Investigating Freshwater

A resource book of ideas for **National Science Week 2003**

AUSTRALIAN
SCIENCE
TEACHERS
ASSOCIATION

Foreword

A resource book of ideas for National Science Week 2003

Investigating Freshwater is the latest in the series of resource books published each year by the Australian Science Teachers Association (ASTA) on the school theme for National Science Week. These resource books aim to assist teachers engage students from early childhood through to senior secondary level to work scientifically on activities, challenges or projects of interest to them under the chosen theme.

For 2003, *Investigating Freshwater* includes scientific background information for teachers and a wide range of teaching and learning ideas, case studies and scenarios around freshwater. The book includes simple to progressively challenging activities, some of which may trigger your own ideas.

Valuable features of *Investigating Freshwater* include questions and activities that could be further developed by senior secondary students for entry into the Australian Junior Water Prize (for the Award Schedule refer to the advert in the centre page of this book). An extensive range of links to extra teacher information, resource kits, and publications as well as internet references suitable for students to follow up can be found in each chapter.

National Science Week, supported by the Commonwealth Government, is a partnership program between the Australian Broadcasting Commission, ASF Limited, the Australian Science Teachers Association and Commonwealth Government departments, the Department of Education, Science and Training (DEST) and the Department of Industry, Tourism and Resources (DITR).

ASTA now has a Science Teachers Association National Science Week Representative in each state and territory across Australia. These science teachers are available to provide information and ideas about National Science Week activities in your local area. Please contact your state or territory representative to find out more about school participation in National Science Week 16 - 24 August 2003. The names and contact details of the eight representatives are included in this book.

ASTA is pleased to have received funding for this resource from DEST through the National Innovation Awareness Strategy and the Australian Water Association (AWA). ASTA Council thanks and congratulates the authors and designers of *Investigating Freshwater*, the ASTA National Science Week Representatives in each state and territory and all the teachers and students who organise and participate in the many school and public activities, events and competitions celebrating science.

Teachers and students are encouraged to utilise *Investigating Freshwater* as a resource for enriching science teaching and learning across Australia.

Peter Russo

Peter Russo

ASTA Secretariat:
Australian Science Teachers Association
PO Box 334
Deakin West ACT 2600

Ph: 02 6282 9377 Fax: 02 6282 9477
Email: asta@asta.edu.au
Website: www.asta.edu.au

ASTA is the federation of the eight state and territory Science Teachers Associations.
This resource is the result of the cooperative efforts of each of the federation members. The federation members are:

Science Educators' Association of the Australian Capital Territory (SEA*ACT)
GPO Box 1205
Canberra ACT 2601
Ph: (02) 6288 1904
www.seaact.asn.au

Science Teachers' Association of New South Wales (STANSW)
Hunters Hill High School
Reiby Road
Hunters Hill NSW 2110
Ph: (02) 9816 5065
www.stansw.asn.au

Science Teachers' Association of Western Australia (STAWA)
PO Box 1099
Osborne Park WA 6916
Ph: (08) 9244 1987
www.stawa.asn.au

Science Teachers' Association of Queensland (STAQ)
C/- School MSTE
QUT Kelvin Grove Campus
Victoria Park Road
Kelvin Grove Qld 4059
Ph: (07) 3864 3340
www.staq.qld.edu.au

South Australian Science Teachers' Association (SASTA)
1st Floor, 211 Flinders Street
Adelaide SA 5000
Ph: (08) 8224 0871
www.sasta.asn.au

Science Teachers' Association of the Northern Territory (STANT)
PO Box 1168
Nightcliff NT 0814
Ph: (08) 8999 1224

Science Teachers' Association of Victoria (STAV)
PO Box 109
Coburg Vic 3058
Ph: (03) 9385 3999
www.stav.vic.edu.au

Science Teachers' Association of Tasmania (STAT)
PO Box 3035
Launceston Delivery Centre
Launceston TAS 7053
Ph: (03) 6263 7131
www.eduart.com.au/stat

Contents

Publisher: Australian Science Teachers Association
PO Box 334 Deakin West ACT 2600

Authors: Dr. Jackie Griggs, Hydro Tasmania and Mr Mike Copland, Wonga Wetlands Education Centre, Albury City Council, NSW. Contributions and review by Sue Fama and David Jamrozik, Hands On Energy Discovery Centre.

Graphic design: Captial Z Design – Sarajayne Lada
Layout: Lavaworks - Kaylee deWet-Jones
Illustrator: Colin Abel
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Scientific authorisation: Chris Davies, CEO AWA and Diane Wiesner, Senior Scientist AWA.

Safety warning: All student activities included in *Investigating Freshwater* have been designed to minimise hazards. However, there is no guarantee expressed or implied that an activity or procedure will not cause injury. Teachers selecting an activity should test it with their own materials before using it in class and consider the occupational health and safety requirements within their State or Territory. Where physical activity is involved, the teacher should be qualified to conduct that activity.

Any necessary safety precautions should be clearly outlined by the teacher before starting the activity. Students must also be provided with any safety equipment prior to commencement.

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Introduction

Investigating Freshwater *has been designed to assist teachers to engage students in hands-on science regarding freshwater. The United Nations has declared 2003 International Year of Freshwater. In doing this, the UN wants to increase our awareness of the importance of sustainable freshwater use, management and protection.*

Water management has environmental, health, economic and security implications. Without good water management practices, water supplies become unsafe for people to use, and once used, may not be disposed of safely for both people and the environment they live in. Having access to safe and sufficient water and sanitation are now recognized as basic human rights. Between 10 and 25 million people die each year because of the lack of clean water and adequate sanitation. The Year encourages integrated water resources management around the world. The Year will promote existing activities and spearhead new initiatives in water resources at the international, regional and national levels and should have an impact far beyond 2003.

How this book is structured

The book has been divided into chapters, each addressing a freshwater issue in the form of a question (WHAT, WHERE, WHEN, WHO, WHY). Early chapters cover background information about freshwater, with the core of the book being "What uses freshwater?" Sustainability of Australia's freshwater resources and present and future issues regarding water use and the science required to manage it are then addressed.

This book covers a wide range of materials and teachers may want to select those areas of most relevance and of greatest interest to their students. Many students will have significant prior knowledge that they bring to the class regarding freshwater. Most schools will have some sort of waterway in their area, whether it is a pond in the local park, a natural or artificial wetland, a creek or river, or perhaps a lake. Some schools may have to use rainwater tanks, farm dams, or underground bores. All students will have used water at home for a variety of purposes.

Information in this book can be used throughout the year, or can be used to provide activities for World Day for Water (22nd March every year) and link Geography Week in June, National Science Week in August to National Water Week in late October.

Organisation of chapters

Each chapter is structured around a lead-in **STATEMENT** or **QUESTION**. Some chapters are limited to one theme, while others have sub-headings that further explore the issues. The chapter is then structured as follows:

SCIENCE – describes the significant scientific background information for the theme.

SCENE SETTING – can be used to set the scene, provide relevance to the topic, or recall relevant prior knowledge of the students.

CHALLENGES & ACTIVITIES – provides teachers with progressively difficult challenges or activities for teachers to be able to engage students. Some chapters will have simple experiments that can be undertaken.

FURTHER INFORMATION / RESOURCES – gives teachers extra information on where to find information and resources relating to the challenges and activities, and provides internet references suitable for students to follow up.

CASE STUDIES – some chapters have case studies that further expand on a particular topic and may also show connections between different topics.

Chapter 5 incorporates scenarios and case studies, which invite the use of other teaching strategies including critical thinking and role-play.

There is a **glossary** on the back page for many of the words used throughout the book.

Curriculum guidelines

Whilst there have been moves to integrate and standardise curriculum across Australia, we still deal with fundamental curriculum issues on a state and territory basis.

This document is deliberately not prescriptive in terms of what must or must not be done but seeks to assist teachers to undertake activities and studies of interest to them and their students, under the broad umbrella of "Freshwater". It is then up to the teachers to place their activities under the appropriate curriculum and syllabus statements operating in their state or territory.

Australian Water Association Australian Junior Water Prize (AJWP)

Throughout the book, this icon indicates questions and activities that may lead to water science projects suitable for students to develop and enter into the AJWP. This competition is for individuals or small teams of senior high school students who carry out a water science project.

In particular, the focus is on our quality of life and how it is improved by innovation and research in the areas of water quality, water resource management, water protection, and water and wastewater treatment. Current water and environmental problems that are highlighted will have suggestions given as to how these can be resolved through research and innovation.

Finalists win a cash prize and are brought to the AWA Conference to present their projects. The winner(s) also earn a cash prize for their school and are sent to Stockholm in August to compete in the worldwide, Stockholm Junior Water Prize.

For information kit and entry forms go to www.awa.asn.au/about/awards/sjwp.asp

Chapter 1 What is Freshwater?

The United Nations (UN) has declared 2003 the "International Year of Freshwater", but what does that mean? While we all know that freshwater is ok to drink, when is water "fresh" and when isn't it?

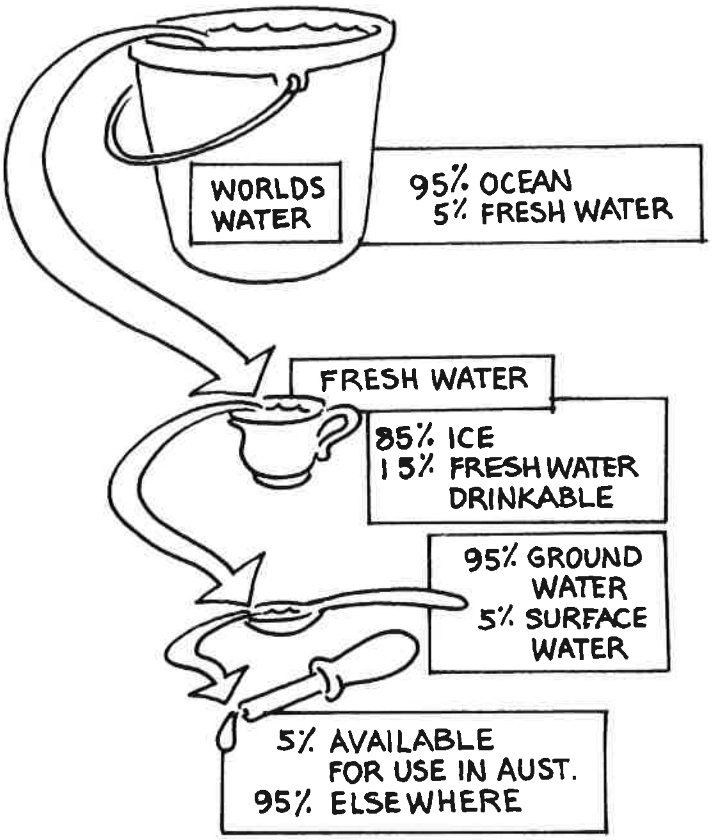
Science

Most of the water on Earth is salty ocean water, with only 3 percent being freshwater. But even that percentage is deceiving because 2.97 percent is unavailable, locked up in icecaps and playing the important role of regulating the planets temperature. Only 0.03 percent is available to plants, animals, ecosystems and humans. All living organisms require water to stay alive.

The scientific definition of freshwater is "water the salinity of which is less than 0.5 parts per thousand (ppt) (or 500 mgL^{-1}), with salinity being the total concentration of all salts in the water". Sodium chloride (table salt) is the most common salt present. The World Health Organisation currently recommends that, for humans, a salinity of 800 electrical conductivity units (equal to 0.48 ppt, or 480 mgL^{-1}) should be considered the upper limit for desirable drinking water.

Even if water has low levels of salt, we may still not consider it "fresh" according to the scientific definition. This may be due to other compounds, both chemical and biological, that may be present naturally or due to human activities. Some examples are blue-green algae, high levels of sediment, pollutants from human activities such as agriculture (herbicides, pesticides, nutrients), industry (heavy metals, chemicals) and sewage (bacteria, nutrients), stagnant water, or highly mineralised water (eg volcanic springs).

One of the world's biggest "killers" is consumption of polluted water. Diseases can be transported by water. Inadequate water and sanitation are primary causes of diseases such as malaria, cholera, dysentery, schistosomiasis, infectious hepatitis and diarrhoea, associated with 3.4 million deaths each year. The United Nations has made a comprehensive assessment of the freshwater resources of the world at www.un.org/esa/sustdev/freshwat.htm



- What sort of pollutants may be found in water that would make it unsafe for us to use?
- How can you ensure water from a stream or river is safe to drink if you were out in the bush camping?
  Solutions could include simple boiling, evaporation/distillation using a still, chemical treatment (bleach, puratab, iodine etc.), filtering (from a piece of cloth to portable water filters).

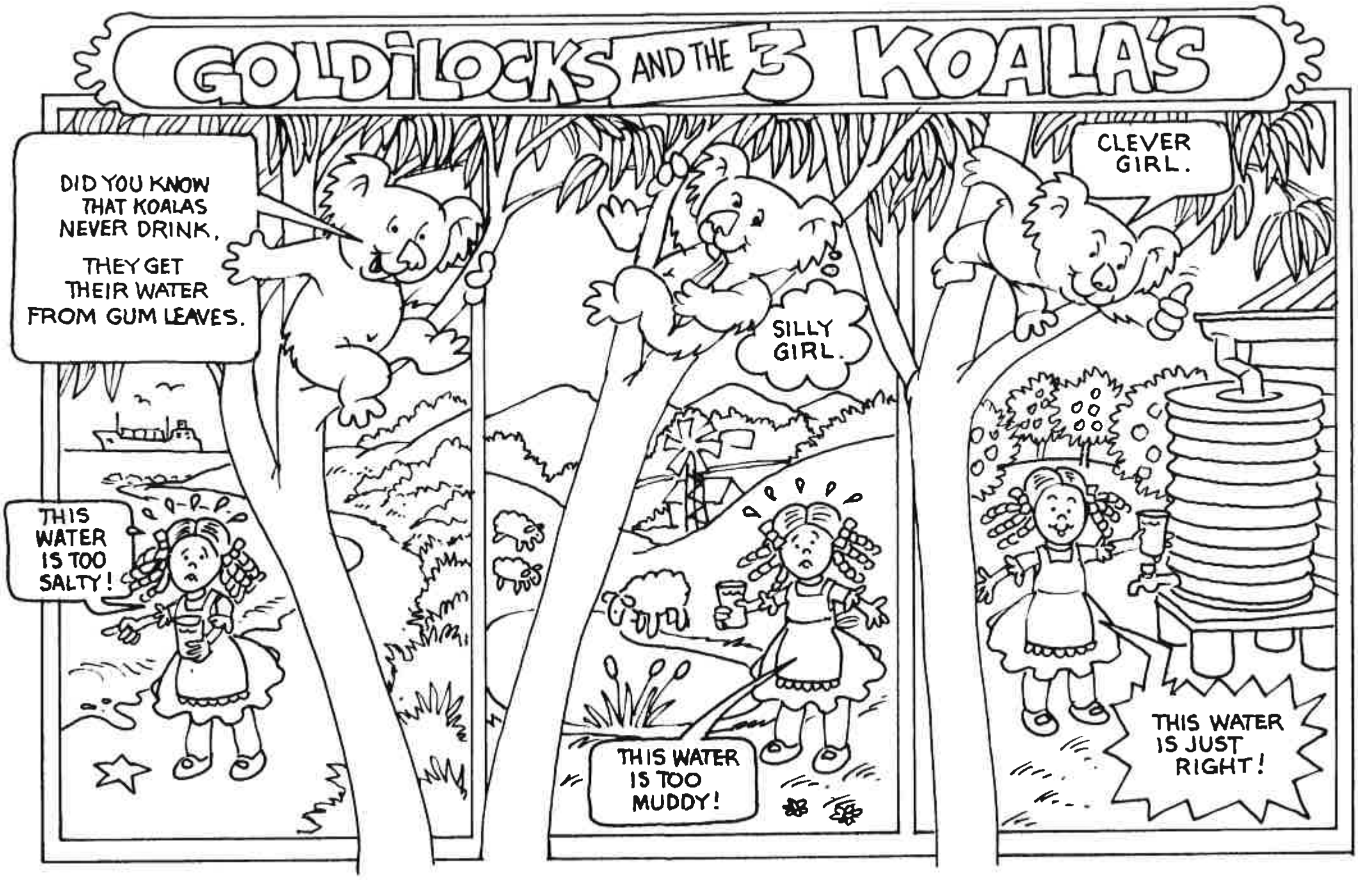
Develop a technique to purify drinking water.

Scene Setting

- What is freshwater? *HINT: Scientific meaning is given above*
- Why is freshwater so important to us, and why did the UN decide to make an international year for freshwater?
- List as many uses of freshwater as you can think of *(drinking, bathing, cooking, washing the car etc.).*
  How many of these could you use different liquids for?
  E.g. salt water, grey water.
- How does the taste of water affect our practices, behaviour and attitudes to drinking it?
- Why can't we drink salt water?
  HINT: At a basic level, our bodies can't cope with high salt levels - this can lead into a discussion of cellular osmosis for senior students.
- What are salts?
  HINT: Salts are a class of chemical compounds formed when the hydrogen ion of an acid is replaced by a metal, or, together with water, when an acid reacts with a base. Salts are named according to the metal and the acid from which they are derived, e.g. Sodium Chloride (NaCl – common table salt), Calcium Bicarbonate ($Ca(HCO_3)_2$).

Challenges

- The water supply in your area is to be cut off for one day or one week. Identify ways to overcome this problem.
- "Audit" water use at home or at school during a day/week/month, and then examine ways to save or better use water.
  Data can be presented in the form of diagrams, pictures, graphs or tables.
- What makes water "hard"?
  Depending on where you are, the tap water may taste different and have different amounts and types of substances dissolved in it. Water that contains high levels of dissolved substances (mainly calcium and magnesium) is called hard water, and water with low levels is called soft water.
- Discuss how you would determine whether your local water is hard or soft.
  How may this affect its use?
  HINT: soaps and shampoos don't work as well in hard water, and scale builds up on kettles etc. and may clog plumbing.



- Investigate which planets in our solar system have water. What state (solid, liquid, gas) does it occur in?
  Find out how scientists detect water on planets and solar systems.
- Find out how astronauts store and drink water.
  What do they do with their waste water?
- What physical properties (eg boiling temperature, density) of water are changed with the addition of table salt (Sodium chloride)?
  Design an experiment to find out.
- Research "freshwater's" chemical composition. Find out:
  - What ionic compounds are present?
    HINT: Examples of ions commonly associated with freshwater are Na^{+} Mg^{++} K^{+} Ca^{+} Cl^{-} HCO^{-}
  - Where do they come from?
    HINT: as rocks are weathered to form soils, they release soluble constituents like silica and the ions mentioned above. River waters can carry carbonate (HCO_3), a by-product of weathering of silicate rocks or limestone. Rainwater may contain small amounts of salt (especially near coastal areas), dust or pollution.
  - Is the ionic composition of freshwater in Australia the same as found on other continents?
    HINT: Most freshwater in Australia is dominated by sodium and chloride, whereas world average freshwater is dominated by calcium and carbonate.

Activities

Water taste tests

- Mix varying amounts of salt or sugar into glasses of tap water. Get students to arrange the glasses in order from most diluted to most concentrated. Or give students 3 samples to taste, two of which are identical. Can they pick the "odd man out"?
- Get drinking water from as many different sources as possible – pure water, mineral water, bottled spring water, bore water, rainwater, river water, tap water etc. Arrange a blind testing with the identity of the different waters hidden. Get students to guess the identity of each type of water, or to rank them in order of which ones they like.

> **Safety Warning:**
> Make sure that any untreated water (eg. rain water, river water) is boiled and safe to drink before use.

- Drinking water tastes different in different places around Australia depending on its source.
  Obtain different types of tap water for the above activity.

Make a simple hydrometer

Is it easier to float in salt water than fresh water? A hydrometer holds the key to this question.

- A basic hydrometer can be made using a cork with a screw inserted in one end. The screw should be heavy enough to have the cork half submerged in pure water. Or a straw and blue tack or plasticine can be used.
- This can be used to investigate how objects float in water of different salinities.
- Use density experiments to compare fresh water to other liquids.
- The hydrometer can be calibrated using the next experiment, by marking the different levels on the side of the cork.

Often hydrometers sold by aquarium shops have the specific gravity of seawater marked in colour on them.
Why might this be?
Where else are hydrometers used?
HINT: **Further Information/Resources** will tell you from where else you can source them.

How salty is the water?

This experiment investigates different methods that can be used to determine the salinity of water samples – any or all methods can be used.

- The Hydrometer measures specific gravity (which is the ratio of the density of a solid or liquid compared to the density of pure water at 4 °C, pure water has a specific gravity of 1) and can provide students with the concentration of dissolved salts in parts per thousand (or ppt).
- Conductivity meters provide a measure of salinity based upon the amount of current that is able to flow through the solution (units are in micro-siemens per centimetre = μS/cm).
- The colorimetric determination gives a measure of salinity using a simple titration (which is the gradual addition of one solution to another solution to determine the concentration of acids or bases in the second solution, indicated by colour change) and colour chart.

Materials

(See resources to help you obtain the more unusual items):

- Conductivity meter
- Hydrometer
- Colorimetric Salinity Test Kit
- Four tall glass containers – able to contain 1 Litre and ensure tall enough for hydrometer to float in.
- Measuring jug (1-2 L capacity)
- Stirring spoon or clean ruler
- Waterproof pen
- Salt
- Scale
- Pure water

Steps

1. Using the waterproof pen, label the containers 0%, 0.5 %, 1%, and 3% (3% is equal to sea water).
2. Fill each of the containers with 1 Litre of water, using the measuring jug.
3. Set aside the beaker of water labelled 0%.
4. Measure 5 grams of salt (1 metric teaspoon (5ml) of salt is approximately equal to 5g) and add to the container labelled 0.5%. Stir the mixture until all of the salt is dissolved.
5. Repeat step #4 with for the rest of the containers using 10g (= 1%), and 30g (= 3%) of salt.
6. Using the conductivity meter, measure the conductivity of each container. Record your data on a table. Distilled water has a conductivity of between 0.5 to 3 μS/cm. Note: the 3% solution may not be able to be measured if the conductivity meter doesn't have sufficient range.
7. Put the Hydrometer into the water. Record the specific gravity of the solution on your table. Pure water (0%) is equal to 1.000. Some Hydrometers also give the reading in ppt.
8. Using the Colorimetric Salinity Test Kit, take a sample of each solution and add the appropriate reagents. The water will change colour. Compare the final colour of the solution with the colour chart provided to determine the salinity of the solution. Record on your table.
9. Plot the data on a graph (conductivity vs. concentration; specific gravity vs. concentration; ppt vs. concentration, colour change vs concentration).
10. Determine the salinity of some unknown samples. Students could even bring in samples of water from their homes and the surrounding area.

Discuss the pros and cons of each method used in the activity and how the results for each solution compare among the different methods used.

Further Information / Resources

Equipment for activities:

- *A conductivity meter, hydrometer and other equipment, information or assistance may be sourced from your local Waterwatch co-ordinator, or your school or local high school may already participate in this program. To find them, go to www.waterwatch.org.au and click on "who to contact" – and follow your state's links. Further information on conductivity meters, their use and calibration can be found in the Waterwatch online library resources.*
- *Colorimetric Salinity Test Kits and hydrometers may also be sourced from aquarium shops. Hydrometers are also used in brewing beer and can be found in Homebrew supplies shops.*
- *Pure (distilled) water may be able to be obtained (by distillation) from your high school science lab or from the supermarket (it is used for ironing and car radiators), or at a stretch you can collect and use rainwater (however the latter may have other impurities in it).*

Environment Australia has information on all aspects of inland waters in Australia including water quality, water policy and water management at www.ea.gov.au/water/index.html

The Australian Drinking Water Guidelines www.health.gov.au/nhmrc/publications/synopses/eh19syn.htm provides the Australian community and the water supply industry with guidance on what constitutes good quality drinking water.

UN International Year of Freshwater official Website is at www.unesco.org/water/iyfw/ Educational material for schools, videotapes and documentaries, are being developed and a link will be made to these resources when available.

Chapter 2 Where do we find Freshwater?

Where does freshwater come from? Water moves in a "cycle", and the main source of freshwater is from precipitation, usually rainfall. We most commonly find freshwater in rivers, streams, lakes, rainwater tanks, pools and underground in aquifers and caves. Humans pipe and pump water from these sources to use more readily.

Science

The sun drives the water cycle. It begins with the evaporation of water, primarily from the sun heating the surface of the ocean. As the water vapour rises, it cools and condenses into moisture droplets to form clouds. It is then transported around the globe as clouds until it returns to the surface as precipitation (rain, hail, snow etc.). Precipitation occurs when the droplets cool and merge and become too heavy to stay in the atmosphere.

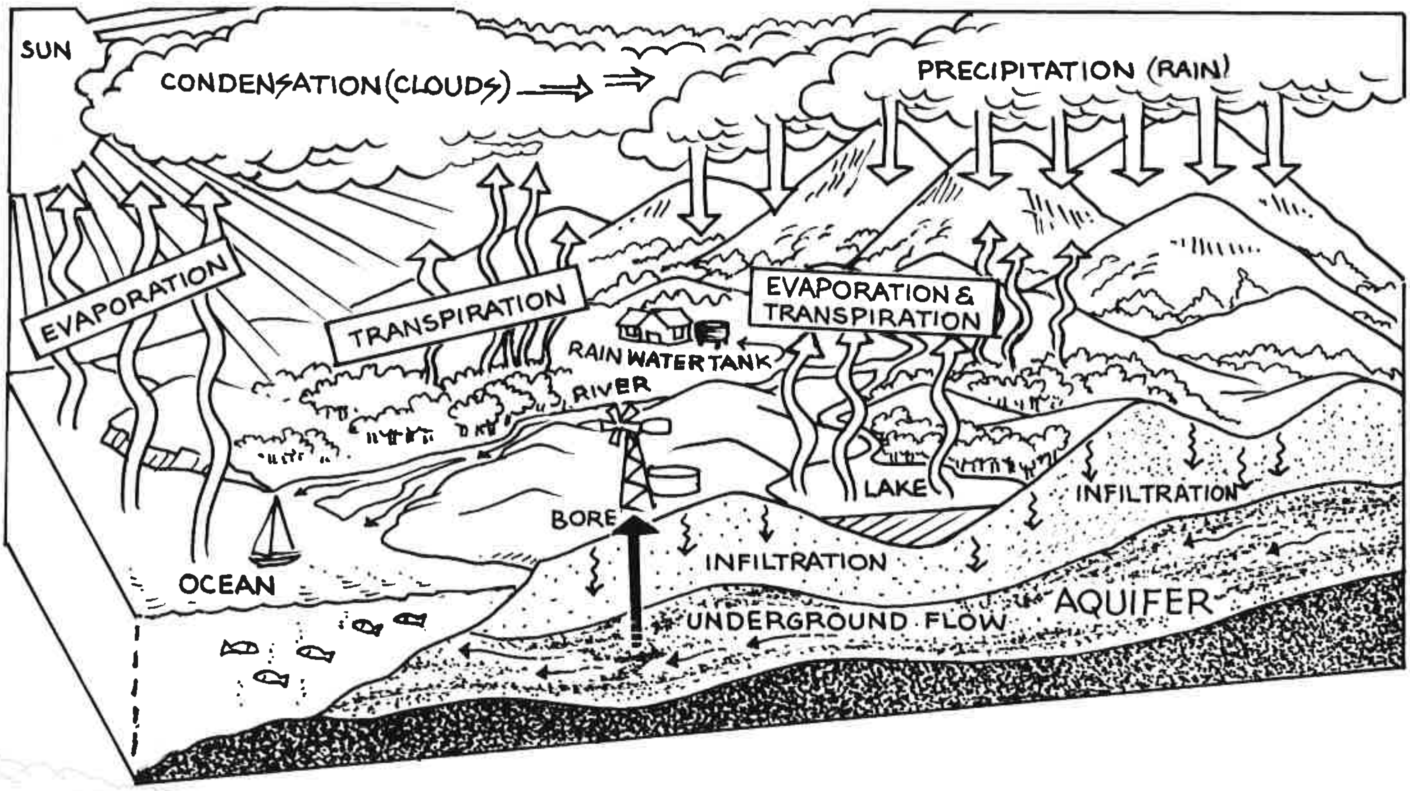
Once the water reaches the ground, several things may happen to it. Some of the water may evaporate back into the atmosphere. The water may penetrate the surface and become groundwater. This water either percolates down into aquifers where it slowly seeps back into the oceans, rivers, and streams, is released via springs and bores, or is released back into the atmosphere through transpiration (evaporation from plants). Rainwater tanks will capture some water. The balance of water that remains on the earth's surface is runoff, which flows into lakes, rivers and streams and is carried back to the oceans, where the cycle begins again. The area that is drained by a particular river system is known as a catchment.

Water moves through the various stages at different rates, with some (eg. atmosphere ~10 days) being very fast while others (deep groundwater ~ 10,000 years) can be very slow. Thus water is continually replenished by the water cycle, but the rate varies according to the climate, land practices, water usage etc.

For example, forests have an important role to play in regulating the flow of water through the landscape, acting like a leaky sponge and thus providing a source of water to rivers and streams during the drier seasons, and also harvesting large volumes of moisture from clouds additional to rainfall. This does not occur to the same extent where the forest has been cleared and replaced by grassland. Mountain Forests at www.mountains2002.org/i-forests.html provides more information on this topic.

Scene Setting

- Identify where the different phases (solid, liquid, gas) of water occurs within the water cycle.
- What catchment do you live in?
  Which catchment does your water come from?
  Which catchment does your waste water flow into?
  HINT: your state Waterwatch web page might have the answer
- What is the largest river in your state?
  How does it compare to rivers in other states?
  Does it exist completely in your state or does it originate or continue into another state?
  How does it compare to rivers on other continents? *(e.g. Nile, Amazon, Rhine, Danube, Ganges, Yangtze).*
- How many rivers/lakes can you name in your state?
  Describe one of them.
  Investigate the largest lakes on each continent, and describe using similar criteria.



Challenges

- The "***Water Cycle Adventure***" is a 10 minute theatre script (with up to 19 characters) suitable for K-3 available at www.enchantedlearning.com/rt/weather
  This page also has other weather related activities (including weather rhymes) that young students can undertake.

- Build 2D or 3D models of the water cycle using modelling clay, paper, glue, paints etc.
  Models can be presented as diagrams, posters, mobiles, diorama's etc.

- Build a model of a catchment using a sand pit (or tarp with sand), sticks, plastic farm animals, toy trucks, lego, blocks etc.
  *A full description of this activity can be found in the AWA **We All Use Water** Presenter's Manual (see Page 20 for details).*

- Freshwater can be "manufactured" from seawater (or muddy water) by desalination – explore different methods of desalination and perhaps even try some.
  HINT: there are many methods out there but they fall into two main groups, evaporation / condensation and reverse osmosis. See glossary for definitions.

Activities

- Put a drop of water on a table. What happens after a while? *(evaporates)*.

- Evaporation is a process by which water turns from liquid to gas, and condensation is the reverse. Place an empty bottle in the freezer for half an hour. Remove and put a quarter of a teaspoon of water in. Screw on the cap and leave in warm place for about 1 hr. The water should disappear.
  Why? (Evaporation)
  What will happen when the bottle cools? (Condensation)
  If this doesn't work then use a smaller quantity of water and warmer conditions.

- Heat a pot of water (representing the ocean) on a stove. When the water is boiling and evaporating, hold a tray of ice cubes (representing cool air in the upper atmosphere) over the steam. Water will condense on the bottom of the tray and form droplets. If done long enough the drops of water will get bigger and fall, like rain.

> **Safety Warning:** Use potholders to protect your hands from the steam. Young children will need this demonstrated by an adult, while older students may be able to do this activity under supervision.

- Condenser apparatus (senior secondary laboratories) can be used to demonstrate an artificial water cycle (evaporation and condensation) and explore the process of desalination. Obtain some seawater and produce freshwater.
  Discuss what else a condenser can be used for
  (e.g. extracting oil from Eucalyptus leaves).

When the water evaporates from the ocean it is pure. However small particles in the atmosphere are trapped in rain, such as dust, smog, and salt. So the rain that falls isn't pure water, but it is more pure than the ocean.

- Collect some rainwater, tap water, mineral water etc. and put the same amount (approx ¼ cup) of each into a glass *(the less water the faster it will evaporate but the less residue will remain).*
- Sit the glasses on a windowsill in the sun and let the liquid evaporate. Compare the amounts of residue left.
- If you have access to a microscope, examine the residue under it and observe different particles (dust, salt etc.).
- To expand the experiment, find a school in an area that has hard water (if you have soft, or vice versa) and organise to swap samples of tap water for each class to test.

Further Information / Resources

*There are two activities on forming clouds on page 33 of Volume 19, No. 5 (2002) of the Science Teachers Association of Victoria's magazine **Lets Find Out**. ASTA may assist with obtaining a copy.*

AWA has an online fact sheet on water sources (Fact sheet #1) at www.awa.asn.au/education

The Bureau of Meteorology has activities to further explore aspects of climate and the weather at www.bom.gov.au/lam/Students_Teachers/learnact.htm It also has information on water resource assessment for both Australia and the world at www.bom.gov.au/hydro/wr/index.shtml

The Queensland Department of Natural Resources and Environment International Year of Freshwater page at www.nrm.qld.gov.au/water/index.html covers topics such as water reform, water planning, water quality, water use efficiency, water recycling and urban water supply. They also have a number of education resources at www.nrm.qld.gov.au/education that include a teaching module on the water cycle, written to address aspects of the Queensland curriculum.

Chapter 3 Is Freshwater Reliable?

Can we rely on always having freshwater available to us? Australia has long been known as a land of highly variable and extreme climatic conditions, as the poet Dorothea Mackellar put it, ***a land of drought and flooding rains****. From long and destructive droughts to sudden and pervading flooding, Australia's agriculture — as well as its natural environment — is often at the mercy of what the skies deliver. Freshwater distribution in Australia is also very uneven, with water being plentiful in the tropical north and Tasmania, and around the margins of the continent and very little water inland. But why is it like this?*

Science

Australia is often described as the "driest inhabited continent" (Antarctica is the driest continent but is often considered uninhabited, which isn't strictly true) and has low average annual rainfall and high water loss through evaporation. Australia owes its climatic conditions to its geographic location (in the mid-latitude, high-pressure belt of the Southern Hemisphere) and also to its low topographic relief (only 2% of the land is above 1000m) or lack of high mountains.

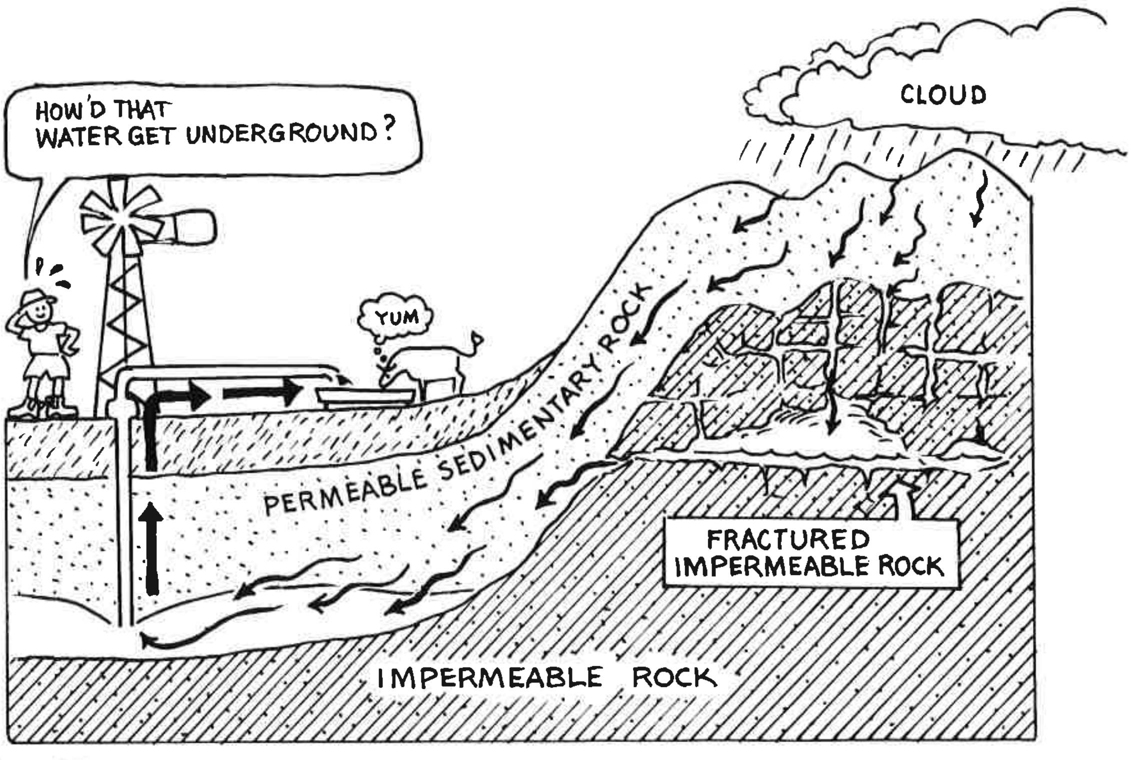
Rainfall is distributed unevenly across Australia. Over three quarters of the land area of Australia runoff is limited to less than 5% of the rain that falls to the surface. Northern Australia has the lowest population but the highest rainfall as it lies in the tropical zone, with a monsoonal wet/dry season (rain falls in December – March). Warm water rising from the Pacific Ocean falls along the East Coast, with the Great Diving Range preventing much of it travelling further inland. Southern Australia lies in the temperate zone and has a Mediterranean climate, with most of its rain falling in June – August and coming from the Southern Ocean. The south-west corner of Western Australia and Tasmania receive the highest rainfall in Southern Australia.

Average rainfall for Australia is approximately 470mm per year but, due to high evaporation rates, only 12% runs off to collect in rivers. Much of the interior receives less than 300mm per year. Flows in Australian streams and rivers are nearly three times more variable than the world average, particularly those in the arid zone. Some rivers even dry up in the summer months. To deal with this seasonal variability, we have built dams and weirs to capture the winter rains so that we can make the water source more reliable, releasing the water when we need it in the hot, dry summer. This has also helped us control, to some extent, floods that would otherwise damage houses and property.

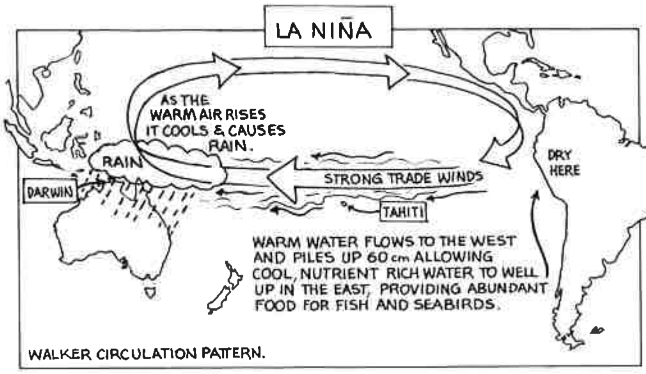
Another more dependable source of water in Australia is found underground. Water soaks through the soil and into rock aquifers where it is trapped. Groundwater is an important water resource in inland Australia because it is more reliable and less prone to evaporation than the sparse surface waters. However the quality is variable, with a high proportion of groundwater having a highly saline content.

Some ground water is not fit for drinking due to the nature of the aquifer in which it is contained, but in some cases it can still be used for mining and other activities. This water resource enabled European settlement to spread into the arid interior of Australia. It is not unlimited, it just has a much longer residence time in the ground. Currently there is a project to cap wasted water for the Great Artesian Basin (90% extracted is used for agriculture and 90% of that is wasted to evaporation), as recharge is not as quick as our use.

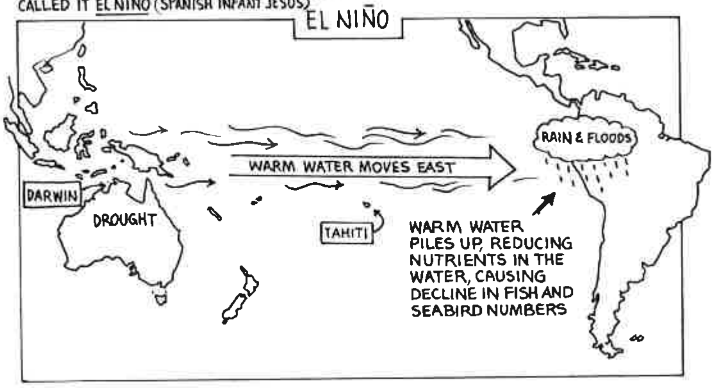
This doesn't tell us why rainfall in Australia is so variable. Australia (together with Southern Africa) experiences higher rainfall variability from year to year than any other continental area. What causes this? The words Southern Oscillation and El Niño are now commonly used when we speak about weather. But what do they mean and how do they affect our weather?



WHEN THIS WEATHER PATTERN IS VERY STRONG FLOODING OCCURS IN AUSTRALIA AND IT IS KNOWN AS LA NIÑA (SPANISH FOR LITTLE GIRL)



THE WARM CURRENT ARRIVES AT PERU AROUND CHRISTMAS TIME, SO THE LOCAL FISHERMEN CALLED IT EL NIÑO (SPANISH INFANT JESUS)



Usually the warm west Pacific Ocean (adjacent to the eastern side of Australia) is a high rainfall area while across the other side of the ocean next to South America is an area of low rainfall. However occasionally (every 5-8 years) this gradient weakens, due to changes in the sea surface temperature. A change of only 1-2°C is all that is needed to change the weather pattern. This change causes a change in air pressure. The Southern Oscillation Index (SOI) is the difference in air pressure between the central Pacific (Tahiti) and Indian (Darwin) oceans and is used to predict climate change. This is a dynamic system. When the SOI is strongly negative it is known as El Nino and results in below average rainfall (i.e. drought) in northern and eastern Australia (and India) and above average rainfall (i.e. flooding) in South America. La Nina is when the SOI is strongly positive, and results in the opposite, with flooding in Australia.

The term "Seasonal Climate Outlook" refers to what the weather was, is, is-likely-to-be for a particular season. It is based on the Southern Oscillation Index (SOI). Sea-Surface Temperature (SST) patterns in the Pacific Ocean are also important in driving climate variability and are useful guides to potential climate patterns in Australia (and other parts of the world too). Being able to predict the climate, and manage the risks and opportunities the season may bring, helps farmers make better decisions about when to plant etc. and assists Australian agriculture in becoming more sustainable. The Climate Variability in Agriculture R&D Program (CVAP) is a national program that addresses these issues (see resources for more details).

Scene Setting

- Are there any aquifers near you?Does your drinking water come from an aquifer?
- How do we extract water from underground?
  HINT: the iconic Australian windmill has something to do with this, as does the fact that some aquifers are under pressure.
- Describe some of the climatic disturbances and resulting effects believed to have been caused by the most recent El Nino event.
  HINT: 2002/03 is considered to be an El Nino year.

Challenges

- Go to the **Ocean Surface Topography from Space** site at topex-www.jpl.nasa.gov/science/el-nino.html and find out how the Topex-Poseidon satellites are used to measure sea surface temperature and how scientists use this to predict El Nino events.
  There are many educational activities at this site, including a recipe for El Nino pudding!
- Research the different types of aquifers and how much water can be stored in, and recovered from each.
  HINT: surficial aquifers = clay, silt, sand, gravel; sedimentary aquifers = porous sandstones and limestones; and fractured aquifers = impervious rocks that are fractured and faulted and thus have space to store water in the gaps.
  Develop a way of constructing and testing different types of aquifers.
- The Great Artesian Basin (GAB) is the largest aquifer in Australia, covering approximately one fifth of the land mass, and has enabled us to undertake agricultural activities in the otherwise arid interior.
  Find out more about this resource.
  Hint, the GAB consultative committee has both general and technical resources that may help at www.gab.org.au)

Activities

Do rocks absorb water?

Different types of rocks are formed in different ways. Each type of rock has a different set of properties. One property is its porosity. This is the ability of the rock to absorb water. Water is held in rocks under the ground. The more porous the rock the more water it can hold.

- Collect two different types of rock *(eg granite, chalk, limestone, sandstone, house-brick)*. Weigh them. Place them in a bowl of shallow water and leave for 30 minutes.
- Take them out and compare by weight, and by looking at how far the water has moved up each rock (or how much water is left in the dish).
  Is one rock more porous than another?
- Find out how we extract water from rocks.

Weather activities

- Measure the daily weather conditions at your school. Make (or buy) a rain gauge and attach it somewhere near the classroom. Obtain a thermometer and include temperature measurements.
  How might you measure evaporation rates?
  Chart your results. Find a school in a different area with which to compare your weather observations.
- Research areas of high and low rainfall, and high and low temperature around Australia by collating and analysing weather maps from the newspaper.
- Find out about indigenous weather knowledge and seasonal calendars based on local sequences of natural events.
  The site www.bom.gov.au/iwk/ will assist this project.

Map the Water Resources of Australia

Geoscience Australia has a useful resource that you can use to make a map of the surface water resources near you, or for the whole of Australia. Log in to www.ga.gov.au/ and go to "Online Mapping". Then select the Maps and Images of Australia page. Select "Make Your Own Map of Australia". Then Select "National Geoscience Datasets Online GIS" and then "Quick Start". This will produce a map of Australia with a number of themes that can be turned on (including geology, roads, population centres, lakes and rivers) and can be zoomed in to the area where you live. There is also a project just on the Murray Darling Basin that can be viewed and explored.

> Did you know that satellite photos are being used to provide data and mapping of floods to provide environmental flows for wetlands in the Murray Darling Basin?

The National Land and Water Resources Audit www.nlwra.gov.au provides access to the Australian National Resources Atlas which can also be used to make a map of the water resources of Australia, and provides plenty of detailed information on the location, availability, allocation, management and use of both our surface and groundwater resources.

Further Information / Resources

EdNA for Schools has an online theme page at www.edna.edu.au/schools/themes/water.html for the International Year of Freshwater. This provides links to many resources including further information on various freshwater topics, lesson plans, and online projects.

Project Atmosphere Australia at www.schools.ash.org.au/paa1/cwabook/ have produced an online education resource ***General Meteorology: Climate, Weather and Agriculture Teacher's Guide****. It contains information and activities in relation to how climate affects agriculture and is designed to assist students to be better able to:*

- *examine the fundamental concepts of climate, weather and agriculture*
- *monitor and evaluate unique climate and weather features of an agricultural system*
- *identify the atmospheric characteristics that harm and help agricultural systems*
- *investigate work in their community involving the use of science*
- *explore the social, technological and environmental impact or speculate about the impact of a scientific application.*

The website www.dnr.qld.gov.au/longpdk, is provided by the Queensland Government - Climate Impacts and Natural Resource System group. ***The Long Paddock*** *supplies decision-support information services to help people better manage climatic risks and opportunities particularly those associated with the El Niño - Southern Oscillation (ENSO) phenomenon. It contains the most recent map (under Climate Forecast - Australia) of the probability of exceeding median rainfall for Australia as well as products used to predict rainfall - Australian Rainman (QDPI), Rainfall and El Niño Poster, HowWet, HowOften, Meteorological data - SILO, Vegetation mapping - SLATS, Queensland Climate Diary. It also has links to the Queensland Centre for Climate Applications (QCCA).*

Climate Variability in Agriculture R&D Program (CVAP) is a national program targeting the Australian agricultural sector. The program goal is to prepare the agricultural sector to respond to the major opportunities and risks arising from climate variability. www.cvap.gov.au has a list of fact sheets on a variety of different topics and about 20 case studies that were developed as part of the Masters of the Climate Competition. They are a resource to assist researchers, landholders and the media better understand how landholders are using climate information to manage land resources.

The ABC's Science Lab has information on El Nino, at www.abc.net.au/science/slab/elnino/story.htm Quantum screened ***El Niño - The Boy Child*** *on ABCTV on 16 October 1997.*

The Australian Water Association has an online fact sheet on groundwater (Fact sheet #3) at www.awa.asn.au/education

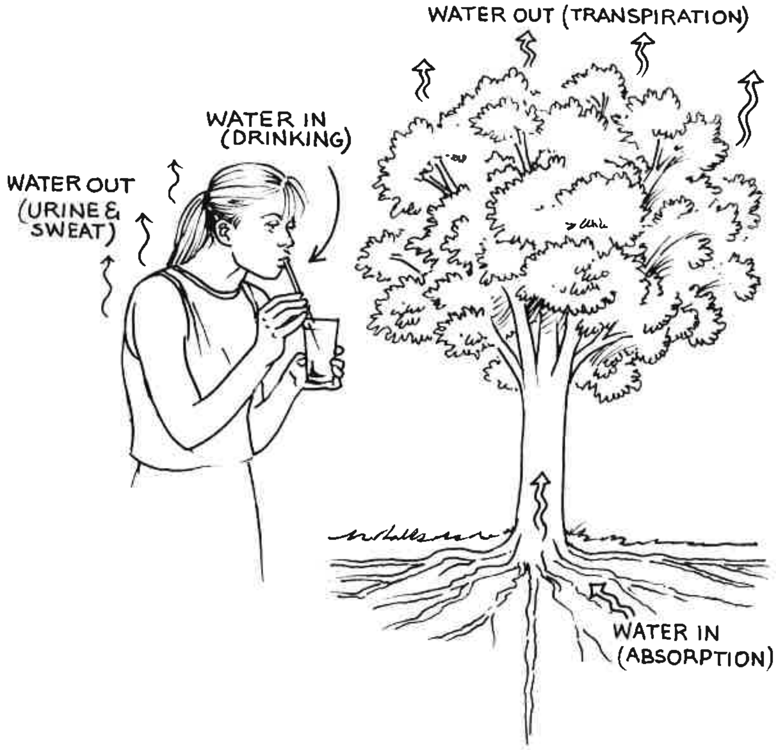
The Bureau of Meteorology's website has many activities to explore the weather (see resources p.9) including a site on ***indigenous weather knowledge*** *at www.bom.gov.au/iwk/*

Chapter 4 What uses Freshwater?
Nature's use of Freshwater

Animals and plants, landscapes and wetlands need clean water too. The possible negative impact of human activity on the environment should be considered when managing water resources in a sustainable way. It is not enough to draw water from nature for use in agriculture, industry, electricity production, and everyday life without also taking account of nature's needs. Wastewater should be recycled so that pollution is minimized. Special areas like wetlands, which play an important part in supporting the delicate and complex food chain of many birds and fish, may require protection from our activities. Human beings should learn to respect the resource base on which life ultimately depends and to see land and water as two sides of the same coin. For this reason, decisions should be made at catchment level, when possible.

Science – living things need water

We all know that water is necessary for life. All living things, organisms, are made up of large amounts of water and need to keep that amount in balance. This means frequently taking in water to replace the water that is lost so that the living organisms can continue to live and grow. Water is also habitat for organisms such as fish, aquatic insect larvae and algae.



Scene setting

This diagram may provide inspiration to answer some of these questions:

- What would happen if there was not enough water for living things?
- What do the roots of a plant do?
  HINT: support, absorb water and minerals – but remember plants don't use their roots to obtain food.
  What do you think would happen if a plant's roots were damaged or removed?
  How would you test this?
- What do plants use water for, apart from replacing what they lose?
  Photosynthesis, transport of nutrients and minerals from the soil, making up the cell structure and shape (= turgidity).
- How does the human body use water?
  This could lead to investigating nutrition (dissolving minerals, etc), temperature control or cellular processes.

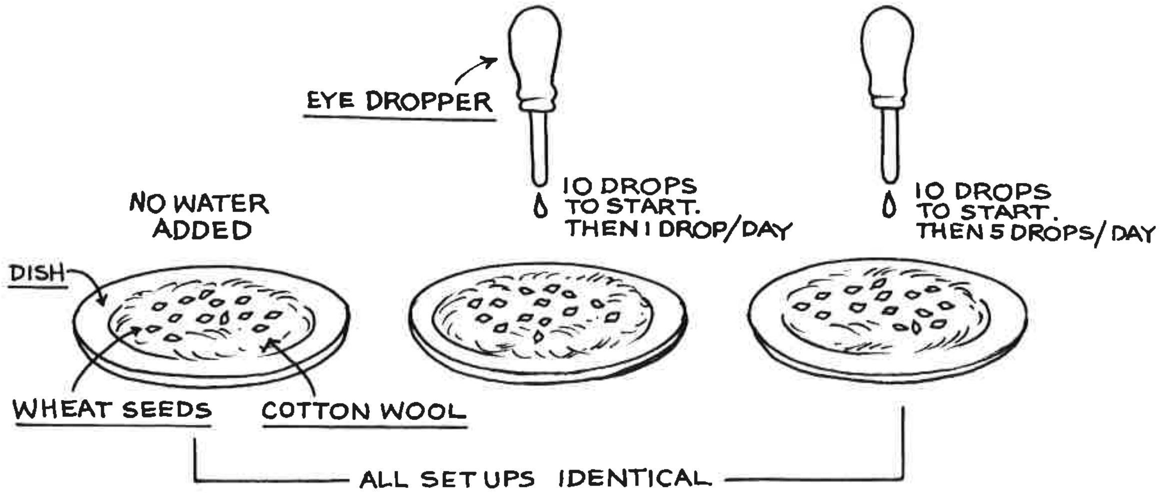
Challenges

- What happens if a plant doesn't get the water it needs?
  Do different species of plants have different water requirements?
  How would you investigate this?
- What would happen if plants received different levels of salty water rather than freshwater?
  Again, you can compare the tolerance of different species of plants to salinity levels.
  What criteria can be used to assess the results?

Activities
How do plants use water?

- Using a nearby tree or pot plant, secure a clear plastic bag around one leaf and leave in a cool but sunny place. What happens? *Water droplets appear in bag, transpiration.*
  Repeat on plants located in different conditions. Compare your results.
- What might happen if the roots of a plant are removed? *The roots not only anchor plants to ground but also absorb water, without them they die.*
  Design an experiment to explore this.
- Reduce the amount of water you apply to some plants by half, quarter, none. What happens?
  Plants may not grow as well, or may die.

Streams Alive is a resource for Years 5-6 students produced by Sydney Water Streamwatch and linked to the NSW Curriculum. For an electronic copy visit www.streamwatch.org.au and go to the Electronic Library. For a hard copy telephone (02) 9952 0358.



Devise an experiment to test a plant's water needs to get seeds to germinate. Above is one example:

- Why are the dishes in the experiments identical, except for the amount of water?
  Teachers can discuss "Controlled Experiments" here.
- Set up an **identical** experiment except try using water of different salinities to germinate the seeds.
  Discuss your results.

How does water moves through plants?

This experiment is detailed fully in ***Streams Alive*** – see Page 13.

- Get four stalks of celery, each with leaves, and four white flowers with stalks (eg carnations, daisies)
- Fill four glasses with water. Using food colouring (red or blue) dye two glasses a deep colour.
- Put a stalk of celery in each glass and a flower. Leave for 24 hours. Observe and explain the results.
  What is your control in this experiment?

Science

Aquatic Organisms that depend on Freshwater

Water bodies (streams, rivers, lakes etc.) are filled with a variety of freshwater life, both plant and animal, and from the microscopic (unable to be seen by the naked eye) to the macroscopic. These animals are totally dependent on, and adapted to the water in which they live. There are also huge numbers of animals and plants that, while not living in these water bodies, are dependent on them for their food (birds, river red gums, etc.).

Aquatic plants and animals cope with, and are adapted to, the physical and chemical conditions of the water body in which they live over a long time. Different organisms have different tolerances to pollution, and changes in physical and chemical conditions of their environment. Some of these are known as indicator species. Scientists, water managers and others can sample what aquatic life is present in a water body and use their presence or absence to tell them how healthy the water body is.

Naturally, aquatic animals and plants are adapted to, and need all the water the environment provides, in its natural variability. Any water we take for our use affects and changes the environment to which the aquatic animals are adapted. Environmental flows (water for the environmental needs of the river) and environmental water allocation (ensuring water is allocated for the various stakeholders in the catchment) is one way of ensuring that our natural water bodies stay healthy.

Healthy River Flows – a balancing act is a 15-minute video presented by Dr. Karl Kruszelnicki and provides an informative overview on environmental flow allocation. It includes interviews with freshwater ecologists, water managers, farmers, community educators and industrial users.

To obtain a copy, check with your local resource centre or contact the Department of Primary Industries, Water and Environment, GPO Box 44, Hobart, Tas 7001. Information on Tasmania's freshwater resources and ecosystems can be obtained from www.dpiwe.tas.gov.au/water

Scene Setting

- What animal life relies on your local waterway?
  Is there any threat to it?
- How might our activities affect animals that live in freshwater?
  What can we do about it?
- Investigate pollution prevention programs in your area?
  e.g. Keep Australia Beautiful, Cigarette Butt prevention, Labelling stormwater drains etc.
  Devise a program of your own?
- Discuss how humans need places to live and work, but there must be a balance between human needs and the needs of animals and plants. Sometimes wetlands are reclaimed for development (farming, building houses etc.), which results in the loss of habitat (places animals and plants need to live, feed and reproduce).

Science

Identifying Aquatic Animals

Taxonomy is the science of differentiating between organisms, by carefully collecting and describing the different features of a species of plant or animal, and then comparing it to other organisms. Scientists use keys to identify the plants and animals they find. Keys are a tool with the clues you need to identify an animal or plant you don't know. Each step asks a question that separates organisms into different groups.

Keys come in a variety of shapes and sizes. You can use books, diagrams, posters, CD-Roms, and the internet to identify animals (see **Resources** below). We also use pictures to identify – "does it look similar to or different from this?" This uses the principle of compare and contrast.

Activities

Be an animal detective

Get a collection of pictures of different organisms and using observation skills to identify what is similar and what is different construct a key to differentiate just these organisms.

Here is a sample key for some aquatic animals, specifically a worm, a true bug, a larval dragonfly, a larval damselfly, a larval mayfly, and a crayfish. Remember, if your organism is not in this group, you cannot use this key to identify it:

1. Does it have legs? If it does, go to 2, if not then it is a **worm.**
2. Does it have six legs? If it does, go to 3. If the animal has 10 legs it is a **crayfish** or **yabby**.
3. The animal is an insect. Does it have hard forewings covering its body? If it does it is a **true bug**. If it does not, then go to 4.
4. The insect has no wings. Does the insect have any tails? If it does, go to 5. If it does not then it is a **larval dragonfly**.
5. The insect has three tails. If the tails are thick it is a **larval damselfly**, if they are thin it is a **mayfly.**

NOTE: In reality, there is a greater variety of animals that live in a water body and you would need a more complex key that would include them all.

What lives in that water body?

Waterwatch is a program that enables schools and community groups to participate in this activity and monitor the condition of many streams, rivers, lakes and other aquatic habitats around Australia. Your school may already participate in this program. If it does, utilise this program to go and find out what is living in your local water body. If not, your local Waterwatch co-ordinator can be contacted (contact details can be found at www.waterwatch.org.au) and may be able to provide assistance and resources.

Simple instructions are given on the ***Waterbug Detective Guide*** insert in the middle of this book. ***Streams Alive*** Sydney Water Streamwatch resource book (see Page 13 for details) has detailed class activities to help students become familiar with and develop an understanding of the needs of freshwater bugs living in our local waterways. Queensland Waterwatch has a more detailed "how to" page for water bug surveys at www.qld.waterwatch.org.au/resources/waterbug_survey.html See resources to identify the animals and plants collected.

- Get students to wade in and shuffle the net backward and forward in the water. Try sampling different areas such as near water plants, in the open water or adjacent to logs.

> **Safety warning:** check the depth of the water and any current present before allowing students to enter the water body.

- Tip the contents, into a light coloured tray containing some water. Identify the aquatic life you have captured using the identification resources.
- Record how many different animals were found. Some groups of aquatic bugs are more sensitive than others to pollution. What does their presence tell us about the condition of the water body that has been sampled?
  HINT: see the Waterbug Detective Guide insert in the middle of this book for guidance.
- Look for aquatic plants, examine their growth habitat *floating attached, floating unattached, on rocks, emerging out of the water or submerged etc.*
  If microscopes are available, you can examine samples of water more closely. If you have used fine mesh in your nets, look at the micro-invertebrates *(invertebrates too small to be seen with the naked eye)*, algae etc.
- Look for signs that larger creatures have been using the water source. Record large animals too.

Remember to act responsibly and not disturb the natural environment too much. At the end of the exercise, return all the creatures and water plants to their habitat.

Resources

Waterbug Identification

Try **Investigating Science in the Bush** (ASTA National Science Week, 2002) activity p.31 and **Exploring Biodiversity** (ASTA, 2001) activity p.23

Wonga Wetlands, an educational wetlands near the city of Albury, NSW has online information about much of the animals and plants found in the wetlands at www.wongawetlands.nsw.gov.au

***The Waterbug Book** – by J. Gooderham and E. Tsyrlin has information on all the freshwater macro-invertebrates of temperate Australia, with simple keys and colour pictures. Text is simply written with information on identification, habitat and ecology, and other quirky facts. Available from CSIRO publishing – phone (03) 9662 7666 or www.publish.csiro.au or check with your local bookshop.*

The Colour Guide to Invertebrates of Australian Inland Waters *(1997) by J. Hawking and F. Smith is a field guide with 200 colour photos of the more easily recognisable invertebrates found in Australian inland waters. Your local Waterwatch group may have a copy, or you can contact the Co-operative Research Centre for Freshwater Ecology (Ellis St, Thurgoona, NSW 2640 ph (02) 6058 2300) to obtain one.*

Waterplants in Australia *by G. Sainty and S. Jacobs is a colour field guide that contains pictures and information of all the different types of water plants around Australia. It can be obtained by contacting J. Corbett, the distributor for Sainty and Associates on (02) 9981 6879.*

The Gould League (ph (03) 9532 0909 or www.gould.edu.au) has a number of inexpensive books containing simple information on how to study and identify aquatic life, and a range of free classroom activities online. ***Ponding*** *by W. Wallis and C. Smyth has heaps of activities that you can do in your local lake, pond or puddle.* ***Wetlands Wildlife*** *by S. Cowling provides information on organisms associated with all types of inland waters, from mountain streams, swamps, and marshes to farm dams, salt lakes and coastal lagoons. Others include* ***Australian Guide to Pondlife*** *by B. Winters; and* ***Freshwater Invertebrates*** *by R. Miller. There are many other excellent resources that Gould League can make available to you, or that you may already find in the school library.*

Activity

How "fresh" is that water – or how healthy?

Physical and chemical tests can be performed on a water body to determine how fresh (or polluted) it is. Some parameters don't tell us much on their own, while others are very significant. Simple tests such as visual clarity and odour are good non-technical starting points. The **Waterwatch** website contains detailed information on carrying out physical and chemical tests at www.waterwatch.org.au/library/module-4/index.html#download. Your local **Waterwatch** co-ordinator or your local high school laboratory may have equipment and protocols on how to test the following parameters, and what they mean:

- Water temperature (compare to air temperature)
- pH (remember, a pH of 7 is neutral, low pH is acidic and high pH alkaline)
- Visual clarity (Turbidity)
- Dissolved oxygen
- Biological Oxygen Demand (BOD)
- Total dissolved solids / conductivity / salinity
- Nutrients – Nitrates, nitrites, phosphate
- Rainfall
- Discharge – stream velocity, cross section of stream, leading to stream volume.

Before undertaking any of these measurements, research what the different measures might mean.
How are these measurements affected by each other? *(e.g. Temperature affects conductivity & oxygen levels)*

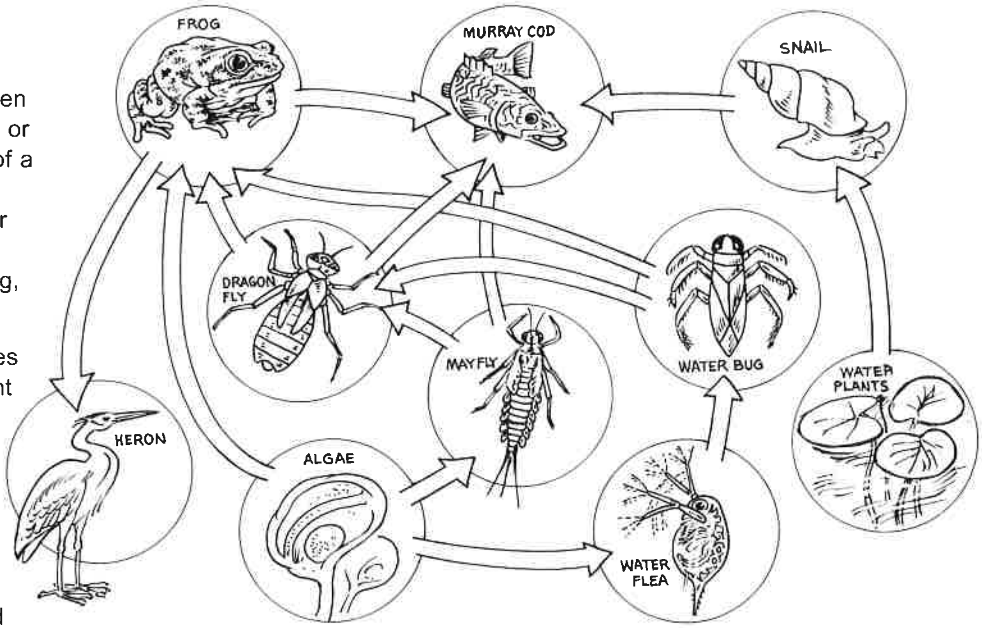
Science
Food Chains and Food Webs

A food chain is the feeding relationship between different animals in a particular environment, or habitat. A plant is nearly always at the start of a food chain and is known as a producer. Consumers are animals that eat producers or other consumers. Arrows always go from organism being eaten to organism consuming, eg producer → first order consumer.

Other terms used in food chains are herbivores (eat only plant material), omnivores (eats plant and animal material), and carnivores (eats only animal material).

For more advanced students, terminology that can be introduced includes detritivores (eats a mixture of leaf litter, woody debris and bodies of dead organisms) shredders (shred coarse debris and plant material), and collectors (or filter feeders – collect fine organic matter).

Food webs are a number of food chains joined together, where organisms may eat or be eaten by more than one other organism.



Activity
Making Food Webs and Food Chains

Assemble various aquatic and wetland organisms (10-20) on cards. You can use the aquatic life discovered in the exercise above or follow the suggestions below.

Arrange the organisms into food chains. Use different colour stars or ribbons to identify them as producers, first consumers, second consumers, third consumers etc. OR herbivores, omnivores and carnivores OR for more complexity, include detritivores, shredders, collectors.

The level of complexity will be dependent on the level of the students. For younger classes, what the organisms eat can be given on the cards, while for older students; their first task could be to find out what they eat and/or what eats them. Use the aquatic invertebrate resources on page 15-16 for further information.

For more advanced classes, the food chains can then be made into food webs, where organisms eat or are eaten by more than one other organism.

Suggested Organisms

- Plant plankton or algae (turns sunlight, water and carbon dioxide into plant tissue)
- Water plant (turns sunlight, water and carbon dioxide into plant leaves)
- Water flea (micro-crustacean that eats plant plankton)
- Water snails (eats water plants)
- Mayfly larvae (eats plant plankton)
- Water beetle larvae (eats water fleas)
- Dragonfly larvae (eats water beetles and mayflies)
- Frog (eats dragonflies and water beetles)
- Heron (bird that eats frogs)
- Murray cod (fish that eats dragonflies, mayflies, water beetles).

Each student could then select one card and either write a story about life from the point of view of this organism, or research its ecology further.

Investigate:

- Where do these insects live?
- What do they eat?
- Does anything else eat them?
- Do they have more than one life stage?
- How long do they live?
- Do they tell us anything about the condition of the water?

Challenges
Habitats Associated with Freshwater

- Investigate how freshwater animals are modified/adapted to their environment? *(E.g. Fish – gills to breathe in water. Dragonflies – two phases to life – in water and out)*
- Find out about the development of a tadpole into frog. How do a tadpoles gills, eyes and tail help it to survive in its environment?
  HINT: consider how they breathe, find food and move.
  What do they eat?
  How do their bodies change as they grow?
  NB Do not remove eggs, tadpoles or frogs from waterways – it is illegal in all states. You may be able to source tadpoles from your local pet shop, who may have a permit to collect them.
- Are there any native aquatic or wetland animals and plants in your area that have had their habitat reduced or that are struggling to survive?
  What might you be able to do to protect them, or their habitat?
  Contact your local Parks and Wildlife office and invite a ranger to come and discuss them with you, or visit your local wetlands. If you don't have local wetlands, go and have a look at Wonga Wetlands online, see p.15 for the address.

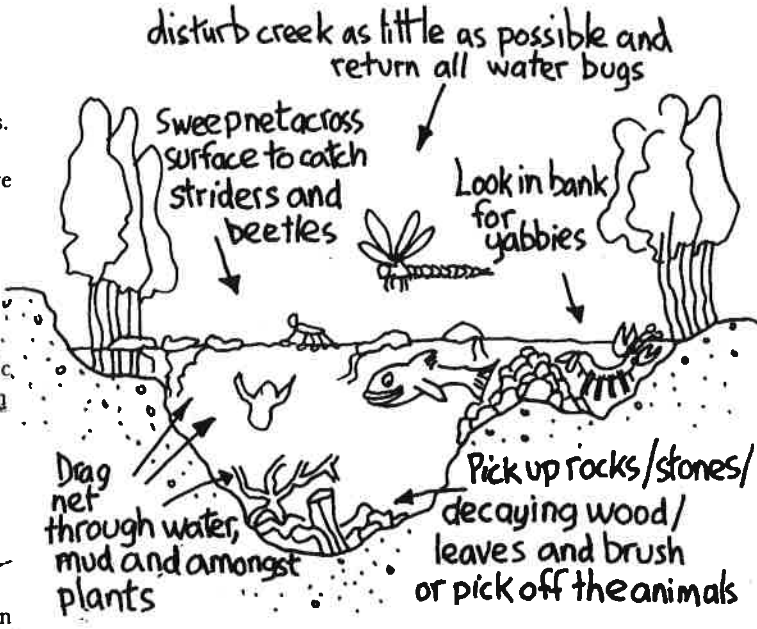
The Streamwatch WATER BUG DETECTIVE GUIDE

Produced by the Water Board (Sydney - Illawarra - Blue Mountains) and CSIRO's Double Helix

Using water bugs to measure water quality

A stream is usually a home for many different types of animals. These include insects, crustaceans, molluscs and worms. They are commonly referred to as water bugs. Scientists have found that the number and variety of water bugs found in a stream can give an indication of the relative levels of water pollution. In other words, by sampling the water bugs in your local stream, you can get an idea about the quality of the water!

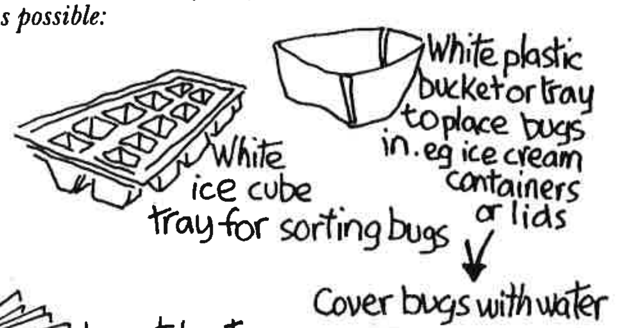
This Water Bug Detective Field Guide is designed to provide you with information on how to collect water bugs, make some basic identifications, and, based on what you've found, work out a Stream Pollution Index for the stream sampled. The higher the Index, the lower the level of pollution, and the healthier the stream.



Collecting Water Bugs

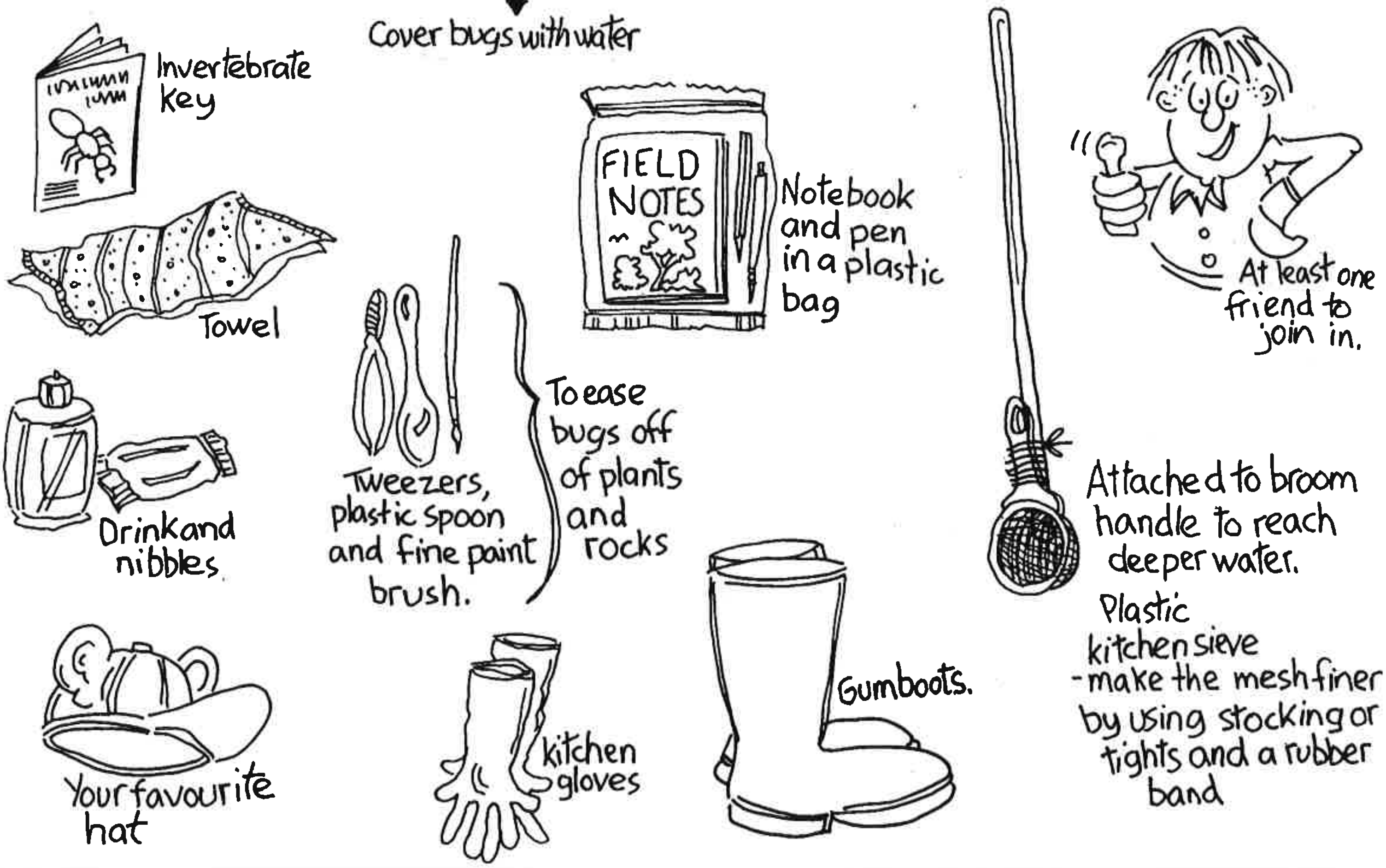
Water bugs live in many different parts of the stream. Some live on the water's surface, some in the water itself, others on or in the bottom of the river or creek, in the surrounding vegetation, or amongst the rocks. The idea is to sample as many of these different 'microhabitats' as possible.

Before setting off on a sampling expedition, assemble as much of the following equipment as possible:



Once you've gathered your equipment, head down to the local stream and try to sample as many of the different stream environments as possible.

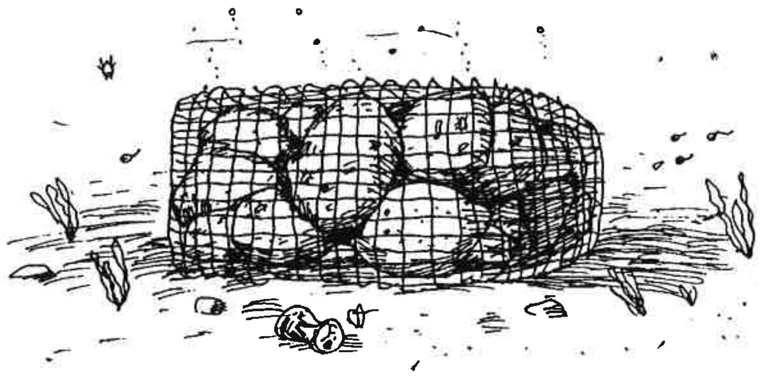
Using your net, strain the water at different depths, including the water surface. Run your net over the surface of the bottom, through the plants growing on the water's edge. Wash larger rocks and stones into the net to remove attached animals. Stir the bottom to a depth of two centimetres for two minutes and run your net through the disturbed sediments.Closely examine rocks and plant for bugs and use your tweesers and brush to transfer them to a collecting container. Examine the banks for yabbies and other life. Even look for their homes – yabby holes or caddisfly cases.



An alternative method is to set up an artificial home made of a wire basket (or a nylon mesh bag) containing rocks and debris, and attach it to the bottom of the stream. After four weeks, which should be sufficient time for bugs to colonise the artificial home, remove the basket and wash all the rocks into a small hand net. Remove the water bugs, and transfer them to a collecting container with water.

Sort the water bugs you've collected into their different types, temporarily storing them in separate compartments of the white ice cube tray. Now, using this Guide (look at the pictures), and any of the invertebrate keys you may have, try to make basic identifications of the bugs you've collected. Record what you've found, and, if you want, make drawings of them.

You don't have to identify the water bugs right down to species. Just determine what kind of water bug they are.



Once you've finished making your records, return the insects you've collected to the stream.

Calculating a Stream Pollution Index

The water bugs listed in this guide are split into four groups depending on how sensitive they are to pollution. The groups are: very sensitive, sensitive, tolerant, and very tolerant. Each water bug also has a number next to it. When you've completed your collection and identification, add the numbers together and you've got a Stream Pollution Index for the part of the stream you've sampled. The higher the total, the cleaner the water.

Pollution Index	Stream Quality Rating
20 or Less	Poor
21-35	Fair
36-50	Good
51 or more	Excellent

Here's an example of how to calculate a Pollution Index from one set of collection results. Note: if you have two or more morphologically distinct (they look different) organisms from the same group, count them separately.

Very Sensitive	Sensitive	Tolerant	Very Tolerant	
Yabbies (7)	Dragon Flies(6)	Leech (3)	Mosquito (1)	
May Flies (7)	Mussels (6)	Beetles (5)	Blood Worm (1)	
	Shrimp (6)	Snails (3)		
Totals				
14 +	18 +	11 +	2	=45

Pollution Index 45 **Stream Quality Rating**: GOOD

Using the Index you can compare your sample site with other sites. You can compare the same site at different times of the year, or with different sites on the same stream, or with different streams.

Keep in mind that the Index is only a rough guide, and its accuracy is very dependant on how well you do your sampling. To make comparisons meaningful, it's important that you use the same sampling technique at each site. It's no good being very thorough at one site, and then not taking the same amount of care at another. It's important that you take the same number of samples, and the same amount of care with each sample.

Water Bug Identification and Ratings

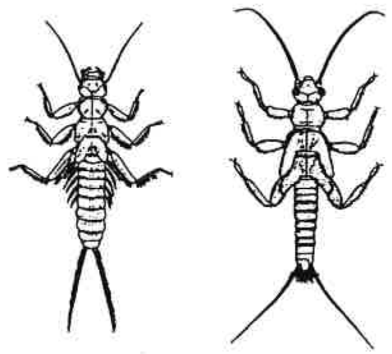
The following pictures and descriptions are of the more common water bugs that are found in most streams. Using this guide and other reference sources, attempt to identify what bugs you've collected.

Pollutions ratings are in square brackets. The higher the number, the more sensitive the animal is to pollution. In other words, water bugs with high numbers usually only occur in healthy streams.

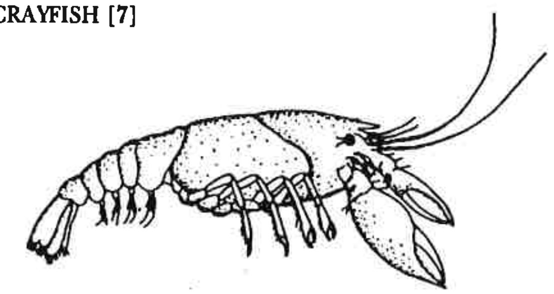
Very Sensitive Water Bugs

STONEFLY NYMPHS [8]

Stonefly nymphs have 2 long tails, tubes of thread like gills on their undersides, wing pads, antennae, and two claws on each foot. Found among stones or plants in clear streams.

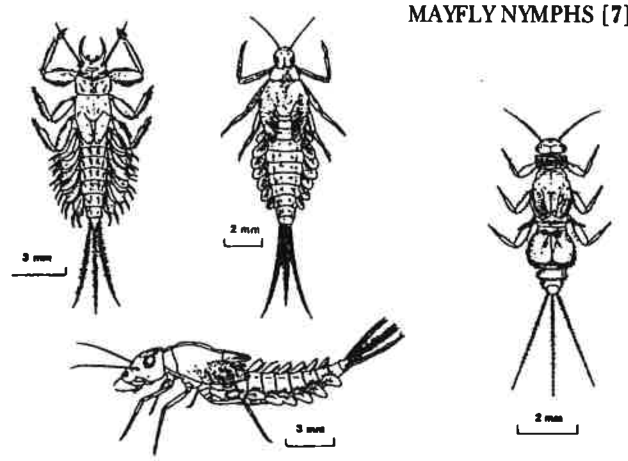


FRESHWATER YABBIE OR CRAYFISH [7]



Strong grasping claw-like forelegs. Grow up to 40cm long. Found in burrows or near rocks on stream banks.

MAYFLY NYMPHS [7]



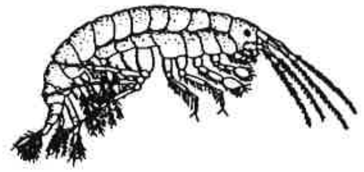
Mayfly nymphs usually have 3 long filaments at the end of their abdomen, with wing pads and lateral gills along abdomen. They have short antennae, and a single claw on each foot. They're found under stones in fast flowing water or among plants in slow flowing water.

Sensitive Water Bugs

FRESHWATER MUSSEL [6]

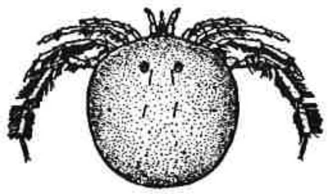
Soft bodied animal. Enclosed in two hinged shells. Found on a stable sandy or muddy bottom.

FRESHWATER SANDHOPPER (AMPHIPOD) [5]



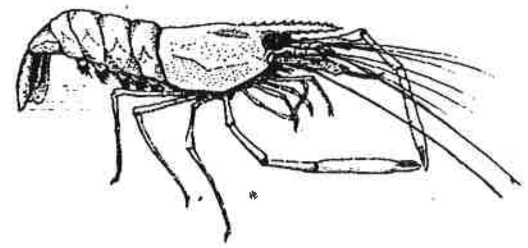
Crustacean less than 3cm long. Flattened from side to side. Free swimming at all levels.

WATER MITE [5]



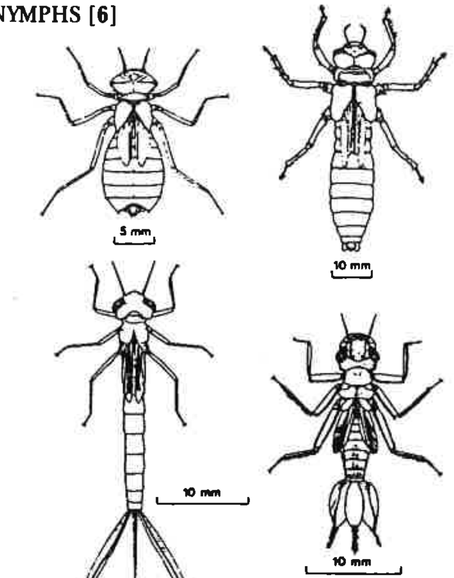
Flat disc-like body. Less than 5mm long Found swimming in water, among plants or on bottom of slowly flowing water.

FRESHWATER SHRIMP [6]



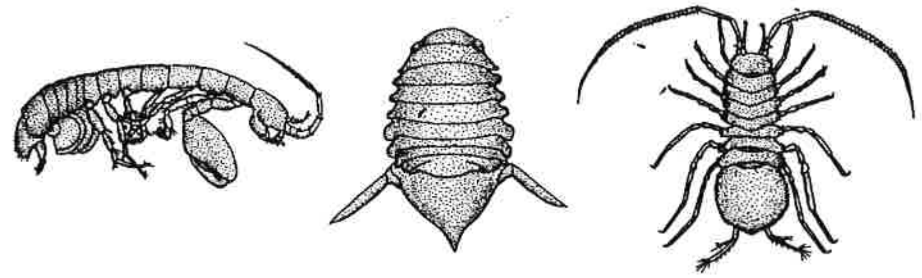
Small crustacean with slender legs and claws found among aquatic plants and loose stones.

DRAGONFLY OR DAMSELFLY NYMPHS [6]



Dragonfly nymphs are short, chunky predators with wingpads and internal gills. Damselfly nymphs are more slender, and have 3 tail like gills on the tail tip. Both have mouth parts and extendable jaws. They are found on plants, among stones, leaf litter or on the bottom.

FRESHWATER SLATER (ISOPOD) [5]



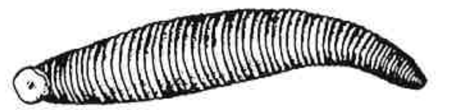
A variety of different shaped free swimming crustaceans. Generally flattened top to bottom — slater like.

CADDISFLY LARVAE [6]

Worm-like insect larvae with 3 pairs of legs on the 1st three segments and possibly stumps on last segment. Some are found in cases such as in leaves, twigs, cemented stones or cone-shaped webs.

Tolerant Water Bugs

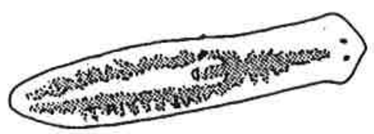
LEECH [3]



Segmented worm with a sucker on one or both ends. Found in water column, on plants in both the water and on land, or on bottom of stream.

FLAT WORM [3]

Small flattened worm like creatures with 2 eye spots. They move in a gliding fashion. Found among loose stones.



SNAILS [3]

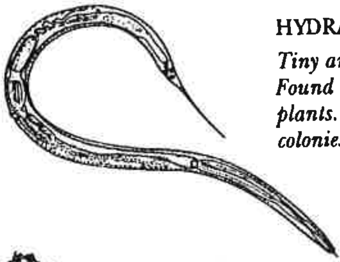
Soft bodied animals with a coiled shell. Found on plants and on rocks.

The Streamwatch WATER BUG DETECTIVE GUIDE

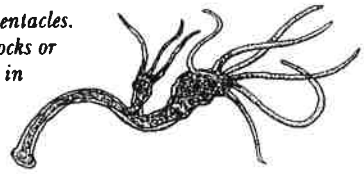
Produced by the Water Board (Sydney - Illawarra - Blue Mountains) and CSIRO's Double Helix

Tolerant Water Bugs Continued

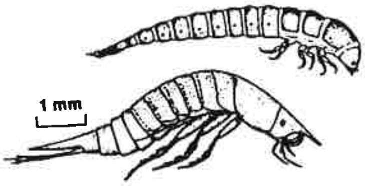
NEMATODES [4]
Thread like worm less than 1cm long, tapering to a fine point at one end. Moves in a whip-like fashion.

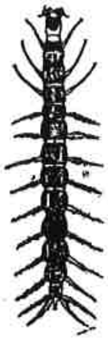


HYDRA [4]
Tiny animals with tentacles. Found attached to rocks or plants. Often found in colonies.

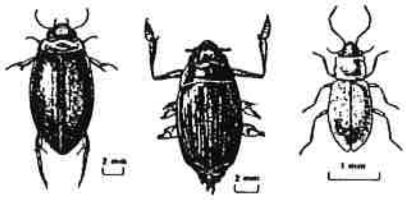


BEETLE LARVAE (COLEOPTERA) [4]
Segmented insect larvae (never found in cases). Very active, aggressive predators. Found in a wide variety of forms and habitats.

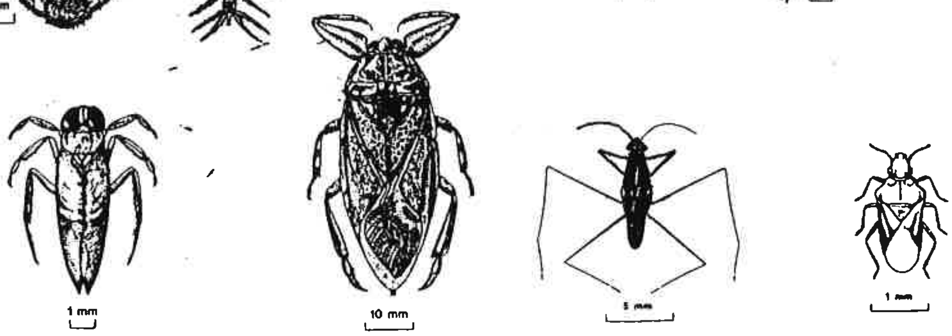




BEETLES — (COLEOPTERA) [3]
Insects with hard front wings. Folded side by side along the centre of the back. Found swimming in or on the water at all levels or on plants.

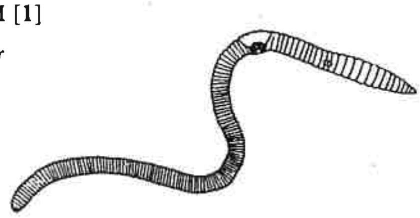


TRUE BUGS (HEMIPTERA) [4]
Front wings are folded, soft and overlapping leaving a small triangle on the back. Found among aquatic plants on water surface, or swimming freely at all levels of slowly flowing water.

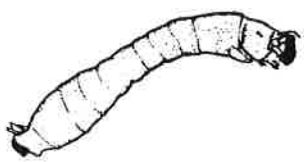


Very Tolerant Water Bugs

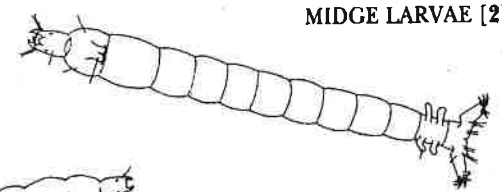
AQUATIC EARTHWORM [1]
Segmented worms, opaque or flesh coloured with round ends and no suckers.

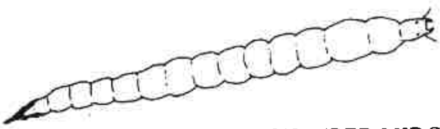


FLY LARVAE [2]



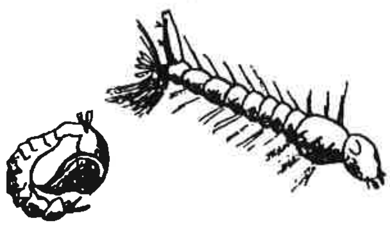
MIDGE LARVAE [2]





BLOOD WORM [1]- (RED MIDGE LARVAE)

*Chironomids —
slender wormlike creatures with no legs, or stumpy, unjointed legs.
Found in all sorts of aquatic habitats, swimming, on rocks, or on the bottom, in soft muddy tubes.*



MOSQUITO LARVAE [2]

References

Lakes and Rivers of Australia by V Serventy & R Raymond
Summit Books 1980
Australian Freshwater Life by W D Williams, 2nd edition
Macmillan 1980
Animal Life in Fresh Water by H Mellanby
Methuen 1965
Freshwater Invertebrates by Ralph Miller
Gould League of Victoria 1983

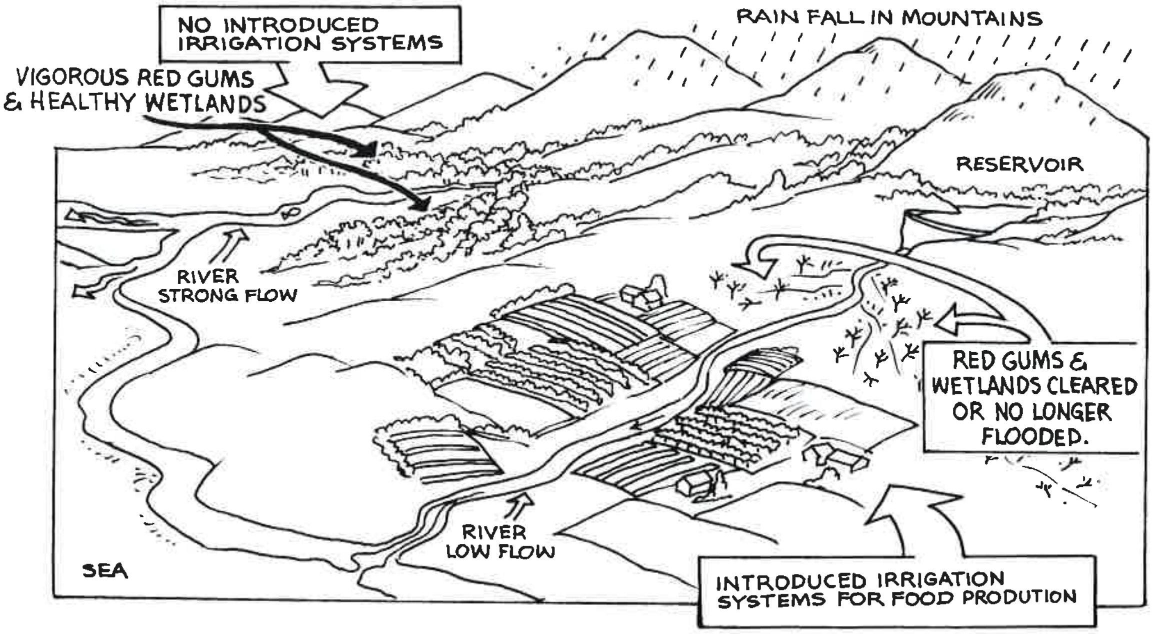
Acknowledgements

Illustrations were provided by W D Williams (Uni Adelaide), Murray Darling Basin Commission, Rob Welan (Water Board) and Alec Ellis.

The Guide was written by Fiona Van Dort (Water Board), Geoffrey Smith (Water Board), Bruce Chessman (Water Board), Rafael Chemke (Water Board), and David Salt (CSIRO).

Human's Use of Freshwater

OK, now we have established that all living things must be supplied with the correct amount of water, where does the water come from and who decides which living thing gets how much?



Science

The diagram of the "water cycle" in Chapter 2 shows that most living things in nature are completely dependant on rainfall and its run-off for their supply of freshwater. However, where humans have decided to grow food and other products on land where there is little rain, then those plants have to be irrigated.

This means taking the rainfall away from "nature" and storing it in reservoirs so that irrigation can take place when humans need it. This can be a bad thing for some native plants like River Red Gums which need the floods created by rainfall run-off to survive, grow, and reproduce, and which aren't adapted to the change in river regulation. This would also affect creatures who depend on River Red Gums for food and shelter.

There is nothing SIMPLE about how we use freshwater.

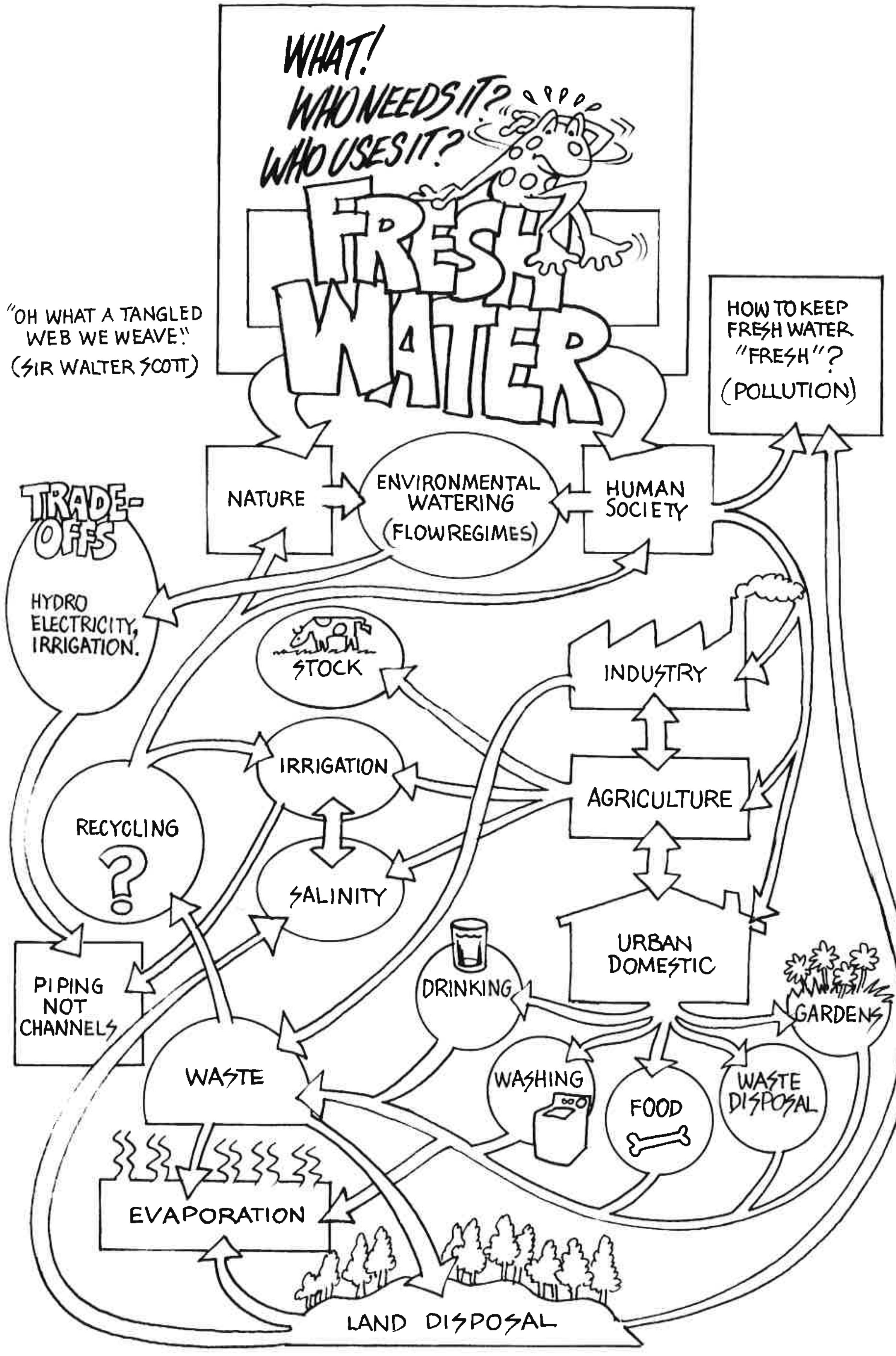
Scene Setting

- For classroom discussion: What are the effects of human interactions with the river in this picture?
- **River Life** www.discover.tased.edu.au/landcare/RiverLife.htm invites students to have an interactive role in the story of the journey a river makes to the sea. This can be used to explore the picture on this page.
- How did indigenous people find water and communicate its location to each other?
  HINT: paintings don't just tell stories, they can be aerial maps of the location of waterholes, vegetation and food.
  Further information is at Indigenous Australia's Website www.dreamtime.net.au/teachers

- Discuss "Who owns the rain?"
  Should farmers be able to build dams on their land?
  Should they be taxed for the amount of rain they prevent from entering rivers?
  What is the role of cloud seeding?
  *See a **Landline** report at www.abc.net.au/landline/stories/s197104.htm for more information on water rights.*

Challenges

- Design and undertake a survey in the local community about water use, water quality and peoples attitudes to water resources in your area.
- Research how indigenous people and other cultural groups traditionally collected, stored and used water. Investigate the different symbols they used to describe water.
- Investigate how the arrival of Europeans impacted on the way indigenous people used and managed their water resources. Did this differ depending on where they were located in Australia?
- Audit water use at home and at school for 1 week. Come up with strategies to better use, and where possible reuse your day-to-day use of water.
  What might need to be done to different sources of water before you can reuse it? *An International Online Project called "Down the Drain" can assist at www.ciese.org/curriculum/drainproj/*
- Develop a device that would save water in your home/school/community.


WHAT!
WHO NEEDS IT?
WHO USES IT?
FRESH WATER
"OH WHAT A TANGLED WEB WE WEAVE!"
(SIR WALTER SCOTT)
HOW TO KEEP FRESH WATER "FRESH"?
(POLLUTION)
NATURE
ENVIRONMENTAL WATERING (FLOW REGIMES)
HUMAN SOCIETY
TRADE-OFFS
HYDRO ELECTRICITY, IRRIGATION.
STOCK
INDUSTRY
IRRIGATION
AGRICULTURE
RECYCLING
?
SALINITY
URBAN DOMESTIC
PIPING NOT CHANNELS
DRINKING
GARDENS
WASTE
WASHING
FOOD
WASTE DISPOSAL
EVAPORATION
LAND DISPOSAL

Concept Map

Activity
Water Allocation Role-playing Scenario

This role-play exercise will work at all levels. Students can take on different personas to make it more lively (eg. landowner, city dweller, kangaroo etc.). Obviously the more senior the class, the more sophisticated the reasoning and discussion.

Discuss the **Concept Map** with the class emphasising that each group has a legitimate claim on freshwater.

Divide the class into 4 groups:

- NATURE
- INDUSTRY
- AGRICULTURE
- URBAN & DOMESTIC

Students can pretend to be different characters within each group.
Groups are given a copy of:

- **Water Allocation Sheet** for the next year (see below)
- **Concept Map** (page 19).

Within their group, discuss the **Concept Map**, the water allocation required by their group, and their own knowledge and feelings, and come up with reasons why their claims for all the freshwater they need, are legitimate.

Each group provides one of their members for the "Water Allocation Board", the Government committee with the power to decide who gets what. Conduct an official "hearing" with each group putting their claim to the Board. Ask the Board to allocate the water. Go back to a whole class discussion to try to resolve the problem.

REMEMBER THAT THIS SCENARIO IS A SIMPLIFIED BUT LITERAL EXAMPLE OF WATER ALLOCATION IN AUSTRALIA.

Repeat the exercise introducing the problem of a drought when there is only half the amount of water in storage.

Further Information / Resources

*The Australian Water Association (AWA) has developed a **We all Use Water** Education Kit which can be used to create a deeper understanding of water issues within the community. The kit consists of a 230 page resource folder of information ($95), 30 assorted flyers on a range of water topics ($12 for a full set), poster and storybook ($12), community involvement presenters' manual and CD ($26).*

*The Queensland Education Committee in conjunction with AWA have identified the way the **We All Use Water** Education Kit links with the Qld Syllabus Outcomes for Science which can be provided as a model for teachers in other states with different curricula.*

Any or all of these resources are available from the AWA National Office in Sydney by ringing (02) 9413 1288. Alternatively information, and all flyers can be downloaded and viewed at www.awa.asn.au/education

All money that is received from sales of any of the education resources is utilised for future developments and promotion of the resource. A number of schools around Australia have purchased the resource folder, as well as local councils, water utilities, and government organisations.

WATER ALLOCATION FOR NEXT YEAR
Water in storages – 22 500 Megalitres
Water required for INDUSTRY – 5 000 Megalitres
Water required for AGRICULTURE – 7 000 Megalitres
Water required for URBAN AND DOMESTIC – 7 500 Megalitres
Water required for the ENVIRONMENT ("NATURE") – 5 000 Megalitres

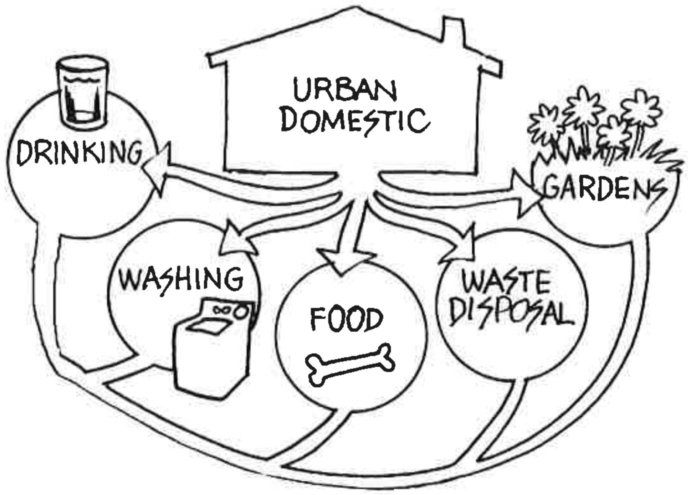
Urban / Domestic Use of Water

Access to clean water is fundamental to good human health. Water is provided by the environment and distributed through structures established by humans.

Science

Depending on the source of water, it may need little to no treatment (rainwater tank, some bore water) or lots of treatment (river water) or anything in between. Treatment can range from just mechanical treatment (eg. Filtration) to chemical treatment (eg. Chlorination).

Our use of water produces wastewater, which needs to be treated to make it safe before it is put back in the environment. Treatment can range from using septic tanks and pits to full treatment at a sewage treatment works.



Activities

- Investigate how the water you use and the wastewater you produce is treated.
  For some students, this may be as simple as boiling rainwater or having a septic tank, for others it may be more complex (and the case study on p.22 may assist).
- Investigate how families in the outback manage on artesian water sources or rainwater tanks.
  How is their use of water affected by its source?
  Compare with urban dwellers use of water.
- Visit a local water treatment plant after designing a set of questions to investigate on the visit.
- Ask a local council/shire water manager/engineer (or similar) to come and speak to the class about their work.
- Invite a scientist who works for the state/territory sewage works to speak to the class about the advances in water treatment and water purification techniques.

Challenges

- Produce your own case study, finding out where the water you drink is filtered and treated, and where it goes after you have used it. If you do you could send it to the Australian Water Association at PO Box 388, Artarmon, NSW, 1570 for inclusion in future copies of **We All Use Water.**
- Are there any wetland filters in your area?
  If not, why not? If so, what do they do?
- Investigate different types of constructed or man-made wetlands and what they are used for e.g. stormwater retention, water treatment, biodiversity and amenity.

One such example is the Whyalla steel factory, where the water used for coal quenching is passed through a wetland containing a reed (*Phragmites australis*). This reed has the ability to take heavy metals out of the water.

Find out:

- Why they decided to use this reed?
- How did they find out it could absorb metals?
- How much metal waste can it absorb?

Further Resources

Case studies on the different ways water is treated and managed in different catchments and towns can be found in AWA's ***We All Use Water*** *Education kit, see page 20 for details.*

The Presenter's Manual has many activities that can be used to explore water sources, catchments, pathogens, water treatment, sewage treatment and much more.

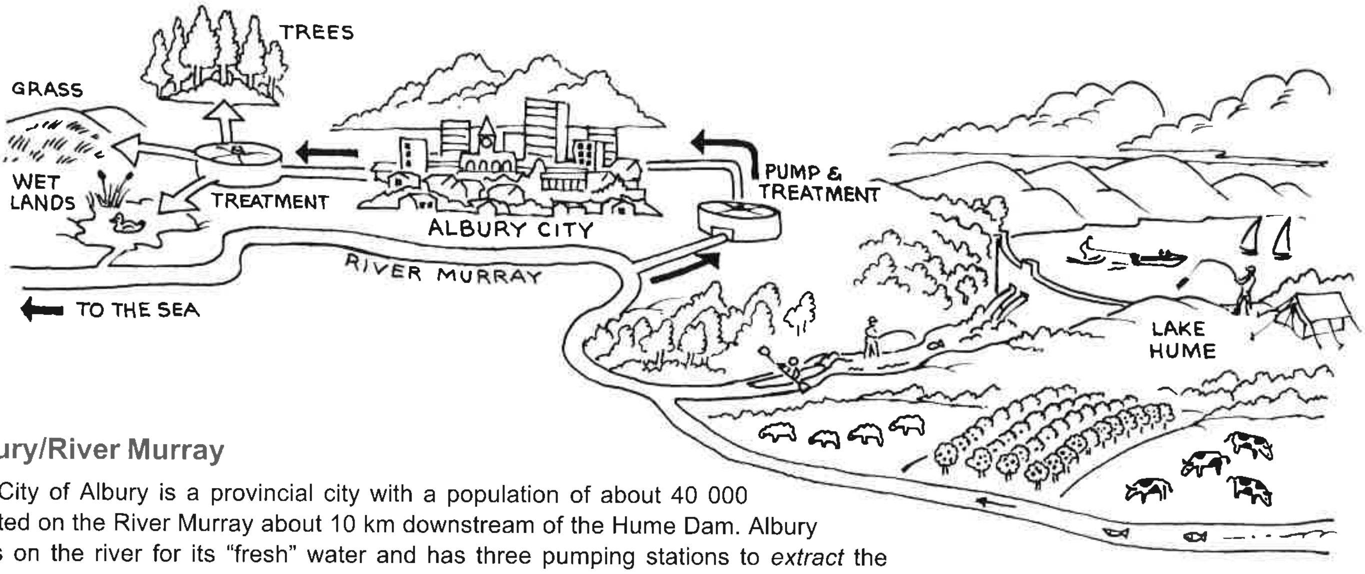
There are 30 pamphlets available at www.awa.asn.au/education covering aspects such as pathogens, disinfection, drinking water treatment, wastewater treatment, and water recycling, all of which can be downloaded.

Case Study

We have provided a simple case study to introduce urban water use to students. This is a **teacher's resource**, providing questions to be asked of the students **"?"** and suggested responses **"!"**. This is purely indicative but taken as a whole; the Case Study will "flow" if the sequence is followed.

Processes have been simplified, and if used for senior classes can be expanded.

It may also serve to guide you on producing your own case study specific to your area (particularly if your water comes from a different source such as rainwater tanks or groundwater). This case study may also provide a lead in for excursions to local water treatment facilities.



Albury/River Murray

The City of Albury is a provincial city with a population of about 40 000 situated on the River Murray about 10 km downstream of the Hume Dam. Albury relies on the river for its "fresh" water and has three pumping stations to *extract* the water, a central *treatment* plant and a *distribution* system covering the city and suburbs. Once the water is "used" it is collected, piped/pumped through the *sewerage* system to the *sewage* treatment plants (see flow chart diagrams).

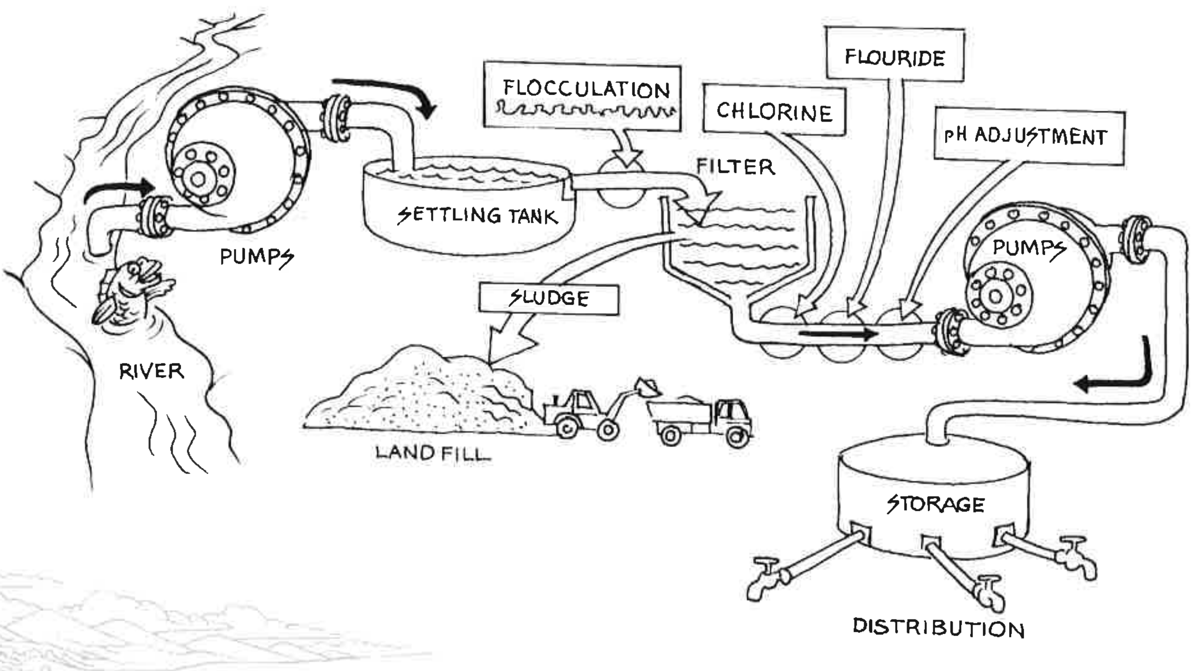
? **What will the extracted FRESH water be used for?**

! Initiate a discussion to provide a list of the likely uses of water by the people of the City of Albury. This could start by asking the students what they have used water for that day and build from there. (Note that the only significant water-using industry in the area is the Newsprint Mill but they have an independent water supply).

? **How could the freshwater be polluted before it gets to Albury?**

! Look at the catchment graphic and work towards getting suggestions about cows, overland flow from agricultural activities and recreational use of Lake Hume, etc.

This is how the City of Albury deals with these unwanted substances in the extracted "fresh" water.

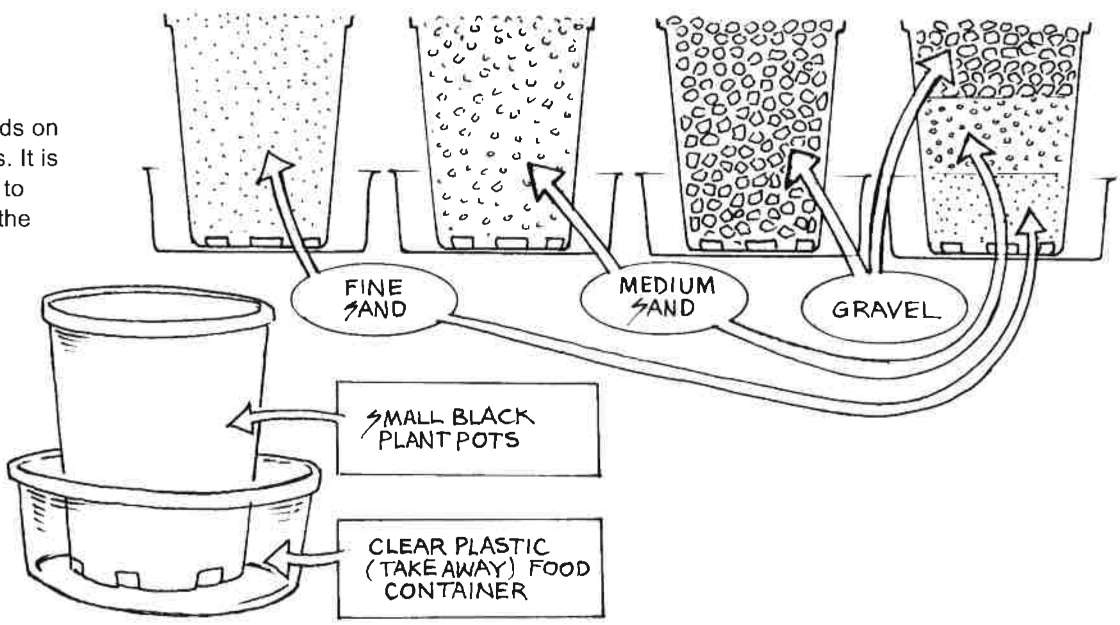


Activity

See for yourself how *FILTRATION* works.

NOTE: This experiment depends on the filter media for success. It is worth doing a trial run first to verify that it will work with the media you have obtained.

Students can be encouraged to design their own filtration system, experimenting with different materials and ways of passing water through.



You will need

- Four 10 -15cm lengths of tube (30 -40mm diameter)
  PVC water pipe or small black plant pots are perfect.
- Washed gravel, medium sand and some fine sand.
- A container with "dirty" water (perhaps fine grass cuttings, green slime, sediments, etc.). Students can have an earlier activity where they bring things from home to make the water dirty.
- 4 clear containers (e.g. plastic takeaway containers) to stand the tubes in.
- A "wet" area to work in.

1. Fill the first tube with the gravel, the second with the medium sand, the third with the fine sand and the fourth with 1/3 fine sand, 1/3 medium and 1/3 gravel in that order from the bottom.
2. Note the colour and texture of the dirty water and carefully pour a similar amount through each tube.
3. Note the colour and texture of the water that emerges into your clear container.

? **What will we need to do to get rid of the very small particles that are still in the water after our filtration experiment?**

! Encourage students to observe the relationship between filter structure and the particle size they remove. The answer to the above question can range from "smaller filter "holes"" with junior classes to introducing the concept of *FLOCCULATION* with senior classes.

BY THE TIME THE EXTRACTED WATER PASSES THROUGH ALBURY'S TREATMENT PLANT, THE FILTERS HAVE MADE IT VERY CLEAN, BUT IS THAT ALL THAT NEEDS TO BE DONE BEFORE IT IS USED?

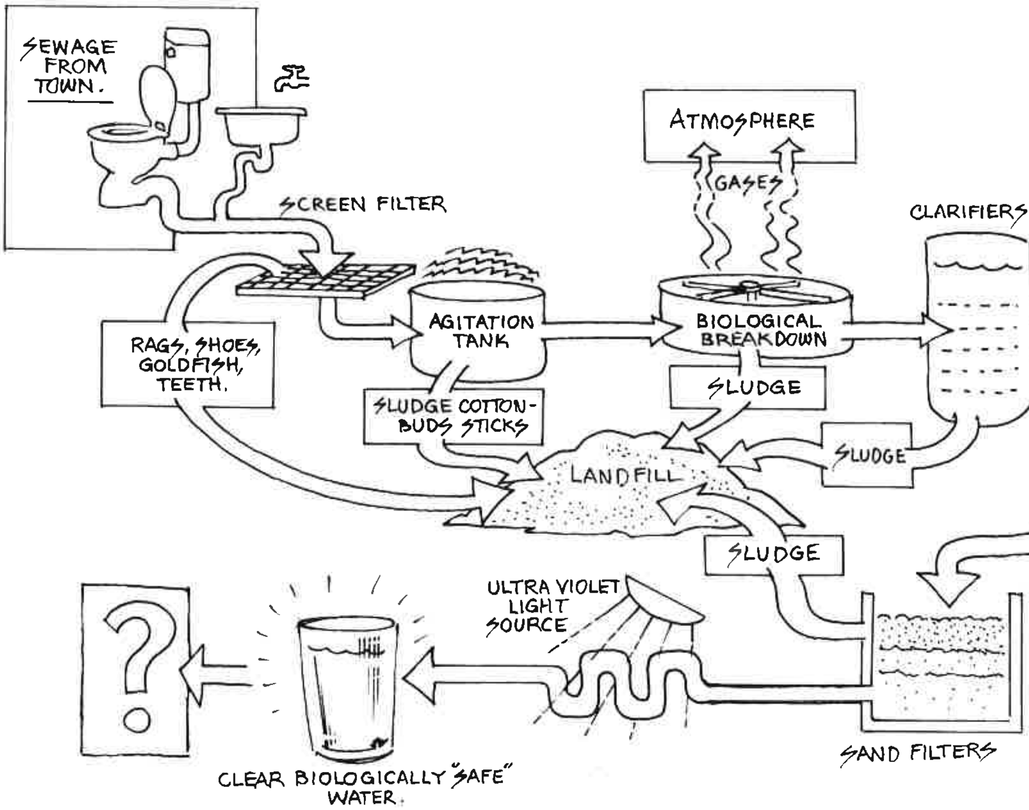
? **When you put the FRESH water from the tap onto your toothbrush or get under the FRESH water in the shower do you ever wonder if the FRESH water is safe for you to wash in, or clean your teeth in? NO? Well it <u>is</u>, and here is why.**

! Look back at the Treatment Plant "*Flow Chart*" and you will see that the chemical CHLORINE is added. Chlorine *disinfects* the water, killing any dangerous germs that might have come from the catchment, and because they are so small, passed through the filters. If someone remarks on the similarities between this system and their home swimming pool system, great! You might also want to mention the reason that fluoride is added.
HINT: A lack of fluoride can cause problems with teeth.
Senior classes can examine the chemistry of how chlorine disinfects water.
HINT: Some of the flyers on AWA's education web page may be able to help www.awa.asn.au/education/page3.asp

? **OK. The water has been made safe, distributed to your home and you have used it for a number of purposes. What then happens to it once it goes down your plughole or toilet ?**

! Students may have a vague understanding of a *sewerage system*, but if not, explain that it is just a "distribution" process in reverse which collects all the wastes from domestic and commercial premises and pipes/pumps it to a Sewage Treatment Works.

These "treatment works", just like the "treatment works" at the beginning of the process, clean up the water so that it is safe for us and for the environment and can be used again! Chlorine and the ultraviolet light source kill any harmful microbes present in the water.



In many towns and cities like Albury, the treated water is put back into the river and the users downstream use it again and again (after they have treated it!) But this no longer happens in Albury's case. Here the *reclaimed* water is used to grow three types of trees, pasture grasses and lucerne but most importantly, during winter when the water is not needed for irrigating these crops, the water is returned to the WONGA WETLANDS! It only re-enters the river if the river floods in winter.

The natural wetland was drained at the end of the 19th Century and became a mixed farm for about 100 years. It was bought by the City of Albury in 1994 and has been restored as a wetland system using treated water from the Waterview Sewage Treatment Plant. It is now known as Wonga Wetlands and is used to educate people about the importance of wetlands.

! Look at the website www.wongawetlands.nsw.gov.au Students can just look at the images, or they can be downloaded and/or the site used to encourage further research into the following questions.

? **Using the website, your own knowledge and group research/discussion, ask the students to answer the following questions:**

- **At what times of the year did the River Murray and its wetlands and billabongs fill and empty in the 19th Century?**
- **Why was the Hume Dam, just upstream from Wonga Wetlands, built in the early/middle 20th Century?**
- **How has this changed the way the River Murray now flows?**
- **When do the lagoons of Wonga Wetlands fill and empty?**
- **Why has this made the scientists and the birds happy?**

!
- They filled when it rained in winter and spring, and dried out when it didn't rain in summer and autumn
- The Hume Dam was built to ensure a supply of water for the establishing irrigation schemes downstream
- The river now flows full in summer and autumn and low in winter and spring
- The lagoons are filled in winter and spring and dried in summer and autumn
- Because the original *flow regime* has been restored, the birds are happy because there is now plenty of water and food at the right time of year for their migration and breeding, and the scientists are happy because this change back to the original flow regime gives them a chance to carry out research into the problems that have occurred due to irrigation flows.

Summary

The City of Albury takes its "fresh" water out of the River Murray, treats it to make it clear and safe for the users, and when they have finished with it, treats it to make it "fresh" again. Unlike most other places, it does not return this "fresh" water to the river but uses it to grow commercial crops and trees and has restored a valuable wetlands system using the original flow regime of the River Murray.

Final Questions!

? **Why is the "fresh" in freshwater always in inverted commas in this case study?**

? What is "fresh"? Have a look at Chapter 1 to find out more.

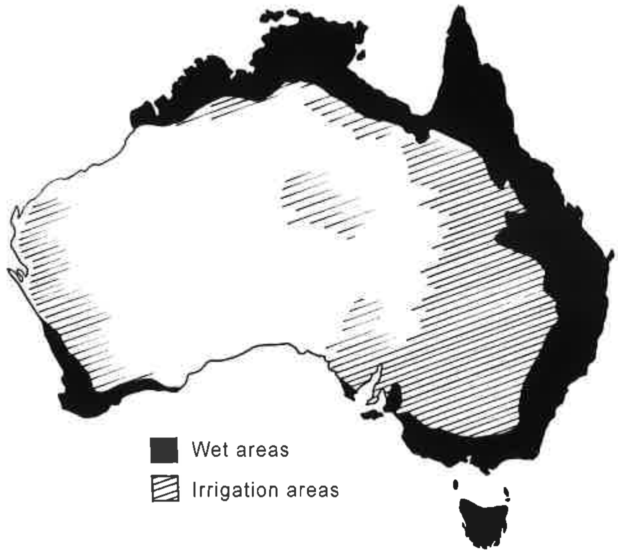
Agricultural Use Of Water

There are many different ways agriculture uses water. Some are more demanding than others. We have given a case study on irrigation, but you may want to explore how other agricultural crops use water during their production.

An example of an innovative use of technology to better manage agriculture is Southcorp Wines. This is a major wine company and operates the world's largest holding of premium vineyards – around 8000 Ha, as well as sourcing fruit from 1000 growers. The diversity of geography, climate and management approaches across the country offers a considerable challenge in optimising fruit style, cost of production and prices paid for grapes for a range of wine grades and brands. Additionally, the environmental issues with which they deal encourage them to find better ways to undertake stewardship of the land. The advent of technologies such as:

- Remote sensing
- Geographic positioning and geographic information systems
- Relatively low cost fixed and portable sensing and logging devices

Combined with both traditional and modern viticultural techniques and mechanisation allows efficient vineyard zone management for improved environmental cost and quality outcomes.



Because Australia is generally a dry continent, it is important that we do not waste ANY of the water we collect, store and transport.

This study will help students to better understand the basic structure of an irrigation "system" and how we have begun to do things better so that we can conserve the water that we do have.

You can see from the map that most of the rain falls well away from the irrigation regions.

We have built very large reservoirs to collect and store the water in the wet areas.

(See the reservoir cross-section diagram below.)

Case Study

Irrigation

Background

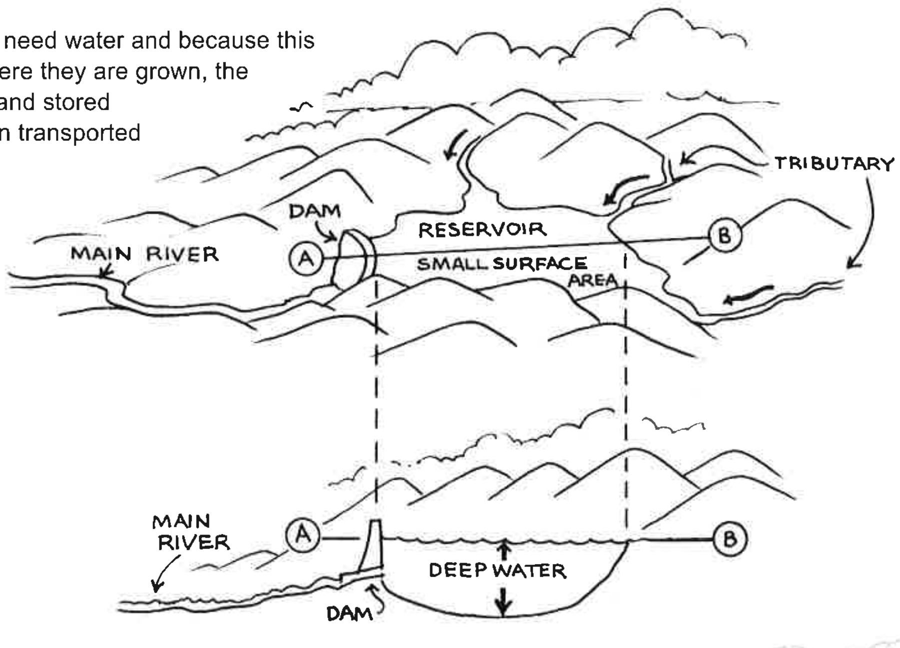
Put simply, "irrigation" is the artificial watering of plants. We "irrigate" when we water the garden at home with a hose. Golf courses are "irrigated" by large sprinklers, and councils "irrigate" their trees with water tankers and hoses.

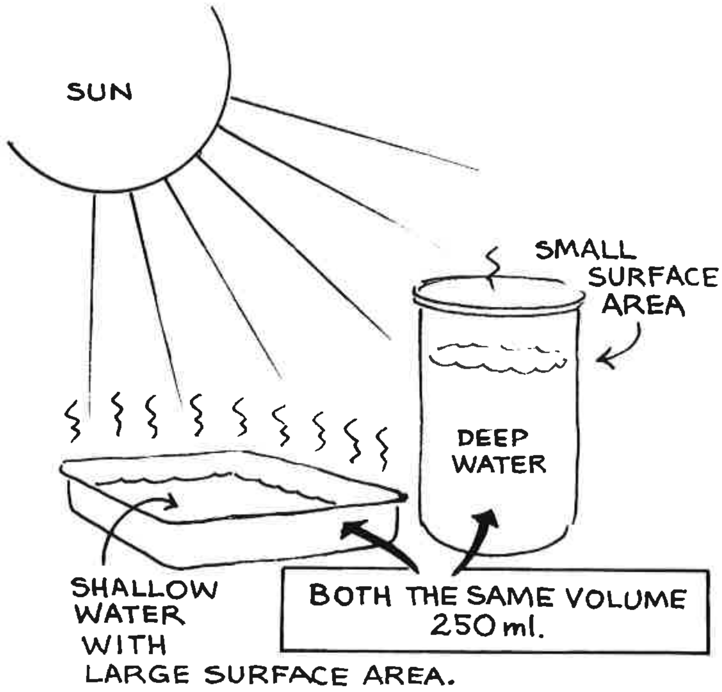
However commercial "irrigation" is when the watering of plants is geared towards making a profit, by producing food such as rice and fruit, wine from grapes and products such as cotton.

In Australia we would not be able to produce enough food for ourselves, let alone for export, if we did not have commercial irrigation.

Irrigated crops obviously need water and because this water is not available where they are grown, the water must be collected and stored somewhere else and then transported to where it is used.

Reservoir Cross-Section





Why are reservoirs very deep with a small surface area? Try this activity.

Activity
Evaporation Rates

- Take a narrow neck container like a vase and an equally sized broad mouthed container and add the same volume of water to each *(1 cup = 250ml)*.
- Mark the level of the water and place both together in the sun for a couple of days.
- What has happened to the levels?
- Evaporation is greatest in which vessel?
  A discussion on surface area/volume differences could follow from this activity.
- You can investigate this further by trying a variety of different container shapes.
- Discuss this activity in relation to the reservoir cross-section diagram on page 25.

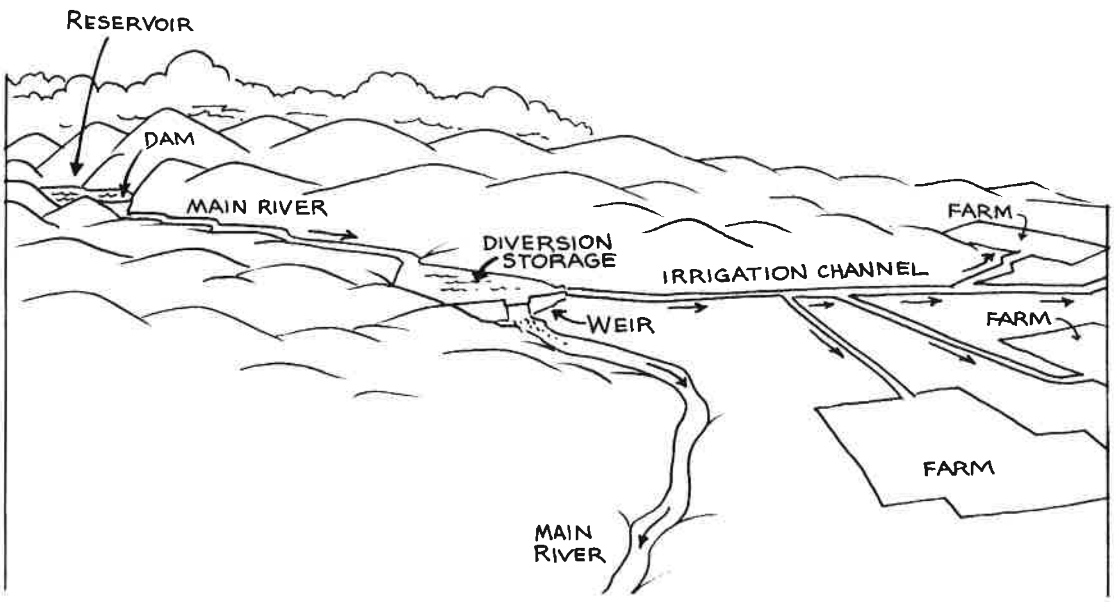
Supply of Water to Irrigation

Water is released from the reservoirs when it is needed by the irrigators, and is usually sent down a river where it can be diverted into an irrigation channel or pumped out straight onto the farm.

Of course some water is lost by evaporation as it moves along the river and the channels but water is lost in other ways too.

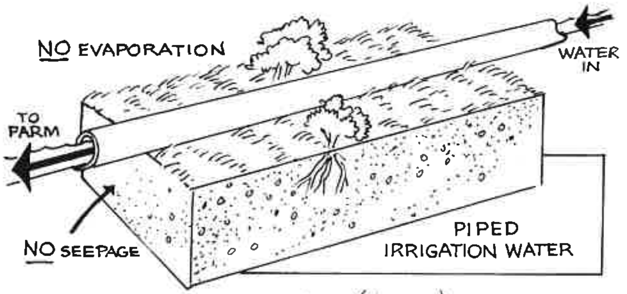
There needs to be some guesswork and plenty of experience in these releases, as it takes time for the water to get from the reservoir to the farm.

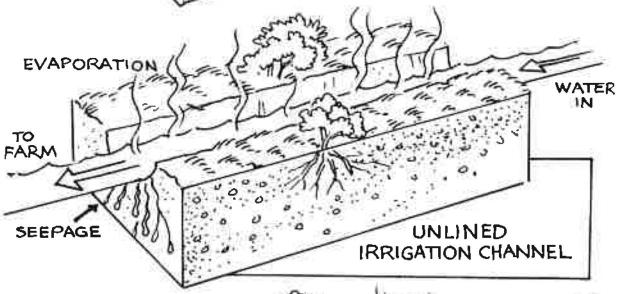
Reservoir to Farm

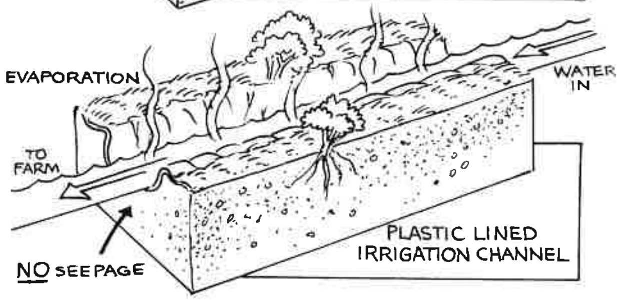


Example

Here are three water delivery methods.
Discuss







The pipe not only prevents evaporation but also loss by seepage into the soil.

What could be done to help avoid the loss of water?

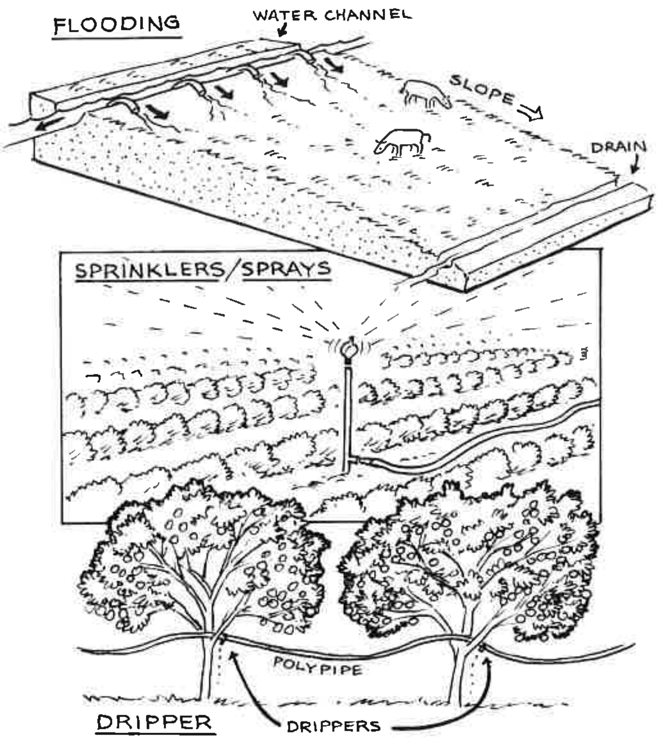
Piping all of the thousands of kilometres of water would be just too expensive, but what about lining the irrigation channels with concrete or plastic? Discuss this.

What other alternatives exist?

Delivery of Water to Plants

When the water reaches the farm, there are various ways to distribute it to the plants.

- Flooding
- Sprinklers/sprays
- Drippers

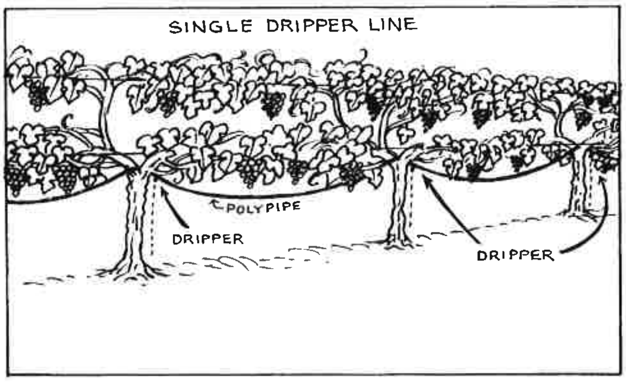


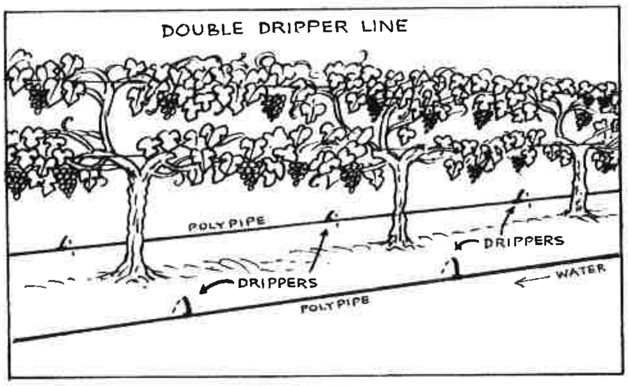
Students can evaluate these different systems of delivery by filling in the table below after completing some research and discussing it with each other.

There is no doubt that drippers are the most effective way to minimise water use but they can't be used in all circumstances, and do involve more expense. Identify when they would not be appropriate.

As research continues, discoveries are being made which continue to help Australia's irrigators to use less and less water to try to produce better and better crops.

	FLOODING	SPRAY/SPRINKLERS	DRIPPERS
Evaporation?			
Wets all soil, not just the roots of the plants?			
Waters weeds as well as crop plants?			
Suitable for all plant types?			
Expensive?			
"Fiddly"?			
Other?			





The following diagrams and description should help explain this.

When a plant "runs out of water" it usually reacts by dropping its fruit, shrivelling up the leaves and growing parts and eventually dying. However grape vines (remember wine!) react by keeping the fruit (grapes), adding nutrients to them and shrivelling up the growing points.

So how can farmers take advantage of the better grapes when water is reduced, without killing the plants?

Simple! Water only half the plant at a time using drippers. Result – the grape vine stays alive and produces better grapes because it "THINKS" it is going to die. For more information, check this out at www.csiro.au/news/mediarel/mr1999/mr9973.HTML

Conclusion

Commercial irrigation in Australia and the fact that it uses vast amounts of freshwater is a fact of life. There is no way that the country could function as effectively in terms of food, products and trade without irrigation BUT to achieve "sustainability" we must continue to refine and improve the way we go about irrigation. We need to improve the way we allocate water resources to irrigation and other demands.

Challenge

Research other ways to better irrigate crops.
Invent and test your own method.

Further information

Salinity

One of the big issues regarding agriculture in Australia at the moment is salinity. This problem is predominantly in the Murray Darling Basin and the West Australian wheatbelt, but is not restricted to these areas. While we will not treat this subject any further, we will give some resources if you wish to follow up this topical issue.

Silent Flood *is a four part documentary series produced by ABC Education's Lifelong Learning in conjunction with Land and Water Australia. It comprehensively examines the nature, extent, and current and future scenarios around dryland and freshwater salinity. It looks at every state affected by salt and talks to Australia's foremost authorities from the farming, environmental and scientific worlds. It was aired on the ABC in December 2002, and the ABC has released the videos and a teacher resource kit. Questions, background information and educational resources/activities are also available online at www.abc.net.au/learn/silentflood/default.htm*

Streams Alive *Sydney Water Streamwatch resource book (see Page 13 for details) has a chapter on Salinity and Growing Seeds, with a set of fully described activities and experiments suitable for junior primary school students.*

Water and Salt in the Murray-Darling Basin – A national environmental problem *(2002) was written by Dr. Allin Hodson to provide teachers and community groups with information about river salinity, dryland salinity, groundwater and social considerations regarding salinity. It's 60 odd pages are jammed with illustrations and information drawn from such sources as CSIRO, the Murray-Darling Basin Commission and the South Australian Government. The focus is on South Australia, but much of the information is applicable elsewhere. Copies of this book may be obtained from Urrbrae Agricultural High School (505 Fullarton Rd, Netherby, SA 5062) for $7.70 plus postage if applicable.*

A Taste of Salt *is an environmental education unit containing information and activities on salinity written in 1999 by NSW Agriculture and Salt Action NSW and is designed to meet Human Society and Its Environment Stage 3 Outcomes (NSW Curriculum). Free copies can be obtained by contacting the Education Officer, Salt Action at Private Bag 1, Yanco, NSW 2703, ph (02) 6951 2611, Fax (02) 6955 7580.*

Industrial Use of Water

Industries use water in many ways, these can include electricity generation, heating, cooling, washing, paper production, ore processing and other functions. Some merely use the water, such as hydro-electricity generation and then pass it on virtually unchanged, and are thus known as non-consumptive water users. Others incorporate water into the finished product, such as food and drink, and are thus known as consumptive water users. Quality requirements vary for different industries, and many premises treat water before use, even if they have received the water through the urban reticulation system. Others are able to use recycled water (from their or other processes) or treated effluent water from sewage systems. Amounts required for use also differ, with some industries such as refineries or coal fired power stations using huge amounts of water, while others such as pharmaceutical producers using very little.

Scene setting

Find out how industries or businesses in your area use water?

- What do they use water for?
  Is it consumptive or non-consumptive use?
- Is it used during the process (eg. Paper making) or part of the finished product (eg. Softdrinks)? Does the process produce any wastewater, and is this water still "fresh"?
- Can you identify any ways in which this industry could better use the water it consumes, or the waste water it produces?
  HINT: The Albury paper mill is one industry that has identified a better use for its waste water than putting it back in the river, it now uses it to grow plantation trees, which are then used for paper manufacture.

This challenge could result in a visit to a local factory, or assigning students different industries to research their use of water.

Resources

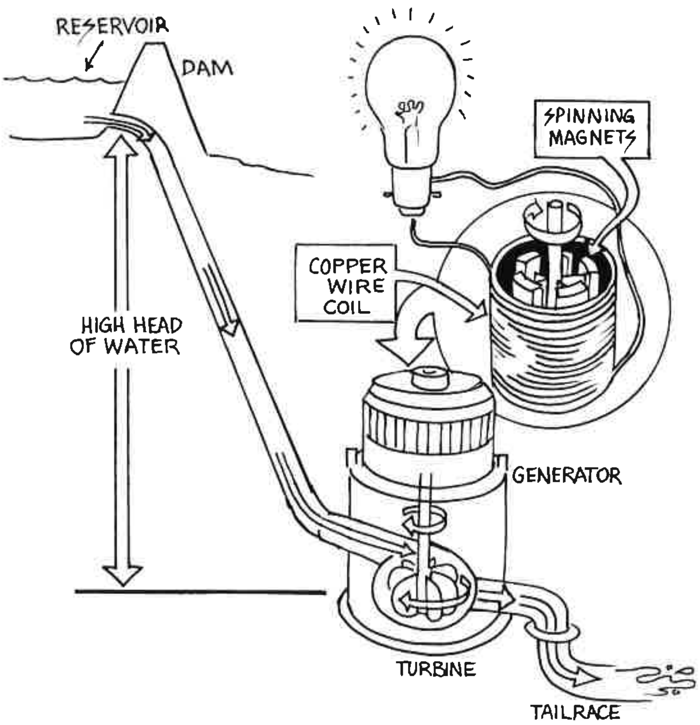
Australian Water Association: water at work www.awa.asn.au/education/15_WateratWork.pdf

The Australian Academy of Technological Science and Engineering and the Institution of Engineers has produced a report on **Water and the Australian Economy**. **The Community Summary Report** (1999) is available at www.atse.org.au/publications/reports/water1.htm
The study provides a glimpse of how Australian industries might use and profit from water in the next 20 years.

We have given one example of industrial use of water, which is using water to produce electricity.

Case Study
Hydro-Electricity

An electrical current can be produced by either chemical (eg. Batteries) or mechanical (e.g. generator in a power station) means. For mechanical action (or induction), electricity is generated when a magnet is moved through a coil of wire. However, something is needed to move the magnet, which can be steam produced by burning coal, oil or gas, or wind, or water falling down a gradient (converting kinetic energy into mechanical energy).



Hydro-electricity uses the energy in falling water to drive a turbine that then moves large magnets through huge coils of wire. To do this, water needs to be held behind dams and then guided through pipes and tunnels. Hydro-electric generation in Australia occurs primarily in the Snowy Mountains and Tasmania, where huge interconnected schemes transfer and use the water, with smaller schemes in Queensland, other areas of NSW and Victoria.

Virtually all of Tasmania's electricity is generated from water, using approximately 13.5 million Megalitres of water a year. This use is known as "non-consumptive, which means the water is not "consumed" and is available for other users downstream. Hydro Tasmania is the largest water manager in Tasmania, and controls water movement in seven large catchments.

As water is renewable (see water cycle in Chapter 2), electricity generated from water is known as "renewable electricity", and does not pollute the environment. It is not without a price however, as the construction of dams and reservoirs to hold back the water until it is needed may have some environmental impact. It's the community that benefits from hydro-electric schemes through provision of power. To assess these benefits against potential impacts environmental guidelines are necessary. Hydro Tasmania has an Aquatic Program to better manage its freshwater resources and minimise the impact of its activities on the environment.

Did you know that the Gordon / Pedder impoundment in Tasmania is so large it can be seen from space?

The Snowy Mountains Hydro-electricity scheme was designed to solve both power and irrigation problems, providing power to Canberra and NSW/Vic and harnessing rainfall in the Snowy Mountains to send inland to the Murray-Darling Basin for irrigation. However building the Snowy Hydro-Electricity scheme also had an impact, as it redirected the flow of the headwaters of the Snowy River from east to west, sending this flow inland. This has resulted in the (poetically famous) Snowy River being much reduced in flow. People are now looking at providing more flow to the Snowy, to restore some of the environmental values to the river. The costs and benefits of this proposal are being considered.

Find the Snowy scenario in the next chapter.

Challenges

- Find out what other forms of electricity generation might use water? What quality of water is required, and what happens to it during the electricity generation process? Other forms of electricity generation include coal, gas, oil, nuclear, solar, wind and tidal.
  HINT: water is used to produce steam in boilers, and can also be used for cooling.
- Design and construct a model of a waterwheel. Investigate where waterwheels are used.
- Compare a water pump that uses an electric motor to pump water, to a hydro-electric turbine that uses water to make electricity. What is similar and what is different?
  This can be as simple (one uses gravity to generate electricity, while the other uses electricity to move water against gravity) or as complex (examining the mechanics and physics of each, and how hydraulic ram pumps work – see resources below) as is suitable for the students.
- Explore the different forms of hydro-electricity, the scales they work on, and the conditions in which they are appropriate – micro-hydro, mini-hydro, small-hydro and large-hydro electric schemes.
  How is hydro-electricity at the small end of the scale helping people in developing countries?
  HINT: check out resources below for online information.

Activity

Induction

Explore induction by getting a long length of copper coil (the longer the better). Wind around a cylinder (toilet roll or large piece of dowel is perfect). Attach each end to a current meter (one of these could be obtained from your local high-school science laboratory).

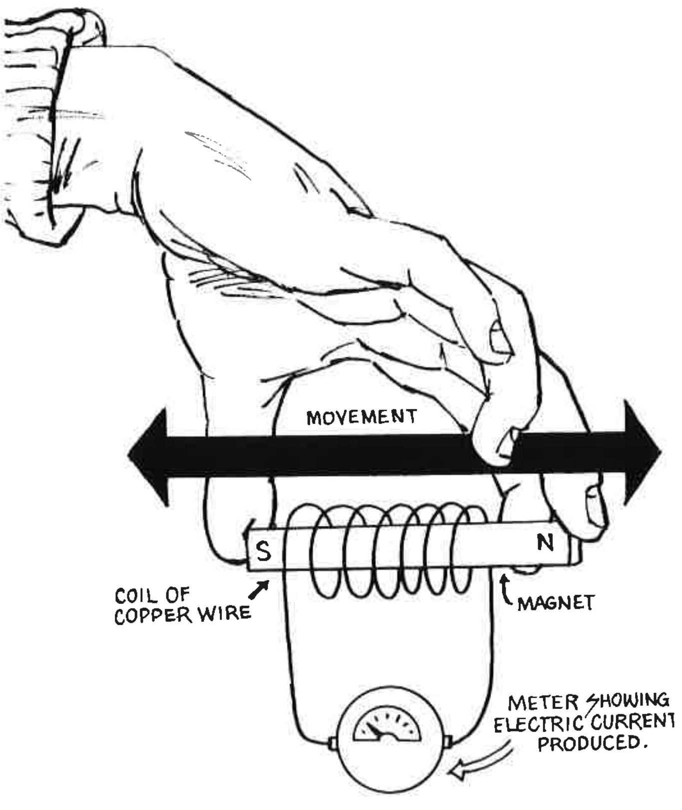
Get a magnet and move it in and out of the copper coil. The meter's needle will swing back and forward, indicating that a current is generated. This is known as induction, and in its simplest form, is how electricity is generated by mechanical means.

Resources

The Hydro Tasmania Website has educational information on how electricity works, and the hydro-electric schemes in Tasmania – www.hydro.com.au/education/index.html
*At the "**Hands On**" Energy Discovery Centre in Hobart students can engage in a range of activities that explain how electricity is generated using "water power". **The Power of Nature** is a resource book they have produced on renewable energy derived from water and wind.*

Snowy Hydro Website has educational information, resources and activities as well as information on the Snowy Hydro-electric Scheme at www.snowyhydro.com.au/education/
Snowy Hydro has a visitor information centre at Cooma where school visits are welcomed.

The Australian Cooperative Research Centre for Renewable Energy (ACRE) has a useful explanation on all scales of hydro-electricity – history in Australia; large, small, mini, and micro-hydro; types of turbines; and how hydraulic ram pumps work at acre.murdoch.edu.au/refiles/hydro/text.html



Chapter 5 Australia's Future?
A trigger for classroom discussion

Freshwater is a renewable resource, but it is not unlimited. The amount available to us at any one time is dependent on the water cycle and climate (see Chapters 2 & 3). If our use of freshwater is in balance with nature (or sustainable) our natural freshwater resources should remain viable and healthy.

Scientists, politicians and the community are seriously looking at the health of our river systems, and how our use (and abuse) has changed many of them. Issues such as degraded water quality, allocation of environmental flows, environmental trade-offs and capping water extraction are becoming more widely used in the media when discussing these issues.

This chapter is one of "suggestion" and "discussion" and should be made fun, but with a serious conclusion. The following issues could be raised within the context of classroom role-play, with groups of children representing different users of the water.

It is suggested that for junior primary students that you confine any work to a simple consideration of Diagram A. For the middle school it is suggested that the Diagram A discussions be expanded to include the social and geographic considerations in Diagram B. For senior secondary it is suggested that the students work through A and B then a political dimension be added as in Diagram C. The conclusion is relevant to all levels.

Junior Primary

In Diagram A we have a balanced use of the freshwater that falls as rain in the mountains and travels to the ocean. As it makes its way to the ocean this water is used to grow crops, water livestock and forests, provide for human activities and sustain (discuss what this means) a town. Some years are wetter or drier than others but there is always a good outflow to the ocean. There is sufficient water for all users in the catchment, including the natural ecology of the river.

The supply and quality of freshwater is so good that many people move to the town from other places. These extra people need more room, more food, more recreation places – and more water.

Consider what will be the good things about an increase in population? What will be the bad things?

Will the river always be able to sustain an increased population? Who/what will suffer? How will the people in the town solve this problem? How could the water use activities (wildlife, forestry, agriculture, town water, recreation) in Diagram A be changed (reduce, recycle, reuse) to provide water for the extra people?

Students could draw their own diagrams to show what they think might happen if the town trebled in size.

Diagram A

A BALANCED USE OF FRESH WATER.

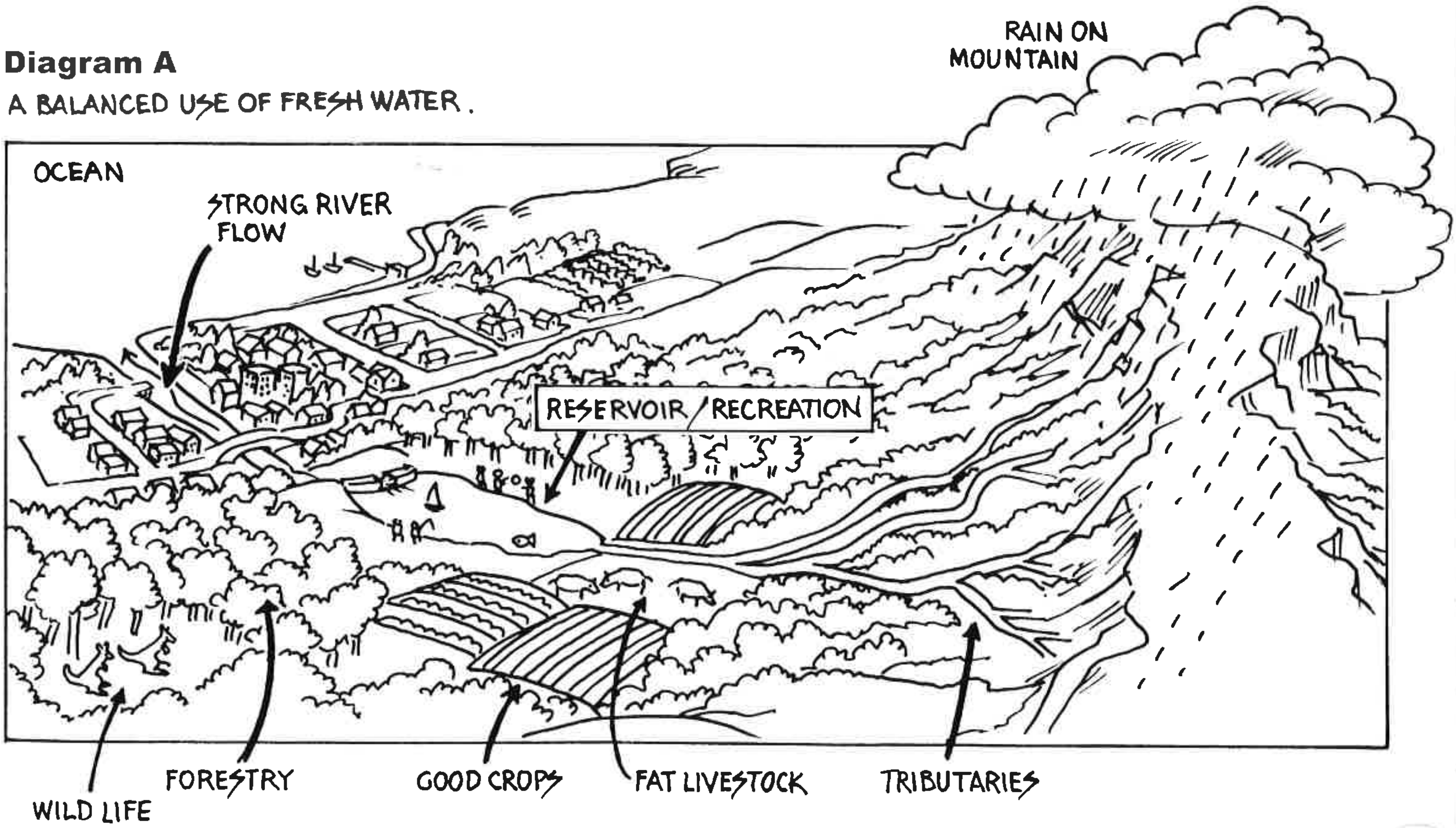
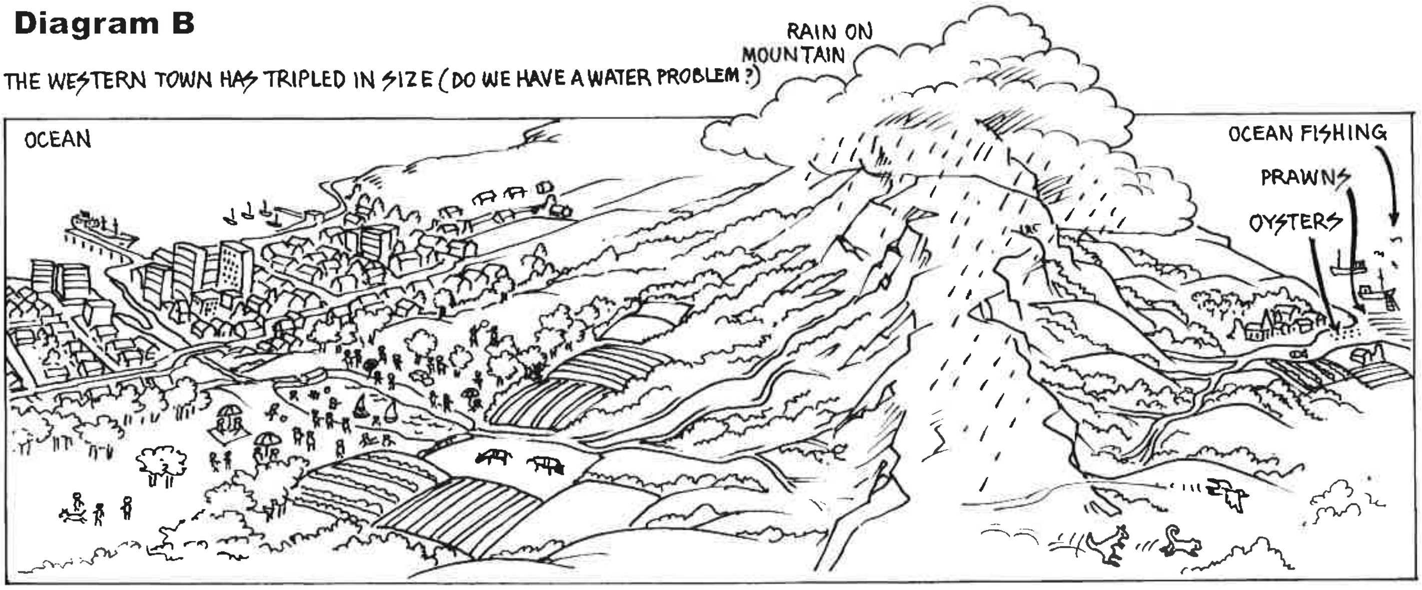


Diagram B



Middle School

In Diagram B, the town is now three times as big, the reservoir never has enough water to keep it full and the livestock and crops are struggling to get enough irrigation water to flourish. The following has been published in the local newspaper:

"One River. One Life. Our Future"

"*There is evidence the River is in trouble. Poor water quality, loss of native plants, animals, fish, forests and wetlands and an increase in pests such as carp, all point to a river and a landscape in decline. Scientific advice indicates that if nothing changes, the river's health will inevitably get worse. This will effect irrigation and other industries, native plants and animals, and the communities that depend on the river for fresh water."*

The population in the Western River valley and their politicians know this. They also know that the rain that falls on the other side of the mountains (the Eastern River side), simply runs to the ocean past a small fishing village and oyster and prawn farms.

There are few people, small numbers of livestock and no crops on the Eastern side. Somebody suggests "Why not turn some of this water inland where it will not be wasted by just running into the ocean? All that it will require will be some dams and tunnels. We can store it in the dams until we need it when it gets dry".

Everybody in the Western River valley thinks this is a great idea. It will cost money, but will mean unlimited water to restore the river valley on the western side of the mountains. But what do the people in the Eastern River valley think? What are the ramifications of this approach for the Eastern River? Is there any guarantee that the diverted water will be enough for the Western Valley town? What if they need more? What about the other users like forestry and agriculture?

Senior High School

Use Diagrams A, B and C for a lively debate in senior classes, either in the formal sense of a debate, or as a mock public meeting. Remember that you really are not trying to resolve the problem, but to enable the students to critically analyse what is put before them in the media.

Be sure to get the following included in the discussion:

- Selective quotations
- Language designed to be quasi scientific or simply confusing
- Language designed to inspire fear or elation, but on closer examination is deceptive
- Banner Headlines
- The "mushroom" factor (being kept in the dark)
- The "if"/ "but" factor (paralysed by indecision)

Recent media clippings may be of great value to this debate. Material could include newspaper quotes, audio from talkback radio, leaked council memos, or comments from government hansard. Points of view from "develop at any cost" proponents, "balanced development" proponents, "reduced development" proponents or "no development" proponents could be presented at the meeting, or as local letters to the editor etc.

Scenario

Australia has gone into a severe recession and the government must boost employment if it is to have any chance in the forthcoming election. The Western River Valley (a marginal seat) is doing it hard. The following headlines and text appears in the national press;

"MASSIVE BOOST TO EMPLOYMENT" and "RIVER TO BE SAVED"

"The federal government is forecasting the creation of 10 000 jobs and the complete rehabilitation of the Western River and its valley, if it is re-elected and the giant "Flow Change" scheme goes ahead."

"Flow Change" means the re-alignment of the Eastern River by 180 degrees through a series of dams and tunnels to augment the flows in the Western River, whose valley and communities are suffering through a lack of water, whilst an estimated 1 800 Gigalitres flows to the ocean unutilised. The water can be stored behind the dams until it is needed in the Western Catchment for use, and can even be used to generate electricity.

Diagram C shows the relative simplicity of the scheme as it is currently proposed.

- Are the pros and cons any different to the Diagram B scenario now that the politicians are involved?
- How and why?
- What are the consequences of turning this extra water inland?
- Will it be enough, or will it lead to further development and a further increase in water demand?
- Should there be a cap on water demand and water use, or can each interest group continue to extract as much water as they need?

This scenario is what happened with the Snowy Mountains, although it is far from being this "simple". The Snowy Scheme should certainly be considered in terms of its benefits, one of which is highly profitable agriculture in the Murray Darling Basin. Irrigation uses about 28% of the land in the Murray-Darling Basin but over 95% of water use, producing an estimated 25% ($4-5 billion) of Australia's gross value of agricultural output.

However, what effect has this had on the Snowy River? Why are we now considering returning some of this water (as an environmental flow) back to the Snowy? And what about our continuing demand for more water from the Murray Darling system? What effect is that having on the riverine environment? Why have we now introduced a cap on water extraction in the Murray, and water trading?

To find out more, go to the Murray Darling Basin Council website at www.mdbc.gov.au.

Conclusion

Ponder the following questions:

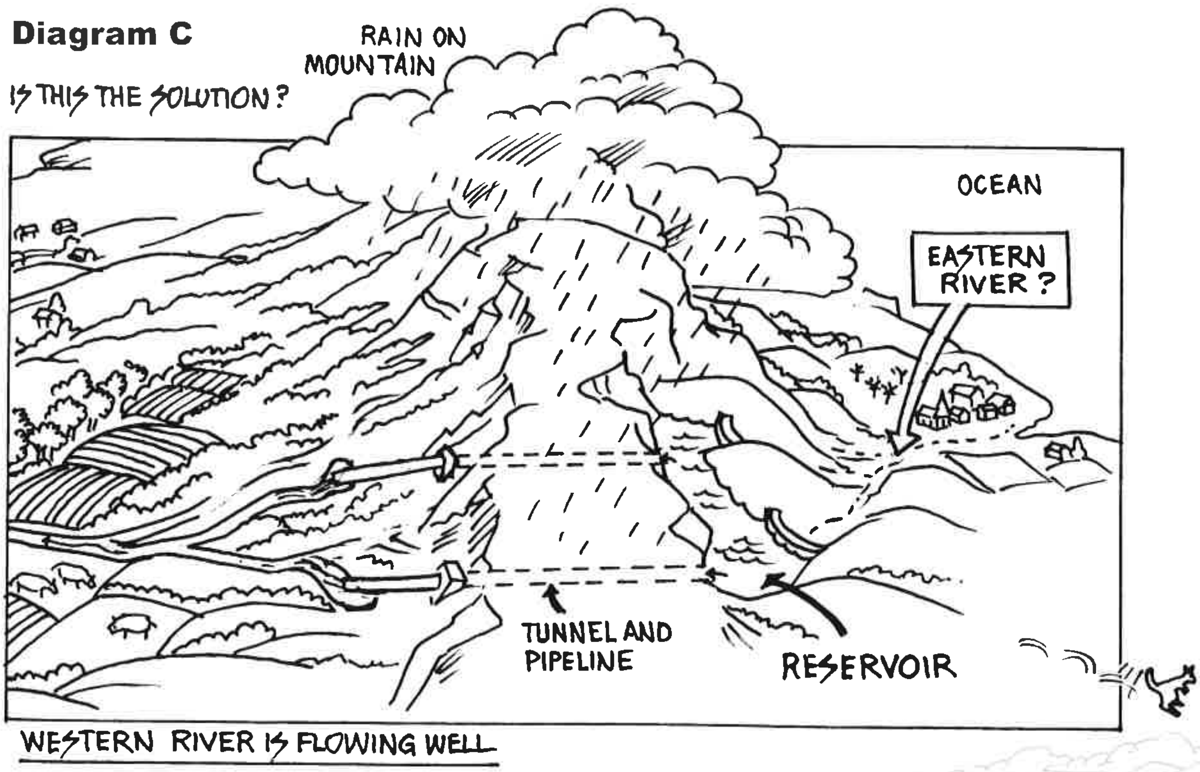
- What might our uses of water and our interaction with the environment look like in 50, 100 years time?
- Discuss to what degree are we are responsible for keeping our waterways clean
  (government – local, state and federal, businesses and industry, local community, individuals)
- Would we ever return all flow to the rivers like the Murray? Why/why not?
- How would you like to see the management of our water resources in the future?
- How could you take an active part in assisting us to live in a more sustainable manner with our water resources?

Parts of Australia, that are not natural desert, have a significant freshwater deficit or are heading in that direction. As well, the "freshness" of the freshwater is declining with significant damage to the ecology of catchments. Many people believe that our society is prone to using a band-aid approach to try to deal with the problems, rather than a well-considered, long-term strategy.

As informed and active citizens within our community, ecologically sustainable use of natural resources is a vital issue requiring an informed, consensus approach. Many individuals and groups are involved in the decision-making process, and have a role to play in utilising our limited freshwater in a sustainable way.

One such group that has recently made headlines is the Wentworth Group (of Concerned Scientists). To find out how they think our freshwater resources should be managed in the future, have a look at their publication **Blueprint for a Living Continent** (2002) www.wwf.org.au/downloads/blueprint_for_a_living_continent.pdf

Diagram C



Glossary

A

Aquifer
: Permeable underground rock that can hold water

B

Blue green algae
: Microscopic cells, some filamentous, able to photosynthesise. Some species are toxic and become dangerous to human health when in high numbers (blooms)

C

Catchment
: A catchment is any region of land where water drains to one point.

Condensation
: The change of a vapour into a liquid

Conductivity
: This measure is the inverse of the amount of resistance an electric charge meets in travelling through water, and is a way to measure how many ions are present. It is measured using a conductivity meter, with units being in electrical conductivity (EC) units or microsiemens per centimetre (μS/cm)

D

Density
: The mass of a unit volume of a substance

Desalination
: The extraction of fresh water from salt water by the removal of salts, usually by distillation

Distillation
: The process of heating a solution in order to separate its components by condensation

E

El Nino – Southern Oscillation
: A climatic phenomenon in the Pacific ocean. A reduction in SE trade winds causes drought in Australia, excessive rain in South America and prevents the upwelling of nutrient-rich cold bottom waters in South America, causing decreased productivity of fish stocks

Evaporation
: The change of a liquid into a vapour

F

Flocculation
: A process of contact and adhesion whereby particles in a solution clump together and can then settle out

Freshwater
: Water the salinity of which is less than 0.5 parts per thousand (equal to 500 mg/L)

G

Groundwater
: Water that seeps into the ground and is stored where it meets impervious rock

H

Heavy metals
: Metals with high relative density such as cadmium, copper, mercury and zinc. Harmful in high quantities to living plants and animals

I

Infiltration
: The process whereby water seeps into the soil and becomes groundwater

L

La Nina – Southern Oscillation
: A climatic phenomenon in the Pacific ocean. An increase in SE trade winds causes excessive rain in Australia, and up welling of nutrient-rich cold bottom waters in South America, with increased productivity of fish stocks

M

Mound spring
: Formed when artesian water leaks to the surface and evaporates away leaving dissolved salts behind. These salts accumulate rapidly and form a hard limestone "mound" that is often topped with moist soil, vegetation and perhaps a pool of permanent water. Often have unique animals and plants present

O

Osmosis
: The passage of water through a selectively permeable membrane (e.g. cell wall) from a solution of low concentration to higher concentration. **Reverse osmosis** is when water passes from high to low concentration

P

Photosynthesis
: The process where living cells (eg. green plants) make organic compounds (food) from light energy using carbon dioxide and water. Oxygen is a by-product of this reaction

Pollutant
: A substance causing pollution

S

Salinity
: The presence of salt in water or soil

Sediment
: Material that sinks to the bottom of a waterway

Sustainability
: Living in balance with nature, utilising renewable resources at levels that cause little ongoing damage to the surrounding environment

T

Topographic relief
: A description of the surface features and their elevation of an area

Transpiration
: The loss of water vapour from a plant, mainly through pores on the leaves

Turbidity
: A measure of the clarity or clearness of the water. Sediment and algae can increase the turbidity of the water and decrease clarity

U

Urban reticulation system
: Water and sewage pipes in a town or city that link houses, businesses and factories to water supplies and remove wastewater for treatment