanging vegetation.	Some snags or boulders present and/or occasional areas of in-stream or overhanging vegetation.	Only slight cover. The stream is largely cleared, with occasional snags and very little in-stream vegetation. Generally no overhanging vegetation.	No cover. No snags, boulders submerged or overhanging vegetation. No undercut banks. Site may have rock or concrete lining.
Bank erosion & stability				
(5)	(4)	(3)	(2)	(1)
Stable; no erosion/sedimentation evident. No undercutting of banks, usually gentle bank slopes, lower banks covered with root mat grasses, reeds or shrubs.	Only spot erosion occurring. Little undercutting of bank, good vegetation cover, usually gentle bank slopes, no significant damage to bank structure.	Localised erosion evident. A relatively good vegetation cover. No continuous damage to bank structure or vegetation.	Significant active erosion evident especially during high flows. Unstable, extensive areas of bore banks, little vegetation cover.	Extensive or almost continuous erosion. Over 50% of banks have some form of erosion; very unstable with little vegetation cover.
Rifles, pools & bends (flowing water only)				
(5)	(4)	(3)	(2)	(1)
Wide variety of habitats. Rifles and pools present of varying depths. Bends present.	Good variety of habitats – eg: rifles and pools or bends and pools. Variation in depth of rifle and pool.	Some variety of habitat – eg: occasional rifle or bend. Some variation in depth.	Only slight variety of habitat. All rifle or pool with only slight variation in depth.	Uniform habitat. Straight stream, all shallow rifle or pool of uniform depth – eg: channelled stream or irrigation channel.

This information was largely extracted from the Community Water Quality Monitoring Manual for Victoria. (1994). The Habitat Survey technique is adopted from 'The Environmental Condition of Victoria Streams' A report by Philip Mitchell for the Department of Water Resources Victoria (Feb 1990).

Student Sheet 5.25: Stream Habitat Record Sheet

(Source: Catchment Education Resource Book, Vic)

Name of monitoring group:	
Person(s) conducting the Survey / Test:	
Date of survey or test:	Eastings (4-digit no.)
Time or survey or test:	Northing (5-digit no.)
Length of stream examined (metres):	

Stream Habitat Rating:

Circle your stream's rating for each factor in the table below:

Rating	Bank Vegetation	Verge Vegetation	In-stream Cover	Erosion & Stability	Pool, Rifles & Bends
Excellent	(10)	(10)	(10)	(5)	(5)
Good	(8)	(8)	(8)	(4)	(4)
Fair	(6)	(6)	(6)	(3)	(3)
Poor	(4)	(4)	(4)	(2)	(2)
Very Poor	(2)	(2)	(2)	(1)	(1)

Add up all the numbers you circled for a total score.

(The minimum score from this rating table is 8 and the maximum is 40).

Total Score:

Compare your stream's total score with the range of scores below to assess the stream habitat rating of your site.

Rating	Scores
Excellent	36-40
Good	29-35
Fair	20-28
Poor	12-19
Very Poor	8-11

Stream Habitat Rating:

Interpreting your results

Excellent	Site in natural or virtually natural condition; excellent habitat condition.
Good	Some alteration from natural state; good habitat conditions.
Fair	Significant alterations from the natural state but still offering moderate habitat; stable.
Poor	Significant alterations from the natural state, with reduced habitat value; may have erosion or sedimentation problems.
Very Poor	Very degraded, often with severe erosion or sedimentation problems.

Rating River Health

B3

(Adapted from the Swan River Education Kit Water and Rivers Commission WA 1999 and from Where Rivers Meet)

Activity 30

Curriculum Links:
SOSE Environments / Environmental Awareness and Care Env 3.2

SOSE Environments / Natural Systems Env 3.3

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Science/Working Scientifically/ Evaluation/WS3.3

Focus Question:

- **How can river health be rated?**

Aims:

1. To complete a preliminary assessment of the health of a river by observing.
2. To devise a useful, realistic health rating system which results in a judgment of waterway health.
3. To explain how the activities of people greatly affect river health.
4. To discuss the ways people can work towards improving river health.

Main Idea:

- Students observe the health of a river at a chosen site, then devise and apply a rating scale to a number of observable indicators of river health. Ways to maintain and improve health are discussed.

Need:

Student Sheets: Waterway health rating guidelines and Health assessment factors and rating scale (below), A wetland/waterways health check. Rating your local wetland or waterway (Waterwatch Australia pamphlet).

Consider:

Introduce students to the idea that they can rate the health of the river using their powers of observation and their senses (as distinct from assessing river health by conducting a scientific investigation of various parameters).

Refer to the Student Sheet: River health rating guidelines and discuss the various factors that may affect river health. Refer to Student Sheet: Health Assessment factors and rating scale and discuss.

Use the pamphlet, (A Wetlands/ Waterways Health Check) to develop with students the idea that the health of a river can be assessed by devising a scaled rating or scoring system. In the case of litter, the rating scale of 0-10 would allocate 0 points for large quantities of litter and 10 points for no litter. Students devise their rating system by considering all health categories on their work sheet. They should think carefully about what they would be looking for in each category to give a score of 10 points.

Analysis:

At the site:

Students check that their rating system is suitable and adjust it if necessary.

Students explore the site, making careful observations and record their observations in the spaces provided on the worksheet. Complete the rating scale and tally the results to give an overall river rating according to their key.

Back at school:

Students report on their results and consider how they could improve their rating system.

They could then consider what would need to happen to make the site perfect or nearly perfect in terms of health, and plan to take further action.

Reflection:

What role has NT and Federal Government played in this exercise?

Answers may include:

- provided training and education of the public through this Education Kit.
- provided a base organisation structure and support for the AUSRIVAS program.
- providing scientific support for positive identification of macroinverterates found through its own studies and those of the general public and schools.
- maintained water quality database and some written reports.

Student Sheet 5.26
Waterway Health Rating Guidelines

Vegetation

Vegetation (trees, grasses and shrubs) helps to keep riverbanks stable and prevent erosion. It also provides habitat for animals.

Trees and shrubs that hang over the banks shade the water and help prevent aquatic fauna from becoming overheated.

Plants that grow in the water provide a habitat for aquatic animals.

Native hard-leafed trees drop leaves that decompose slowly in the water and provide food. Introduced deciduous trees are weeds that compete with native plants and produce leaf litter that decomposes rapidly, increasing nutrients in waterways.

Healthy green lawn may indicate the excess use of fertiliser that can leach into the river.

Bare ground may indicate that the banks have eroded, adding sediment to the river.

Water

If the water is murky green or has a green scum floating on the surface there are algae present and the river may be stagnant. An oily slick or too much froth can indicate pollution. Light slicks and froths may be natural.

If the water is clear but stained brown it may be due to tannin from paperbark trees growing on the banks further upstream. (This is quite natural and healthy.) If the water is cloudy (turbid) it could be because too much soil is washing into the stream. Trees, shrubs and reeds stop this happening. If the water is very turbid there will be few aquatic animals present.

The Waterway

Bends in the river or stream may show that it is still in its natural form and has not been changed into a drain or ditch. This is a good sign of river health.

Rocks, logs and leaves in the river create different habitats, and allow for a stable stream bottom. This is better for some aquatic plants than moving sand.

Where water flows quickly over rocks it gets mixed with oxygen. (This is called a riffle.) The more oxygen that mixes into the water, the healthier the water.

Pools in a river are a good sign of river health because they provide an alternative habitat to the straight stretches of the river. The more types of habitat, the better. Pools also provide important refuges for animals if the rest of the stream dries up.

Animals (native)

Animal sounds indicate that the area has habitats for animals. The more types of animals you find under rocks, on the stems of plants or in the sediment of the stream, the healthier the water.

Litter

The presence of litter or rubbish shows that people don't respect the site. The type of litter present may indicate how poorly the site is regarded. If people bring litter to dump at the river it shows they think of the river as a rubbish tip.

Land use Activities

Buildings, roads and car parks encourage stormwater to run off hard surfaces directly into the river. This often results in vegetation and banks being altered from their natural form. Signs of industrial sites may indicate that effluence were present in the past or that soil is contaminated.

The water of most freshwater streams would have been drinkable before being affected by human land uses.

Drains from urban areas could carry hot water from roads and car parks, chemicals and oils from road runoff, and fertilisers and pesticides from garden water runoff.

If people use the water for swimming, water sports and fishing it means that the water is generally healthy.

Student Sheet 5.27
Health Assessment Factors and Rating Scale

	HEALTH ASSESSMENT FACTORS	OBSERVATION	RATING
VEGETATION	Are there many trees and shrubs along the river bank? Do trees and shrubs hang over the bank into the water? Are there any plants growing in the water? Do the trees or plants look like they are native plants or introduced plants? Are there large areas of lawn along the banks? Are there any patches of bare ground along the banks?		
WATER	Does the water look frothy or scummy? Is the water clear or cloudy (turbid)? Does the water smell clean and natural?		
ANIMALS	Can you hear or see any birds or frogs? Are there animals under rocks, on plant stems or in stream sediments?		
WATER BODY	Are there any bends in the waterway? Are there any rocks, sticks, logs or leaves? Is there any water flowing over rocks to form a riffle? Are there any nearby pools?		
LITTER	Can you see any litter or rubbish? How damaging is it?		
LAND USE	Are there any buildings beside the river? Are there any drains into the river at this site? Could you swim or fish in the water?		

Water Quality Testing & Data Interpretation

B3-B5

(Adapted from Waterwatch Education Kit VIC Waterwatch Barwon Water 1995)

Activity 31

Curriculum Links:
Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Focus Question:

- **How can accurate water quality testing and data interpretation be achieved?**

Aims:

To explain how physical and chemical data provides a way of considering all abiotic changes that take place in a waterway – source, effects of change and status in terms of river health.

To discuss the factors (such seasonal variation) that cause variations to water conditions.

To relate the physical and chemical indicators of water quality to biological indicators (macroinvertebrate populations and vegetation) and to the catchment's land-use activities.

To develop skills in the technical processes associated with measuring physical and chemical parameters used to test water quality.

To show understanding of the fact that a water sample represents just a moment in the life of the river, and variables such as diffuse-source and point-source pollutants will cause changes in the values.

To assess the health of the site through interpretation of measured physical and chemical parameters.

To relate physical and chemical indicators of water quality to biological indicators and land-use activities of the catchment.

Main Ideas:

- Students investigate sources of water pollution, its effects, and consider appropriate solutions.
- Students develop technical skills while measuring the physical and chemical parameters of stream water quality. Values measured may include temperature, pH, turbidity, conductivity, dissolved oxygen and phosphate and nitrate concentrations.

Need:

Water quality monitoring kit. Technical video. Waterwatch Coordinator assistance likely to be required.

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Consider:

Choose one or two waterways. Water quality comparisons could be made between a drain outlet or tributary and the main stream within the same study site.

Familiarise students with the use of water-testing equipment. For information on the loan and use of equipment, contact your Regional Waterwatch Coordinator.

Analysis:

At the site(s):

Students select the most appropriate sampling point, ideally midstream, and halfway between the surface and the bottom. Otherwise, sample as far out from the bank as possible, and avoid eddies and backwaters. (To avoid contamination, thoroughly rinse sampling equipment 3 times downstream of the sampling point.)

Record results for the following activities on the Student Sheet 5.28: Water quality testing.

Carefully observe the water, surrounding vegetation and land uses and make informal predictions about the results of all parameters to be tested. Students should briefly describe the site and water conditions and note the weather conditions so that their results can be analysed in context.

Collect water samples and test them according to instructions given. If results seem unrealistic, students should re-appraise their methods and if necessary resample and retest. Check results of water testing for all sites and display in tables for easy comparison.

Compare each fieldwork site in terms of the parameters measured. Construct bar graphs to compare results from the different sites. Suggest reasons for any differences between data from the different sites and explain results in terms of the differences in vegetation and/or land uses of the sites and catchment.

Be aware that rainfall can cause sudden changes in values (especially phosphate and nitrate). Form an assessment of all parameters tested, rate the water quality at each site.

Using data from your Regional Waterwatch Coordinator, compare data collected with data previously collected from the same site(s) at roughly the same time of year. Compare and explain results.

Using data from your local Regional Waterwatch Coordinator, graph data collected for each parameter from the site(s) over a year, and examine the seasonal changes. Identify those parameters that show the greatest seasonal range/fluctuation and try to explain why.

Obtain rainfall data for your regions over the last few years to see if any of the changes on the graphs can be explained in terms of previous rainfall events.

Focus on a pollutant investigation:

Investigate how the parameters measured relate to water quality and the presence of pollutants. Consider why the values vary and what levels of change in the parameters are acceptable. Identify the source of the major pollutants of waterways (eg. nutrients, chemicals, sediment and metals). Differentiate between, and give examples of, point source and diffuse-source pollution.

Develop a hypothesis that attempts to explain the results at the site(s) visited. Plan an investigation to test the hypothesis.

Extension:

Contact a community group who is involved in the Waterwatch program and volunteer to help with further water sampling. Waterwatch and Landcare can put you in touch with various groups.

Student Sheet 5.28
Water Quality Testing

Site: Sampling Location:

Predictions of water quality based on preliminary observations	
Observations of site features	**Predictions**
Water	Temperature
Vegetation	pH
Land use	Phosphate/Nitrate levels
Site degradation	Dissolved oxygen
Pollutants	Salinity
Macroinvertebrates	Turbidity
Weather conditions	Flow and depth

Results of Water Quality Testing		
PARAMETERS	**SITE 1**	**SITE 2**
Temperature		
pH		
Turbidity		
Dissolved Oxygen		
Salinity		
Phosphate levels		
Nitrate levels		
Flow and Depth		

Interpretation of Results	
SITE 1	**SITE 2**
Health Assessment of River Sites	

Review of Water Quality Terminology

B3

Activity 32

> ***Curriculum Links:***
>
> **Science** Working Scientifically / Science in Society WS 3.5
>
> **Indigenous Languages and Culture** Natural Environment

Aims:

1. To review terminology.
2. To make comparisons between communication about water quality historically and today.

Main Idea:

- Use Glossary (Introduction Booklet – NT Waterwatch Education Kit).

Need:

The students need previous exposure to the terms listed on Student Sheet 5.29 (below).

Consider 1:

The Glossary (Introduction booklet of this education kit.

Analysis 1:

Make a crossword or word maze (find a word) from the terms on the student sheet. Alternatively create some sentences with these terms to be identified and placed in the missing space. This could be done in conjunction with the crossword clues. Another fun way of reviewing these terms is through the creation of your own 'pictionary' or glossary.

Use the game to review the terms' understandings.

Consider 2:

Investigate indigenous languages:

The following terms have been translated into Yolngu Matha:

Flow	"ganydjarr"
Temperature	"gorrmur' yal'yunaya"
Turbidity	"ganu'mi"
Salinity	"mouk, damurru"
Oxygen	"wata or wa\"
Nutrients	"gapuwu atha"

Research other indigenous languages within the NT.

Draw up a map of the NT with the terms on the map where they originate from, eg: the term 'water' could be mapped across the NT.

Analysis 2:

What importance do traditional owners place on the passing on of knowledge related to water quality?

How does/did the local indigenous community transfer this knowledge?

What were some of the terms they used?

Reflection:

What are some of the communication tools (art forms and use of language) that were used by the local community both historically and today?

Student Sheet 5.29
Review of Water Quality Terminology

Acidic
Aeration
Algae
Alkaline
Anoxic
Bacteria
Bloom
Buffer
Coliform
Colour
Conductivity
Contamination
Cycle
Decomposers
Depth
Discharge
Dissolved
Erosion
Eutrophication
Flow
Heavy metals
Inorganic
Ions

Macroinvertebrates
Nutrients
Odour
Organic
Oxygen
Parameter
Pathogenic
Pesticides
Photosynthesis
pH scale
Pollution
Respiration
Salinity
Sediments
Sensitivity
Stratification
Suspension
Temperature
Toxic
Turbidity
Velocity
Wastes
Water quality

Take Home Messages

B3

Activity 33

Curriculum Links:
SOSE Environments **/** Environmental Awareness and Care Env 3.2

Aim:

Students take home some basic watery facts to share with their family and friends to emphasise the importance of looking after our planet's water resources.

Need:

Pens, scissors and card, magnets or double sided sticky tape/blue tack.

Consider:

Students may use the samples below or design their own.

Cut the following cards out and use them at home. Start a collection or share cards with family and friends.

Did you Know?

Waterwatch monitoring enables early detection of problems and through appropriate action, can reduce costs of rehabilitation.

Did you Know?

Warmer waters will conduct electricity better than cooler water.

Did you Know?

Since fish and most aquatic animals are Ectothermic (cold blooded), their metabolic rate and growth rate change with the temperature.

Did you Know?

Soil particles suspended in the water (turbidity) absorb heat from the sun and raise the water's temperature. This lowers the waters capacity to hold oxygen. Turbidity also reduces plant growth because less sunlight is able to reach the leaves growing on the lake or riverbed. This means valuable food and habitat is lost for many aquatic animals.

Did you Know?

Increased phosphate levels can stimulate algal blooms which in turn lead to increased turbidity, pH changes, a reduction in biodiversity, and the occasional production of toxins and unpleasant odours.

Did you Know?

Faecal bacteria are common in the intestines and faeces of both endotherms (warm) and ectotherms (cold-blooded) animals and their presence in water indicates possible sewage contamination

Did you Know?

Many pesticides are soluble in water. Others attach to suspended soil particles or sediments in water. Some persistent pesticides tend to accumulate in animal tissues.

Did you Know?

Heavy metals are a group of metals which are often associated with pollution and toxicity. Examples include copper, zinc, cadmium, lead and mercury. Excessive amounts of these metals cause toxicity.

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