A close-up photograph of a young girl with dark skin and hair, drinking water from a green ceramic pot. She is holding the pot with both hands, and water is pouring out from the bottom. The background is blurred, showing other people and colorful lights.

Water in
the world

SAMPLE

unit

1

Water as a resource

A resource is anything we use to satisfy a need or a want. Resources we use from the natural world are called environmental resources. All life on Earth depends on these environmental resources to survive. The water we drink, the Sun we depend on for light and warmth, the soil we use to grow our crops, and the trees we rely on to produce the oxygen we breathe are all environmental resources.

As the world's population grows, we continue to place more and more pressure on these resources. The availability of many of these environmental resources (including oil, forests, and of course, fresh water) is becoming increasingly uncertain.



1.1

How is water an environmental resource?

- 1 Which environmental resources do we need to survive?
- 2 How are the people in the photograph using the Ganges River as a resource?

1.2

How does water connect and affect places?

- 1 How do you think the Ganges River connects places in India?
- 2 List three ways that water from the Ganges River might be used.



Source 1.1 Hindus in India believe that bathing in the holy waters of the Ganges River gives them spiritual blessings.

1.3

How much water do we have?

- 1 Water covers about 70 per cent of the Earth's surface. Why, then, do we have a shortage of water to drink and to wash in?
- 2 Where do you think the wettest and driest places in Australia might be found?

1.1 How is water an environmental resource?

Environmental resources: an overview

Over thousands of years, humans have developed ways of life that depend on almost all **environmental resources** found on Earth. Water from rainfall, minerals from rocks, and food from the forests and oceans have allowed us to build homes, farms, cities and highways all over the world. We have found and used resources in almost every corner of the Earth. Oil is drilled from beneath polar **ice caps** and water is drilled from far below barren **deserts**. Deep in the rainforests we have found plants that can cure illnesses and we have even worked out how to generate electricity from the waters flowing in our rivers.

Types of environmental resources

Geographers divide all of the environmental resources on Earth into three types:

- renewable resources
- non-renewable resources
- continuous resources.

The first type – renewable resources – will replenish themselves naturally over time if we do not use them too quickly. The **trees** in a forest are a good example of a renewable resource. We can cut them down for wood, but they will grow back in time. We just need to manage them carefully. In countries such as Australia, fresh water is considered a renewable resource but it needs to be carefully managed to ensure that enough is available for everybody.

The second type – non-renewable resources – are only available in limited (finite) amounts. If we overuse them, they will one day run out. Minerals such as coal, oil, diamonds and uranium are good examples of non-renewable resources.

The third type – continuous resources – are available in unlimited (infinite) amounts. No matter how much or how often we use them, they will never run out. Energy from the Sun and wind are both examples of continuous resources.

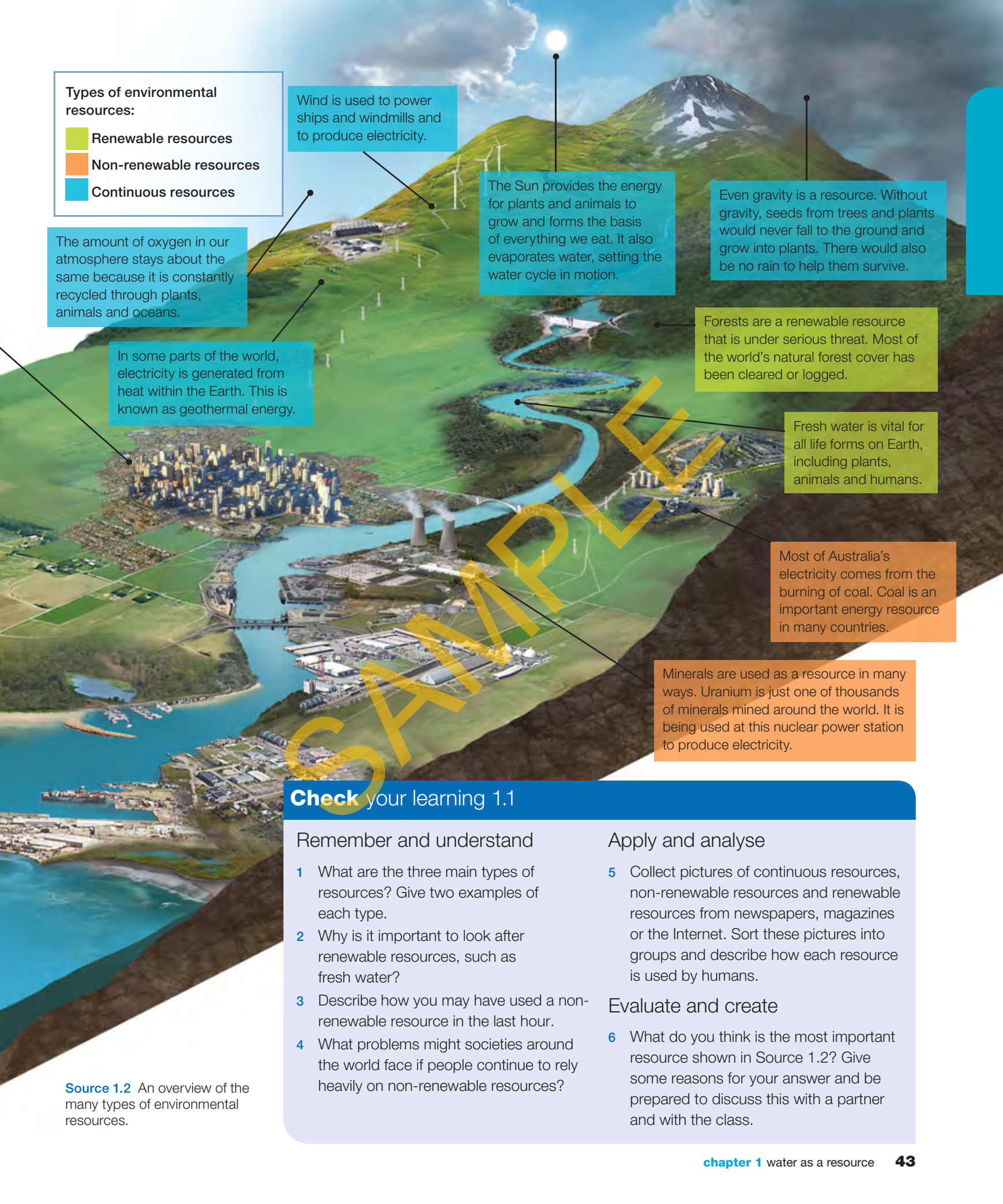
Plants, animals and human beings are renewable resources. Humans, however, are unique in that our use of the Earth's resources is disrupting the Earth's natural systems.

Plants are renewable resources because they produce seeds in order to reproduce themselves.

Soil is formed when rocks break down. We use soil to grow the crops we eat. The animals we farm for food also rely on the soil for the grass they eat.

Ocean waves are resources for surfers and holiday-makers. They can also be used to generate electricity and may be a valuable natural resource in the future.

Oil is the world's most commonly used source of energy. It is also used to make many important goods, such as plastics, petrol and fertiliser for farms.



Types of environmental resources:

- Renewable resources
- Non-renewable resources
- Continuous resources

Wind is used to power ships and windmills and to produce electricity.

The Sun provides the energy for plants and animals to grow and forms the basis of everything we eat. It also evaporates water, setting the water cycle in motion.

Even gravity is a resource. Without gravity, seeds from trees and plants would never fall to the ground and grow into plants. There would also be no rain to help them survive.

The amount of oxygen in our atmosphere stays about the same because it is constantly recycled through plants, animals and oceans.

In some parts of the world, electricity is generated from heat within the Earth. This is known as geothermal energy.

Forests are a renewable resource that is under serious threat. Most of the world's natural forest cover has been cleared or logged.

Fresh water is vital for all life forms on Earth, including plants, animals and humans.

Most of Australia's electricity comes from the burning of coal. Coal is an important energy resource in many countries.

Minerals are used as a resource in many ways. Uranium is just one of thousands of minerals mined around the world. It is being used at this nuclear power station to produce electricity.

Check your learning 1.1

Remember and understand

- 1 What are the three main types of resources? Give two examples of each type.
- 2 Why is it important to look after renewable resources, such as fresh water?
- 3 Describe how you may have used a non-renewable resource in the last hour.
- 4 What problems might societies around the world face if people continue to rely heavily on non-renewable resources?

Apply and analyse

- 5 Collect pictures of continuous resources, non-renewable resources and renewable resources from newspapers, magazines or the Internet. Sort these pictures into groups and describe how each resource is used by humans.

Evaluate and create

- 6 What do you think is the most important resource shown in Source 1.2? Give some reasons for your answer and be prepared to discuss this with a partner and with the class.

Source 1.2 An overview of the many types of environmental resources.

Where water comes from

Water is one of our most precious environmental resources. Without it, nothing can survive. It is an essential, renewable resource that occurs naturally on Earth. It can exist as a solid (such as ice in a **glacier**), a liquid (such as water in a river) or a gas (such as steam). Fresh water is an available resource when in liquid form and a potential resource as a gas or a solid. Liquid water is constantly being recycled through the atmosphere, rivers and oceans in a natural system known as the **water cycle** (see Source 1.4).

In the water cycle, water from the oceans and lakes is heated and evaporated by the Sun. The evaporated water vapour, which is like steam, then rises until it reaches the cooler parts of the atmosphere. Cold air cannot hold as much moisture as warm air, so the water vapour turns back into liquid water in a process known as **condensation**. These drops of water then form into clouds, which may be carried on to land by winds and forced to rise. The colder air can no longer hold the condensed droplets and they fall as rain. The rainwater finds its way back to the world's lakes and oceans through rivers and streams and the process begins again.

As you can see in Source 1.4, rain falls when **wet air masses** are forced to rise. There are three reasons that air masses rise. Each of these will produce different types of rainfall at different places on the Earth's surface.

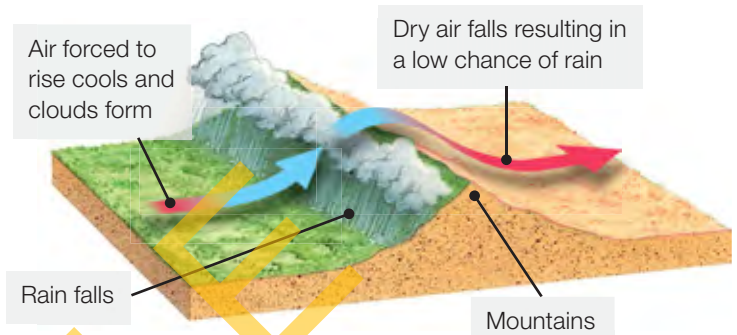
keyconcept: interconnection

The water cycle

The water cycle links together large areas of the natural environment (see Source 1.4). The world's oceans, mountains, rivers and atmosphere are all important parts of this cycle. The water cycle links together the natural and human environments because water is so central to all human activities. The presence of water is key when settling new farms and cities. For more information on the key concept of interconnection, refer to section GT.1 of 'The geographer's toolkit'.

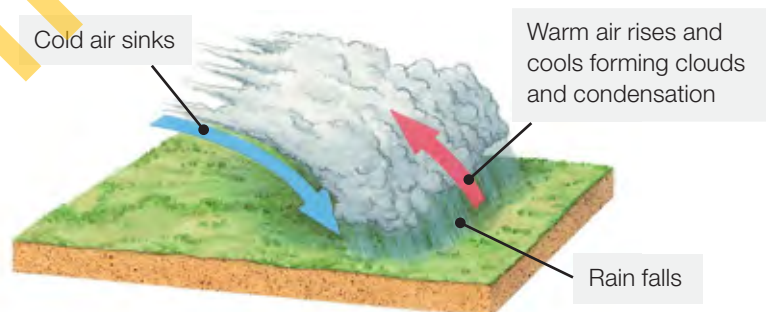
Orographic rainfall

Air is forced to rise due to the height of landmasses, such as mountains. As the air cools, condensation forms, producing rain. As the air begins to fall from the high land, it warms up, creating dry regions.



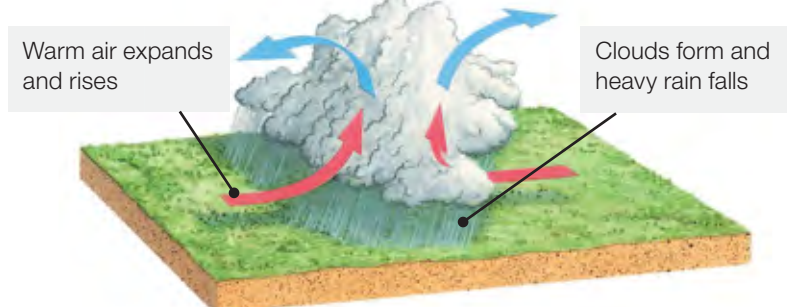
Frontal rainfall

Two air masses meet and the cooler air mass wedges itself under the warmer air mass. This forces the warm air to rise and cool, causing condensation and rain along a distinct line.



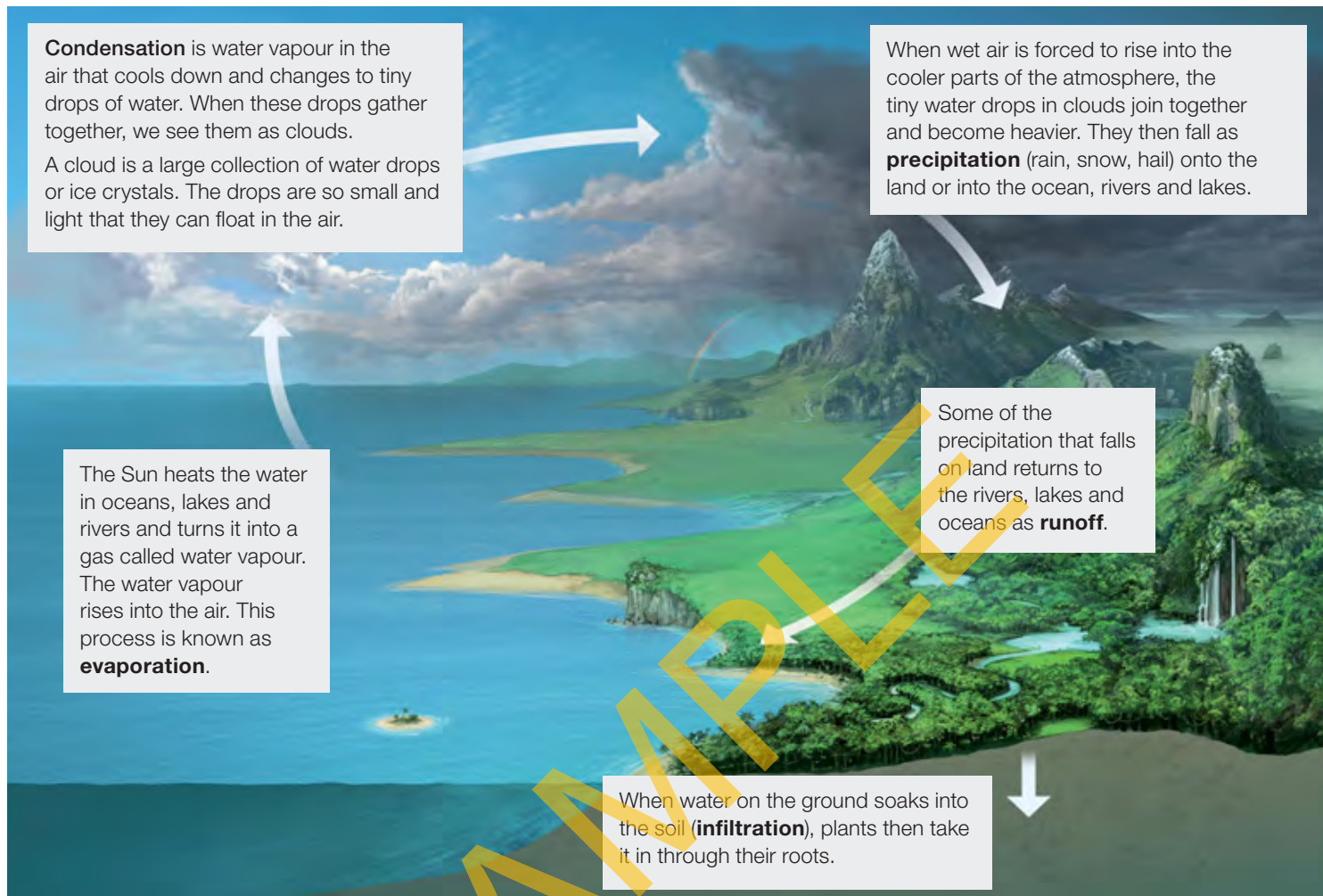
Convective rainfall

Temperatures during the day warm the ground causing warm air to rise rapidly and condense at high altitude. This produces heavy rain and thunderstorms.



Source 1.3 Different types of rainfall

The water cycle



Source 1.4 The stages of the water cycle

Check your learning 1.2

Remember and understand

- 1 What is the water cycle?
- 2 What causes water to fall as rain?
- 3 List these words in the correct order within the water cycle: precipitation, condensation and evaporation. Now write a definition for each in your own words.

Apply and analyse

- 4 What is the difference between frontal rainfall and orographic rainfall? How are they similar?
- 5 Why do you think the wettest place in Australia is near Tully on the eastern slopes of the Great Dividing Range in Queensland? You might like to find Tully in an atlas to help with your answer.
- 6 The water cycle helps us to understand how water moves

in our world but it can also help us understand how rivers change the landscape. How do you think the rivers shown in Source 1.4 have changed this landscape?

- 7 What type of rainfall do you receive most often in the place where you live? Why will the answer differ for students who live in other parts of Australia?
- 8 Salt water in oceans cannot be used to drink or water crops. Is salt water an available or potential resource?

Evaluate and create

- 9 Imagine that you are a water droplet in a cloud. Describe your journey through the water cycle in language that a young child would find interesting. Here is a start: 'Floating along with billions of my closest friends, I thought nothing would ever change ...'

Accessing water resources

Although the surface of the Earth is covered with water, only a tiny percentage of that water is fresh and available for consumption. Typically this is found in surface water, such as lakes and rivers. Source 1.6 shows the breakdown and availability of this water. As populations grow and more water is used, people are also using groundwater locked away in underground **aquifers**. This water supports every man, woman, child, animal and plant on Earth. This makes water our most precious resource.

To further complicate matters, the available fresh water is not evenly distributed across the planet. Some areas of the world have much more than they need, while other areas do not have enough.

Countries with large rivers, such as the Amazon River in Brazil, and those with high rainfall, such as Indonesia and Papua New Guinea, can be thought of as being 'water rich'. Other countries, including Australia, can be considered to be 'water poor'.

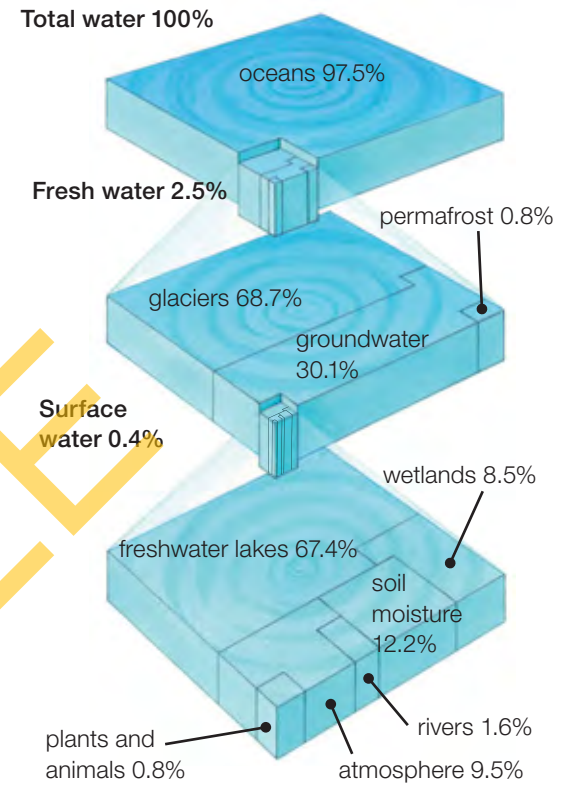
Groundwater

When it rains, water seeps into the soil to provide moisture for plants to survive. As water passes through the spaces between soil and rock it becomes groundwater. In the saturated zone, all the spaces between soil and rock particles are filled with water. The top of this zone is referred to as the water table (see Source 1.5).

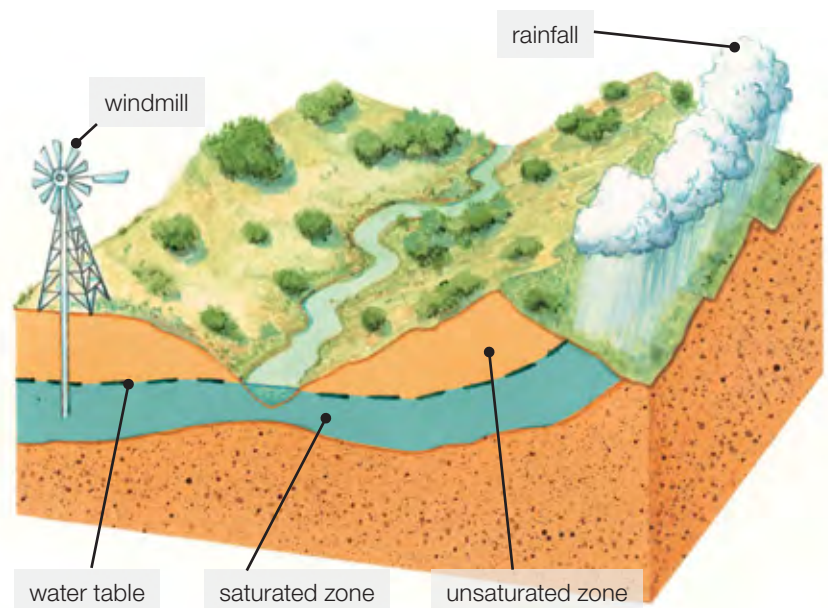
Groundwater is fed by surface water from rainfall and rivers and naturally comes to the surface at springs or at oases in dry areas. Groundwater is also drawn to the surface by bores drilled into the ground. Most of Perth's water is drawn from an underground aquifer, a layer of permeable rock that stores water.

The world's freshwater resources

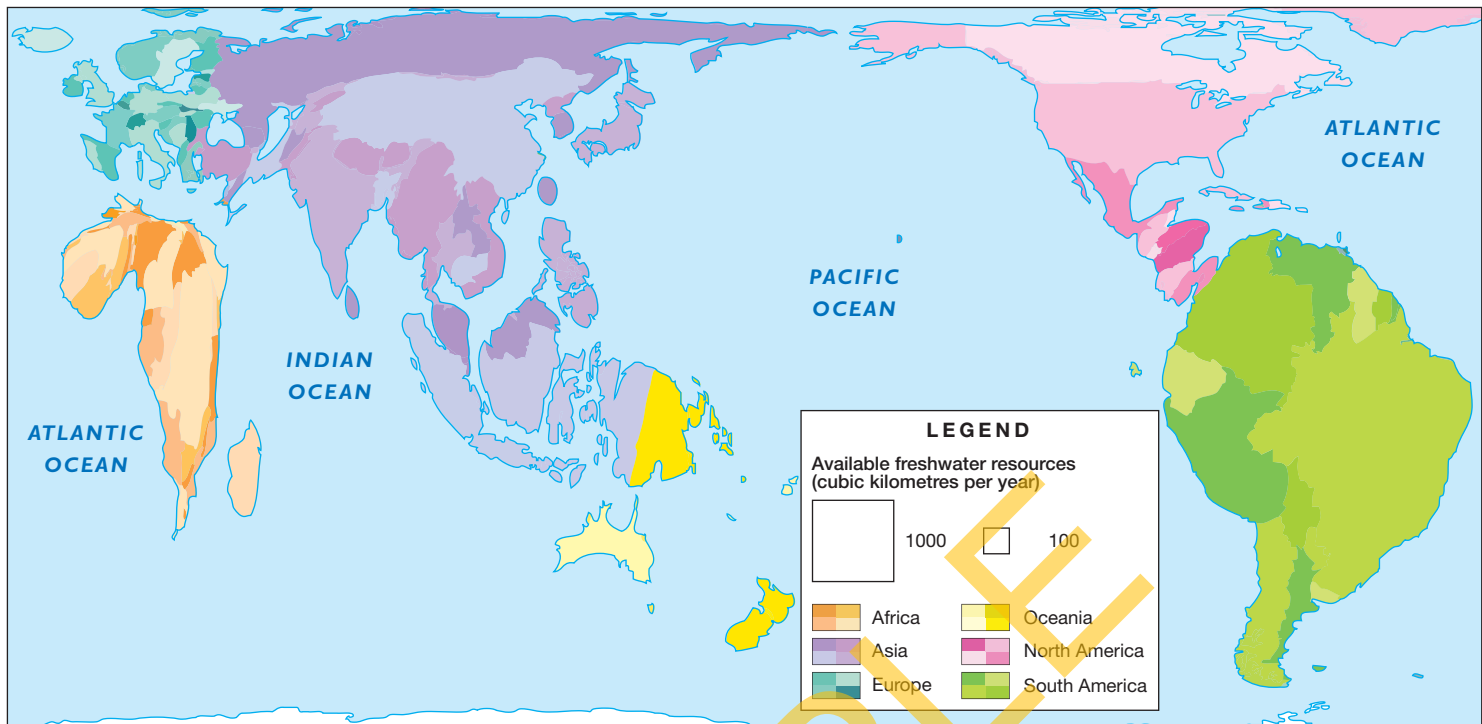
Source 1.7 is a map of the world as you have never seen it before. While each country is shown in its correct location, its size shows the proportion of the world's freshwater resources found there. Countries that appear fat are water rich; those that appear thin are water poor. Comparing the size and shape of countries in Source 1.7 with the same countries on a standard world map (like the one provided at the back of this book) will clearly show which are water rich (larger than normal) and which are water poor (smaller than normal).



Source 1.6 Distribution of the world's water



Source 1.5 Groundwater from aquifers is pumped to the surface via bores for use by humans



Source 1.7

Source: Oxford Big Ideas: Humanities 1

skilldrill

Using the PQE method to describe maps

The PQE method is used by geographers to identify trends and patterns in data and draw conclusions. For more information on the PQE method refer to section GT.2 of 'The geographer's toolkit'. There are three steps to follow when using the PQE (pattern, quantify, exceptions) method to describe maps:

Step 1 Pattern: Give a general overview of the pattern, referring to particular places. Which areas seem to have common features? (For example, 'The map of the world's freshwater resources shows that countries throughout South America have lots of fresh water'.)

Step 2 Quantify: Quantify your general overview using data for specific regions or countries. (For example, 'Brazil has more than 5000 km³ of fresh water a year'.)

Step 3 Exceptions: Point out any exceptions to the pattern you have described. (For example, 'Madagascar, the island off Africa, appears to have abundant water supplies, whereas the rest of the African continent does not'.)

Apply the skill

- 1 Use the PQE method to describe the world's freshwater resources. Be sure to describe areas that are water rich and those that are water poor. The world map on the inside back cover will be useful.

Check your learning 1.3

Remember and understand

- 1 How much of the world's water is fresh water, available for our use?
- 2 Is Australia water rich or water poor? What does this mean?
- 3 Study Source 1.7.
 - a Which countries would you consider to be the most water rich? Which are the most water poor?
 - b Compare the freshwater resources of Australia, New Zealand and Papua New Guinea.

Apply and analyse

- 4 What can countries that are water poor do to access more fresh water? Brainstorm this as a class. Think first of those methods that you already know about, perhaps those used in your local area, and then expand these into other possibilities.

Stored water

The water cycle is the movement of water through the Earth, but most of the fresh water on Earth is in storage. Fresh water can be stored for days or weeks in a lake or for thousands of years underground or in an ice cap, such as the one that covers much of Greenland. About 97.5 per cent of the Earth's water is found in the oceans and is too salty to drink. Much of the remaining 2.5 per cent, which is safe for us to drink, is locked in the polar **ice caps** and in flowing rivers of ice, known as **glaciers**.

Antarctica contains nearly 70 per cent of the world's fresh water as ice in an ice sheet that covers large sections of bedrock (solid ground) in Antarctica. The ice sheet has an average thickness of 2500 metres and scientists have found places where the ice is thought to be twice this thickness. If this ice were to melt, sea levels around the world would rise by up to 60 metres. Because the temperature in the interior of Antarctica remains below freezing, any snow that has fallen there in the last few million years has never melted and has gradually formed into a great dome of ice. The ice is gradually moving towards the sea away from the centre of the **continent**. As it reaches the sea, the ice breaks off into gigantic **icebergs**.

Source 1.8 The ice of Antarctica stores most of the world's fresh water.

Check your learning 1.4

Remember and understand

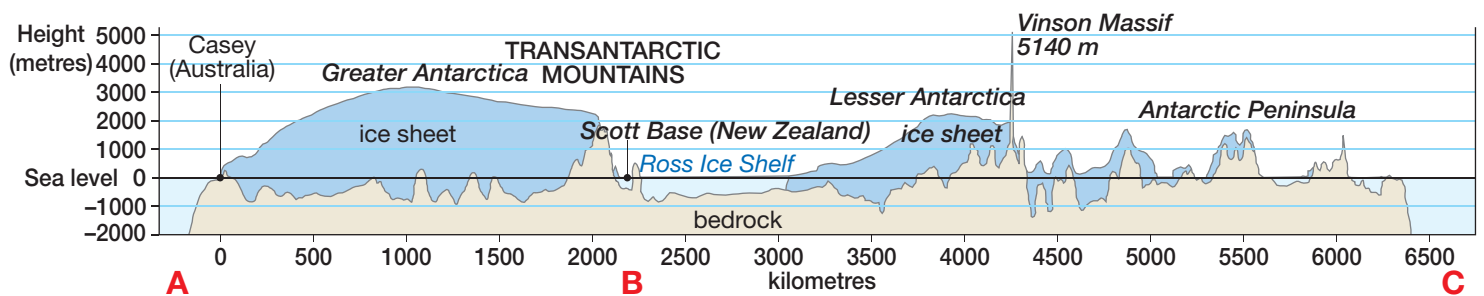
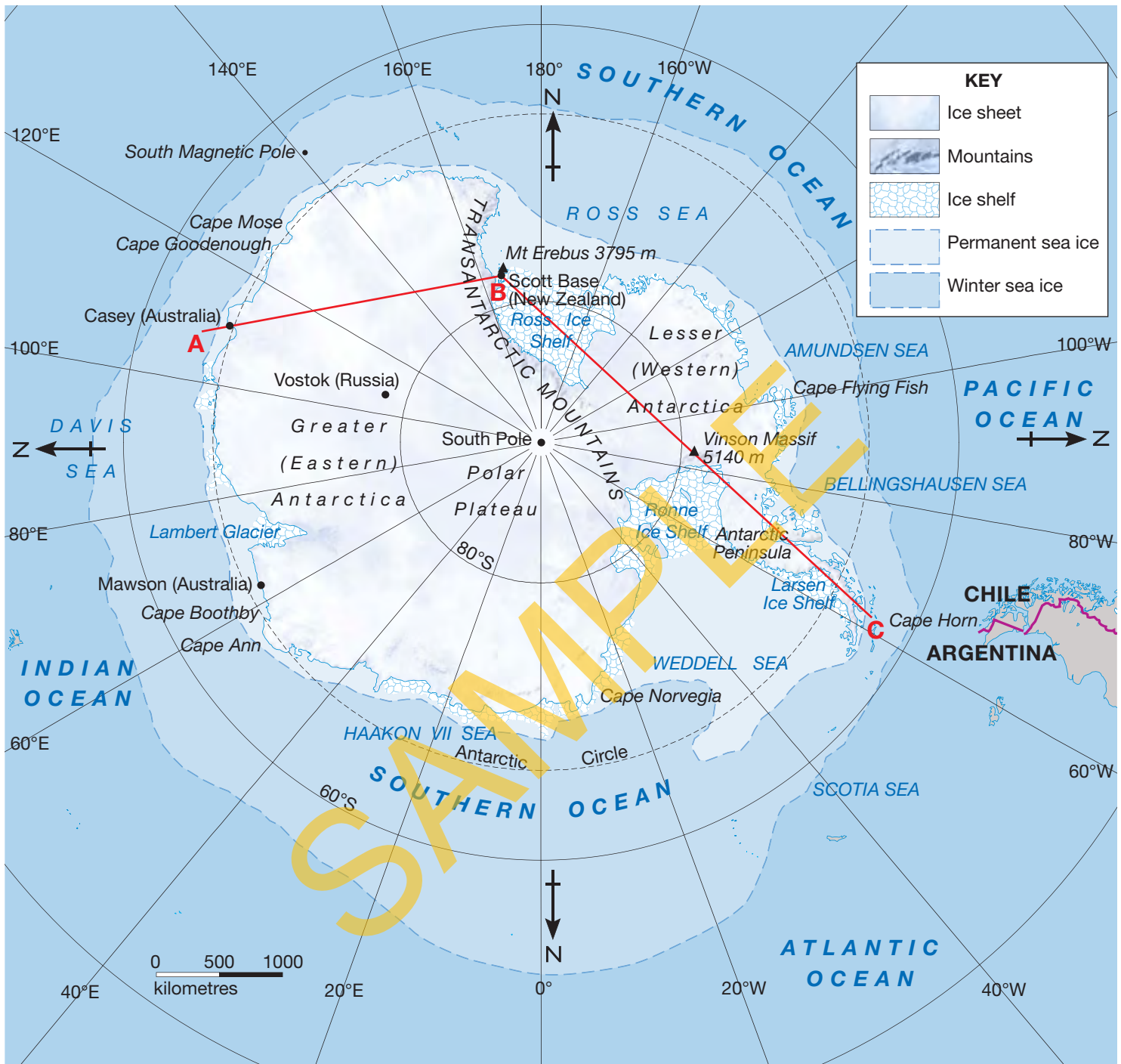
- 1 List three places where ice is stored.
- 2 Where is most of the world's fresh water stored?
- 3 Why doesn't the ice in Antarctica melt?

Apply and analyse

- 4 Look carefully at the map in Source 1.9.
 - a What happens to the sea surrounding Antarctica in winter?
 - b What is the difference between an ice sheet and an ice shelf?
- 5 Look carefully at the cross-section of Antarctica in Source 1.9. This shows a view of Antarctica from the side as if it had been cut along the A–B–C line on the map.
 - a Over which part of Antarctica is the ice sheet the thickest?
 - b Describe what Antarctica would look like without its ice sheet.
 - c Why is this cross-section a better way of showing the thickness of ice in Antarctica than the map?
- 6 What would happen if all the ice in Antarctica were to melt? What conditions might cause this to happen?



ANTARCTICA: LANDFORMS



Source 1.9

Source: Oxford University Press

1.2 bigideas: broadsheet

Perth's water supply

Like many Australian cities and towns, Perth faces many challenges in supplying its population with enough fresh water. A decline in its rainfall over the last 100 years has meant that the people of this rapidly growing city can no longer rely on rivers, lakes and dams to supply all their water needs. About half of Perth's water now comes out of the ground. North of the city are large aquifers which have collected rainwater for thousands of years and stored it within sand or limestone layers. Wells are dug to access the water which is treated, mixed with rainwater and used by Perth residents in their homes, farms and gardens. Up to 20 per cent of Perth's water comes from two large desalination plants. The city was one of the first in Australia to use desalination plants to provide fresh water. The Western Australian state government hopes that expansion of these plants will help to 'drought-proof' Perth.

PERTH: WATER RESOURCES

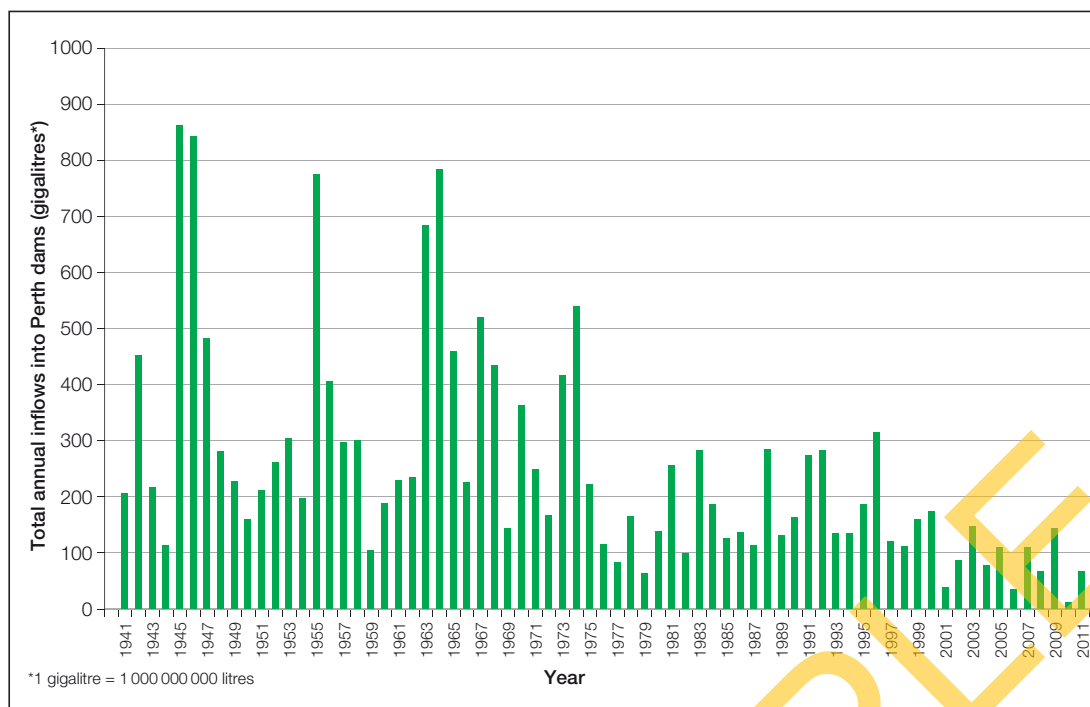


Source 1.11

Source: Oxford University Press



Source 1.10 One of Perth's desalination plants. The Perth Seawater Plant removes the salt from sea water to produce fresh water.



Source 1.12 Water flowing in to Perth's dams 1941–2011

skilldrill

Using a map legend

In order to show the features on maps clearly, various symbols and colours are used. To help us unlock the information on the map these symbols are explained in a legend (or key). There are three main types of map symbols:

- **point symbols** – show features in one particular place (such as a railway station or desalination plant)
- **line symbols** – show features that connect places on the map (such as roads and rivers)
- **area symbols** – use colours or patterns to represent large areas (such as lakes and cities).

Apply the skill

- 1 Study Source 1.11.
 - a What symbol has been used for desalination plants on this map?
 - b Give an example of an area symbol used on this map.
 - c How many groundwater treatment plants supply water to Perth?
 - d What do you notice about the location of the dams on this map?

Extend your understanding

- 1 Look carefully at Source 1.12.
 - a Compare the annual flow of water into Perth's dams before and after 1975. What difference can you see?
 - b List the four years with the smallest annual inflows of water. What do you notice from this pattern?
 - c Why do you think the annual inflow of water changes so greatly between years?
- 2 What two other sources of water does Perth use to access water other than dams fed by rain?
- 3 Do you think it is possible to drought-proof a city? Give some reasons for your answer.
- 4 What do you think will happen to the water in an aquifer if water continues to be pumped out of it for use in a city such as Perth?
- 5 Why does Perth need more water now than it did 100 years ago?
- 6 What are some of the strategies being tried to address water problems in other parts of Australia?

1.2 How does water connect and affect places?

Water connects places

Because people rely on water to survive, easy access to water influences where people choose to live. Cities, towns and villages are often located near fresh water sources such as rivers, lakes and underground water reserves. Water sources also directly influence the way people live; for example, the crops they grow or the transport they use. As human settlements tend to cluster around the same types of water sources, these water sources need to be shared by the communities. Because of this, many places around the world are connected with each other through these water sources. Generally, three main factors relating to water influence where people settle. These factors are discussed below and shown in Source 1.13.

Historical and environmental factors

Historically, towns and cities have developed along rivers and near lakes and other fresh water sources. People will settle anywhere there is water, adapting their way of life to the local environmental features. Communities in the Hindu Kush region of the Himalayas in Pakistan and Afghanistan depend on the seasonal melting of the snow and glaciers to provide them with fresh water. This melt also feeds the great rivers in the region, the Indus River and the Ganges River, that supply water to the many cities and communities that have been established along their banks – around 1.5 billion people.

Agriculture

Communities also rely on fresh water to grow crops and farm animals. The availability of fresh water will determine the sorts of crops grown. In places where water is limited, crops that need little **irrigation**, such as corn, will be grown. Crops that rely heavily on water, such as rice, are grown on **floodplains** where water is plentiful. These floodplains and **deltas**, located on flat land where rivers meet the sea, have particularly rich soil due to the deposits of silt that has travelled down the river from the mountains.

Trade and transport

Rivers move water across the Earth's surface, carrying water great distances to the sea. Rivers, lakes and oceans also act as transport networks, allowing products and people to move easily from one place to another, connecting the communities established on their banks.

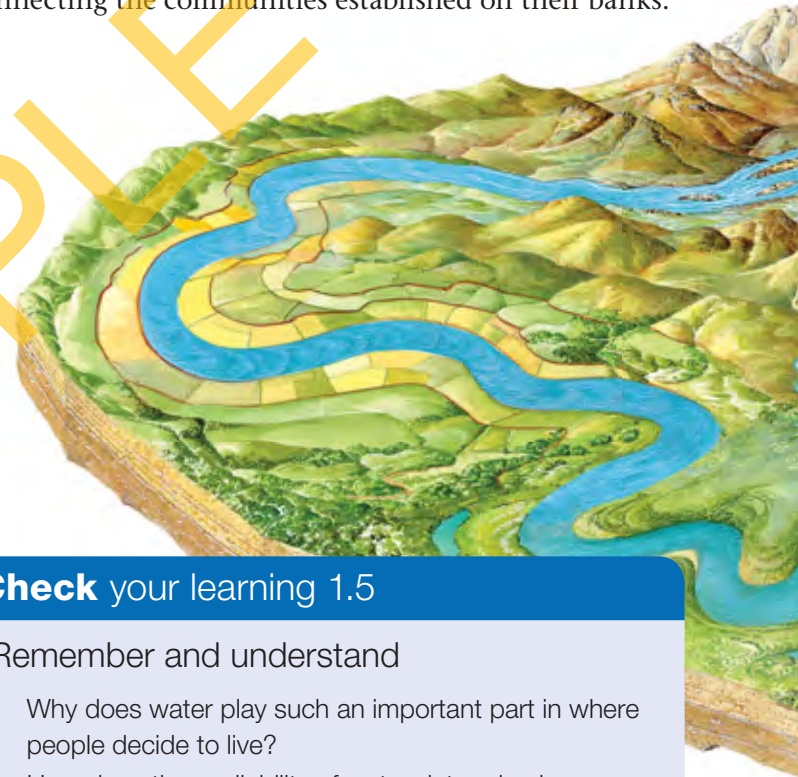
Check your learning 1.5

Remember and understand

- 1 Why does water play such an important part in where people decide to live?
- 2 How does the availability of water determine how people in different places live?
- 3 Name three factors relating to water that influence where people choose to settle. In your own words, describe each of these factors briefly.

Apply and analyse

- 4 Describe how water flowing along a river can connect people living at different points along it.
- 5 How has the choice of crops being grown in Source 1.16 been determined by the environment? By contrast, what types of crops do you think would be grown in the location shown in Source 1.14?



How rivers connect people and places



Source 1.14 Communities in the Himalayas (a mountain range in Asia) depend on annual glacial melts to replenish their water supplies. Once replenished, excess water flows into rivers, connecting these communities with others downstream.



Source 1.15 Large cities and towns around the world are connected by rivers. River waters allow people to travel and goods to be transported and traded. This barge on the Rhine river is carrying coal from the city of Cologne south to Switzerland.



Source 1.16 Farming communities along the Mekong Delta in Vietnam plant their rice crops in the rich soil of the floodplains.

Source 1.13 The water that flows through the river systems around the world connects people and places in many ways.

Water affects places

As well as connecting different people and places, water can also affect them – in both positive and negative ways. On the positive side, water from the rain and rivers is used to irrigate the crops and farm the livestock that we eat. This water has a positive effect on the places in which we live. Without it, no life could exist. On the negative side, water in all its states – whether as a liquid (water), a solid (snow and ice) or a gas (fog) – can cause serious problems and damage in different places. Snow storms can shut down cities for days, heavy fog can disrupt air travel and cripple airports, and heavy rainfalls can cause widespread flooding.

A good way of understanding how water affects places is to look at some case studies relating to rivers. Rivers are interesting to study because if there is a problem upstream (such as a flood or pollution) this problem will quickly travel downstream, affecting the people who live there. Flooded rivers can affect many settlements along their banks, collecting and carrying debris, such as trees and cars, as they go. If pollution or toxic chemicals enter the water at one location on the river, they quickly affect other parts of the river downstream, as well as the people who use it.

Case study: Tisza River pollution, 2000

In 2000, a storage pond used by a gold mine in Romania burst its banks. Around 100 000 cubic metres of water containing poisonous cyanide spilt into a local river that flowed into the Tisza River in nearby Hungary.

The cyanide spill killed much of the fish and plant life for several 100 kilometres downstream. Drinking water was polluted in four different countries: Romania, Hungary, Serbia and Bulgaria.

Source 1.17 A Hungarian fisherman pulls out toxic fish from Lake Tisza on the Tisza River 12 days after a serious chemical spill upstream in Romania on 30 January 2000.

Case study: Thailand floods, 2011

In 2011, the people of Thailand experienced some of the worst flooding they had seen for decades. Areas of Thailand are prone to flooding as the annual monsoon brings heavy rain, particularly in the north of Thailand. In early 2011, a tropical cyclone combined with the monsoon to more than triple the amount of rain falling on northern Thailand. As heavy rains continued for several months, rivers burst their banks in the mountainous north, resulting in flash flooding and at least 13 deaths.

Flooding continued downstream in many large towns built beside rivers. Soon the country's capital, Bangkok, became the area of greatest concern. Located on a low floodplain at the mouth of the Chao Phraya and Tha Chin Rivers, Bangkok is very prone to flooding and, despite an intricate system of flood walls and canals, much of the city flooded. By the time the floodwaters receded, they left more than 500 people dead and a damage bill of more than US\$45 billion.





Source 1.18 Floodwaters in the main street of Ayutthaya during the floods in Thailand in 2011 shut down the city and resulted in many deaths

THAILAND: TIME LAPSE MAP SHOWING THE SPREAD OF FLOODWATERS, MID-AUGUST 2011 TO 15 NOVEMBER 2011



Check your learning 1.6

Remember and understand

- 1 Give examples to show how water affects places in its gas, liquid and solid states.
- 2 What problems did the gold mine in Romania cause downstream?

Apply and analyse

- 3 Look carefully at Source 1.19.
 - a When did floodwaters reach Bangkok?
 - b How far had some of the floodwater travelled? (Use the scale provided to calculate the distance.)
- 4 Decide whether each of the following facts makes flooding in Bangkok more likely or more dangerous. Justify your answer for each one.
 - a Between June and October Thailand experiences its wet season with heavy monsoon rains.
 - b Bangkok has been built on the Chao Phraya River delta.
 - c Between 1985 and 2010 Thailand's population increased by more than 10 million people.
 - d The land on which Bangkok is built is sinking by 30 millimetres a year.

Source 1.19

Source: Oxford University Press

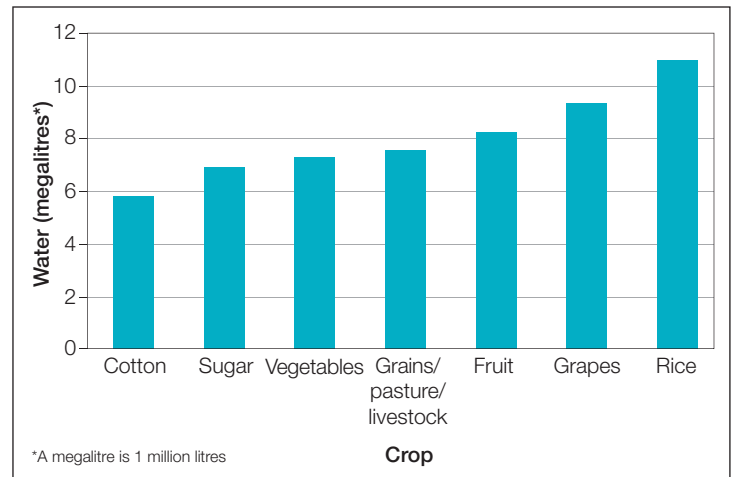
Water for food

Farmers are by far the biggest users of water in Australia. About 70 per cent of the fresh water used each year in Australia is used in agriculture. This water is used to produce an enormous range of products, many of which you consume every day (see Source 1.20).

You may not realise it, but a lot of water was needed to produce your breakfast. Many everyday products use even more water. For example, it takes up to 50000 litres of water to produce 1 kilogram of beef, and 685 000 litres to produce enough wool to make one suit. The amount of water needed to produce an item of food, such as a steak, or a piece of clothing, such as a suit, is known as **virtual water**.

In Australia, many crops are grown in the Murray–Darling Basin in south-eastern Australia (see Source 1.23). While a lot of the water used in this region falls on the farms as rain, much of it is taken from the rivers. Movement and control of water has a large economic impact in this region.

In the past, the rivers in this region had a normal cycle of flood and drought. Farmers needed a more reliable flow of water and so a system of dams and weirs was built along the river. These collect water during wet times and release it gradually during dry times, thereby controlling the flow of the river.



Source 1.21 Water used per hectare (10000 square metres) to grow selected crops

Farmers are allowed to use a certain amount of water each year and are charged for the amount of water they use. Because they have to pay for their water, farmers in this region use it very carefully. Another reason for farmers to use water as efficiently as possible is the scarcity of water in many parts of Australia. In the early years of the twenty-first century, a widespread and severe drought turned the Darling River and many others into a series of pools separated by kilometres of dry river bed. Because of these factors, many farmers and farming industries have developed more water-efficient methods of farming.



Apricots

Apricots are grown and processed in northern Victoria and southern New South Wales. They are processed in various plants centred around Shepparton, Victoria.

Estimated water needed to produce 1 kilogram of apricots: 1391 litres



Bread

The main ingredient in bread is wheat. New South Wales produces the most wheat in Australia, most of this in the east of the Murray–Darling Basin.

Estimated water needed to produce 1 kilogram of wheat: 750 litres



Milk and butter

More than 60 per cent of Australia's milk and milk products comes from Victoria. Leongatha in Victoria is home to a huge dairy factory.

Estimated water needed to produce 1 glass of milk: 200 litres
Estimated water needed to produce 1 kilogram of butter: 18 070 litres



Raspberry jam

The main ingredient in raspberry jam is sugar. Virtually all of Australia's sugar is grown in Queensland. Raspberries grown in the Goulburn Valley make up 40 per cent of the jam.

Estimated water needed to produce 1 kilogram of sugar: 173 litres
Estimated amount of water needed to produce 1 kilogram of raspberries: 713 litres



Rice Bubbles

Rice Bubbles are made from 89 per cent whole white rice, which is grown in the Murrumbidgee Irrigation Area (part of the Murray–Darling Basin). Much of the rice industry is centred around Deniliquin in southern New South Wales.

Estimated water needed to produce 1 kilogram of rice: 1550 litres

Source 1.20 Water requirements to produce typical breakfast foods



Source 1.22 An irrigation channel in the Murray–Darling Basin

Murray River irrigation

Lake Hume is an artificial lake formed by the Hume Weir near Albury–Wodonga on the Murray River. Completed in 1936, it is one of a series of dams and weirs built to control the flow of water in the Murray River. Its main purpose is to trap water during periods when there is a large amount of water in the Murray River and release it gradually to keep the flow of the river relatively constant.

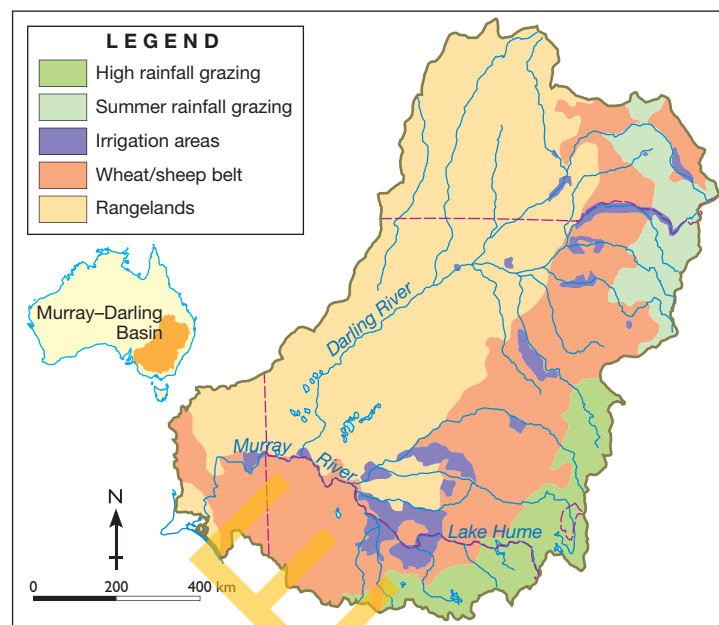
A network of irrigation pipes and open channels carries the water from the Murray River hundreds of kilometres to individual farms. Open channels are generally less efficient than pipes as water is lost to evaporation and water seeping into the soil. However, they are much cheaper to build than pipes.

When the water reaches the farms it flows through gravity or is pumped onto the crops or pastures. A common method of irrigation is the use of a pivot spray. A giant arm with sprayers attached moves around a central pivot point, creating distinctive circles of green.

Source 1.24 Pivot spray irrigation



MURRAY–DARLING BASIN: LAND USE



Source 1.23

Source: Oxford Atlas

Check your learning 1.7

Remember and understand

- 1 How much of Australia's fresh water is used on farms?
- 2 How does water for irrigation of crops and pastures reach the farms?
- 3 Rank the breakfast foods shown in Source 1.20 in order from greatest water need to least water need.

Apply and analyse

- 4 Can farmers use as much water as they want?
- 5 Look at Source 1.21.
 - a Which crop uses the most water?
 - b Which crop uses the least water?
- 6 Why do you think it takes so much water to produce 1 kilogram of rice?
- 7 In what ways is the Murray–Darling Basin one of Australia's most important resources?
- 8 Look closely at the map (Source 1.23).
 - a What relationship do you notice between irrigation areas and rivers?
 - b Explain the nature of this relationship.

Evaluate and create

- 9 Draw a labelled diagram to clearly show how pivot spray irrigation works. Use Source 1.24 to help you.

Water for energy

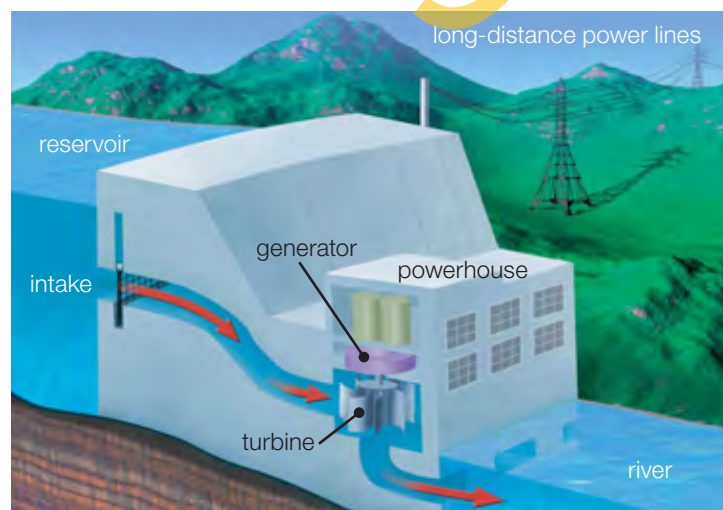
Moving water has been used as a source of power since 240 BCE, with the invention of the water-driven wheel. Watermills use the force of the flowing water to drive the blades of a large wheel or turbine. This, in turn, rotates an axle to drive the machinery inside the mill.

Hydroelectricity

Hydroelectric power is generated in the same way that early watermills operated. A dam is built across a river, creating a large reservoir of water. This water is then released through turbines, causing them to turn. The spinning turbine rotates giant magnets around a huge coil of copper wire to create electricity. The faster the water flows, the more electricity is created.

Australia's largest plant is the Snowy Mountains Hydroelectric Scheme. More than 100 000 people from over thirty countries constructed the huge tunnels, dams and power stations. Electricity generated by the scheme is used in the Australian Capital Territory, New South Wales and Victoria.

Hydroelectricity is the largest source of renewable, non-polluting energy in the world. The main negative impact of building a hydroelectric plant is that the natural flow of the river is stopped and the land behind the dam is flooded. The flooding of valleys behind the dam can destroy natural habitats and human features, such as houses, fences and roads.



Source 1.25 How a hydroelectric power station works

Case study: Three Gorges Dam, China

China's Three Gorges Dam is not only the world's largest dam, it is also the largest power station ever built. More than 2 kilometres long and 180 metres high, the dam has turned the Yangtze River into a lake 660 kilometre long. As well as producing electricity, the dam has increased the Yangtze River's shipping capacity, and has reduced the flooding hazard downstream. The building of the Three Gorges Dam stirred protests around the world, as it involved displacing 1.25 million people and flooding more than 600 square kilometres of land; that is about 30 000 times the size of the Melbourne Cricket Ground.



Source 1.26 An oblique aerial view of the Three Gorges Dam on the Yangtze River in China. Water flows through the open sluice gates. The hydroelectric power station is to the left of the sluice gates.

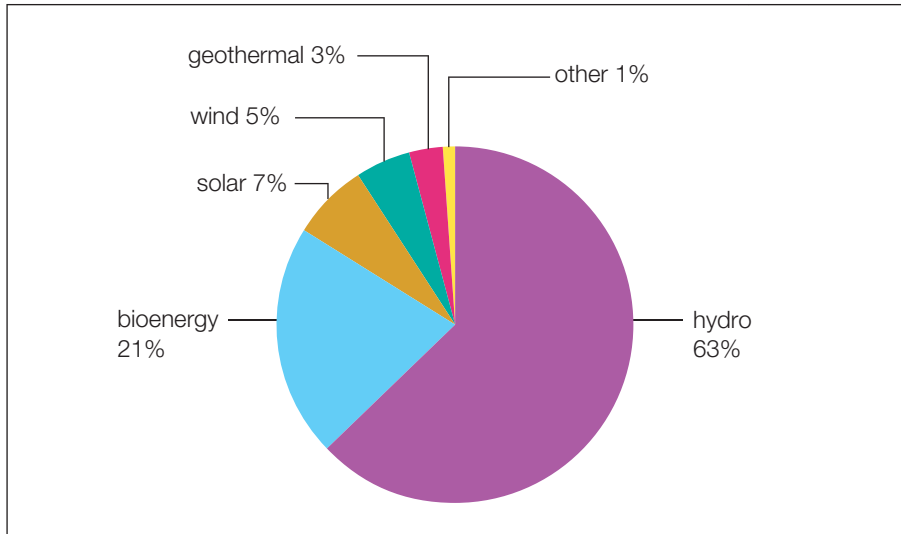
Check your learning 1.8

Remember and understand

- 1 How is water used to create electricity?
- 2 What is the main source of renewable energy in the world?
- 3 What advantages and disadvantages does the building of dams bring?
- 4 How can you stop a river flowing to enable a dam wall to be built?

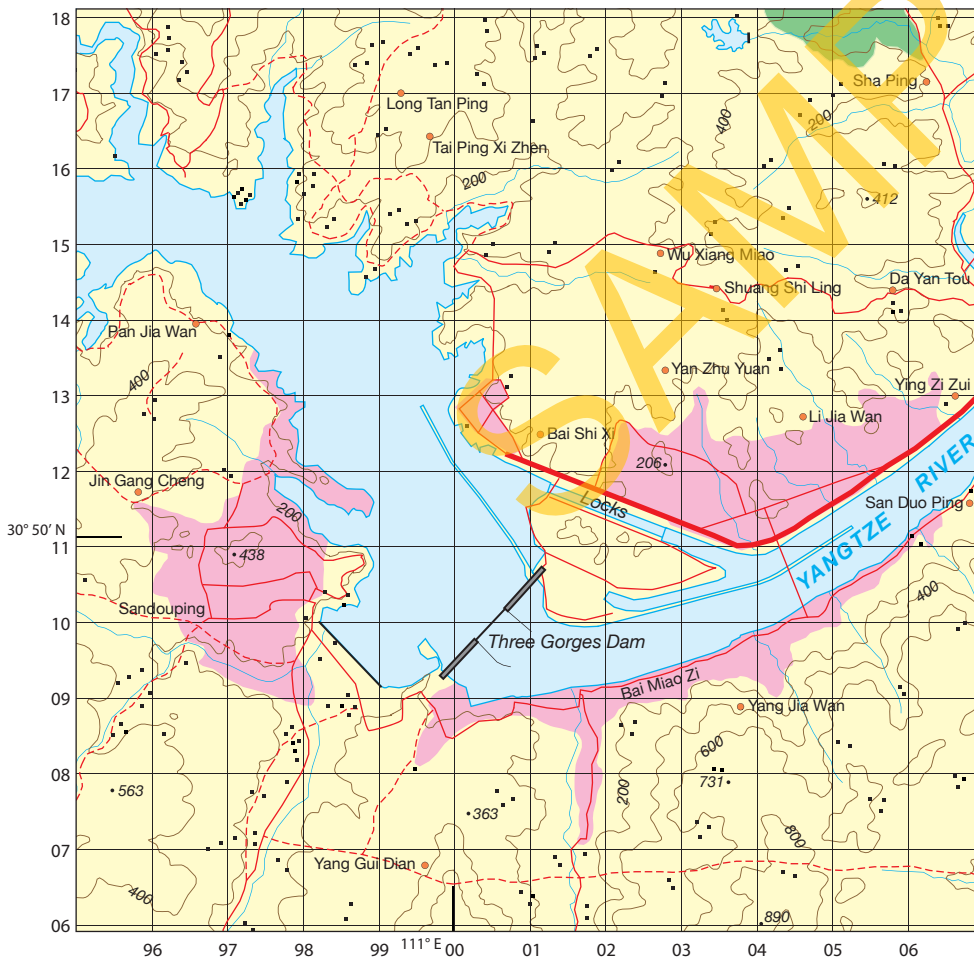
Apply and analyse

- 5 Look carefully at Source 1.26. Oblique aerial images are taken from an angle and show a foreground and a background. Is the dam wall in the foreground or the background?
- 6 Draw a sketch of the oblique aerial image (Source 1.26) and label the following:
 - Three Gorges Dam
 - Yangtze River
 - hydroelectricity plant
 - flooded valley.
- 7 What happened to the towns, villages and farms upstream of the Three Gorges Dam on the Yangtze River?



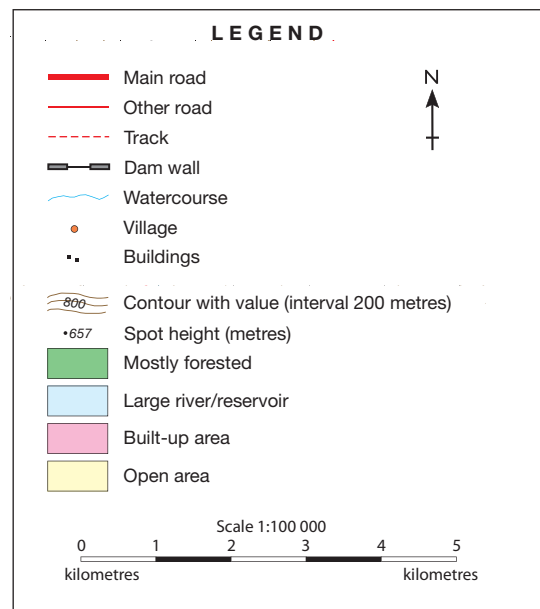
Source 1.27 Energy from renewable and continuous sources. Hydroelectric power accounts for most of the total energy produced from these sources around the world.

CHINA: THREE GORGES DAM



Source 1.28

Source: Oxford University Press



1.2 bigideas: broadsheet

The Ok Tedi mine

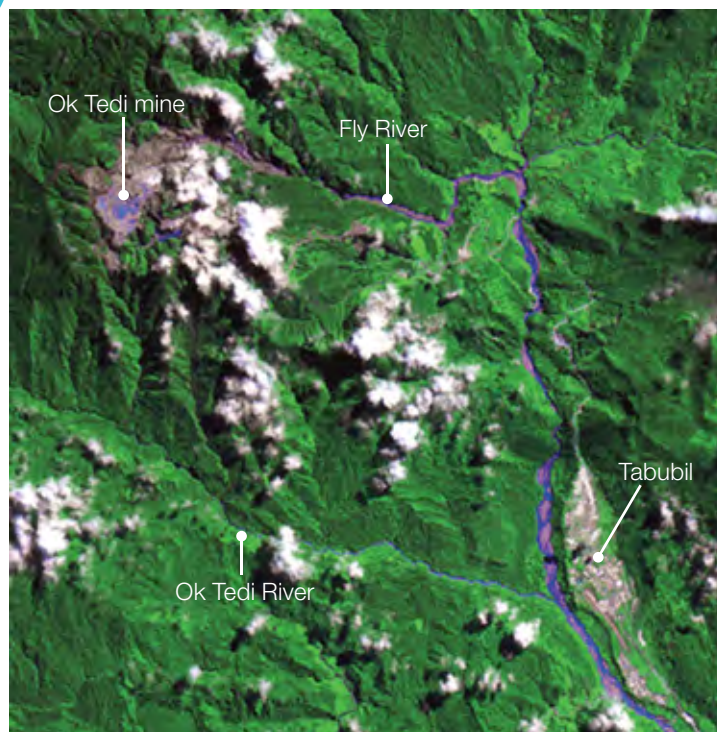
The Ok Tedi copper and gold mine is located at the headwaters of the Ok Tedi River, a tributary of the Fly River, in Papua New Guinea. During mining operations large amounts of chemicals are used to separate the precious minerals from other rocks. These chemicals, along with the residue of rocks and ore (known as **tailings**), need to be disposed of. In order to do this, the mine owners (BHP) built a dam known as the tailings dam. The tailings dam allowed heavy metals and solid waste from the mine to settle. Cleaner water would then be released into the river system.

Unfortunately, an earthquake in 1984 collapsed the tailings dam. BHP argued it was too expensive to rebuild it.

Since 1984 the mine has discharged 70 million tonnes of tailings into the river system each year. Chemicals from these tailings destroyed wildlife, particularly fish, in the river, and the materials dumped into the river changed a deep and slow river into a shallow river with rapids. Transport up and down the river became more difficult. The change in the river bed led to frequent floods that spread contaminated mud onto 1300 square kilometres of farms by the Fly River. The discharge from the Ok Tedi mine caused great harm to the 50 000 Indigenous people who live in the 120 villages downstream of the mine. Millions of dollars in compensation was paid to those affected by the misuse of the river system.



Source 1.29 Ok Tedi mine



Source 1.30 Satellite image of Ok Tedi mine, 5 June 1990



skilldrill

Identifying change over time

By carefully examining photographs, satellite images or maps from different times we can see the changes that occur at a location. When studying the same area at two different times:

- Step 1** Find a key feature, such as a river or main road, as a reference point on both sources.
- Step 2** Note the areas of the image where there has been little or no change.
- Step 3** List the differences in the later image where there has been change.
- Step 4** Look for other information on the image that shows what might have contributed to the change.
- Step 5** Describe the type of change – permanent change or seasonal change (such as different stages of crop production or plant growth).

Apply the skill

- 1 Study Sources 1.30 and 1.31.
 - a In what two years were the satellite images taken?
 - b Were the images taken at different times of the year?
 - c What changes to the rivers occurred between the two years when these images were taken?
 - d Why did these changes occur?
 - e Are these changes permanent or seasonal?
 - f Draw a sketch map of the area in 2004, using a key and labels to outline the changes that have occurred since 1990.



Source 1.31 Satellite image of Ok Tedi mine, 26 May 2004

Extend your understanding

- 1 What competing uses were there for the Ok Tedi and Fly Rivers?
- 2 What problem did BHP have managing the polluted water in their tailings dam?
- 3 What environmental impact did the tailings have on the rest of the river?
- 4 What social impact did the actions of BHP at the Ok Tedi mine have on the Indigenous users of the river?
- 5 Give another example where change in water use in one part of a river has impacted on water users downstream.

1.3 How much water do we have?

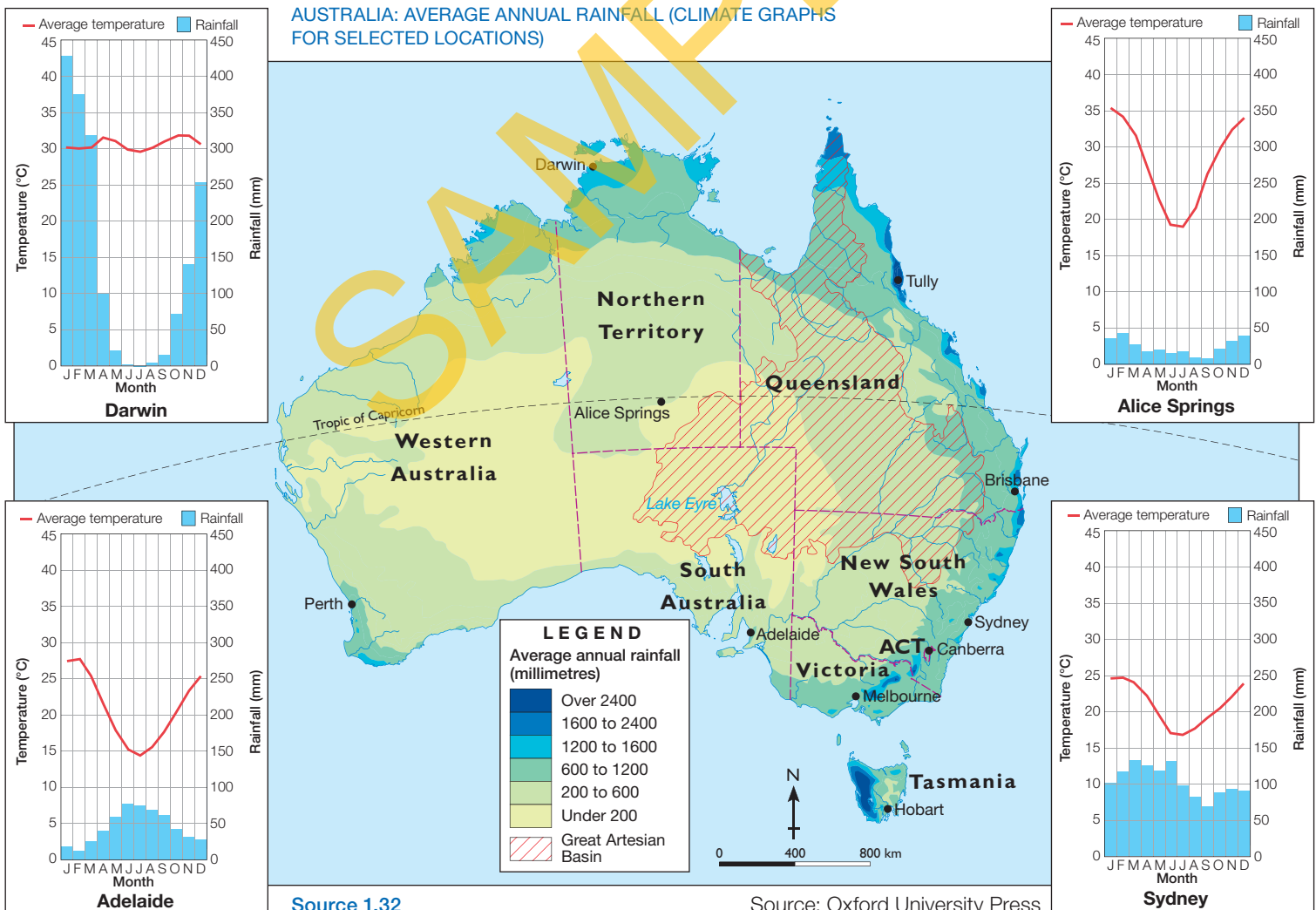
Water in Australia

Australia has the lowest volume of water in rivers and the smallest number of permanent wetlands of any continent except Antarctica. Australia's water supplies are not evenly distributed. The northern third of the continent lies in the **tropics** and receives heavy rainfall with **monsoons** in the summer. It is a water-rich area. By comparison, vast areas of the interior receive very little rain.

Virtually all of Australia's large cities and towns are positioned on the coast, especially in the east and south-east. While most of these areas receive good, reliable rainfall, pressure from a large number of water users has put great strain on water resources in these areas.

Rainfall distribution in Australia

Much of the Australian continent is dry. It is only the northern, eastern and south-western coastal regions that receive good annual rainfall. The climate of the eastern half of Australia is influenced by the Great Dividing Range. It extends 3500 kilometres from the northern tip of Cape York to southern Victoria. Moisture-rich winds from the south-east push warm, moist air over the land. Forced to rise and cool, the water droplets fall onto the east coast as rain, but as the air descends to the west, it becomes warmer and drier.





Source 1.33 Australia's heaviest rainfall makes Tully the white-water rafting capital of Australia.

Being such a large country, Australia has a great deal of variation in rainfall. It is common for one part of the country to have floods while another has a long drought. The wettest place in Australia is Tully, near Innisfail in north Queensland, which averages 4204 millimetres of rainfall a year. Tully receives so much rain because of its location within the tropics on the north-eastern facing slopes of the Great Dividing Range.

The driest place in Australia is on the shores of Kati Thanda (Lake Eyre) in South Australia, which receives little more than 100 millimetres per year. Kati Thanda receives so little rain because it lies far from any supply of moisture. Air masses reaching the interior of the country have generally dropped their rain on to the south-eastern corner of Western Australia, and so they are dry by the time they arrive at Kati Thanda.

Many communities in the interior of Australia rely on underground water as well as the little rain that falls. Lying beneath much of eastern Australia is the world's largest underground water supply, the Great Artesian Basin (see Source 1.32). It is over 1.7 million square kilometres in size and covers approximately 22 per cent of Australia. The water is trapped underground in a sandstone layer covered by sedimentary rock, creating an aquifer. Farmers and communities access this water by drilling a well and pumping water to the surface with a windmill.

Australia's river resources

Rivers are a vital source of fresh water for many people. Australia, though, has the lowest volume of water in rivers of any inhabited continent on Earth. On average, just 12 per cent of Australia's rainfall is collected in rivers; this is referred to as the river discharge. The remaining 88 per cent of rainfall is used by plants, held in natural water storages (such as lakes, wetlands and aquifers) or returned to the atmosphere through evaporation. The Darling River, part of Australia's largest river basin (the Murray–Darling Basin), loses enough water every year through evaporation to fill Sydney Harbour four times.

Check your learning 1.9

Remember and understand

- 1 Why do many Australians live on the southern and eastern coast?
- 2 Where are the wettest regions of Australia? Where are the driest regions of Australia?
- 3 How do many farmers and communities in inland Australia access more water?
- 4 Use the map in Source 1.32 to estimate how much rainfall is received every year on average where you live.

Apply and analyse

- 5 Use the PQE method outlined on page 47 to describe the distribution of Australia's rainfall.
- 6 Four climate graphs are shown in Source 1.32. Each of these gives us two important pieces of information about the climate at a particular place. Rainfall is shown as a series of blue bars while average temperatures are shown with a red line. The trickiest part of reading a climate graph is reading the correct scales. Temperature is shown on the left-hand side, rainfall is shown on the right-hand side, and months along the bottom. For more information on reading a climate graph refer to section GT.2 of 'The geographer's toolkit'.
 - a Which is the most water poor of the four places shown? Why is this?
 - b Which has the most even or reliable rainfall throughout the year? Why is this?
 - c Which has the most seasonal rainfall?

Variations in Australia's water supply

Water is particularly difficult to manage in Australia, the driest inhabited continent on Earth. Australia has the lowest amount of water in rivers and the smallest areas of permanent wetlands in the world. Australia's water supplies are not evenly distributed. The northern third of the continent is water rich, while vast areas of the interior receive very little rain. Variable rainfall patterns make it quite common for one part of the country to experience major flooding while others experience extended periods of drought.

The Darling River

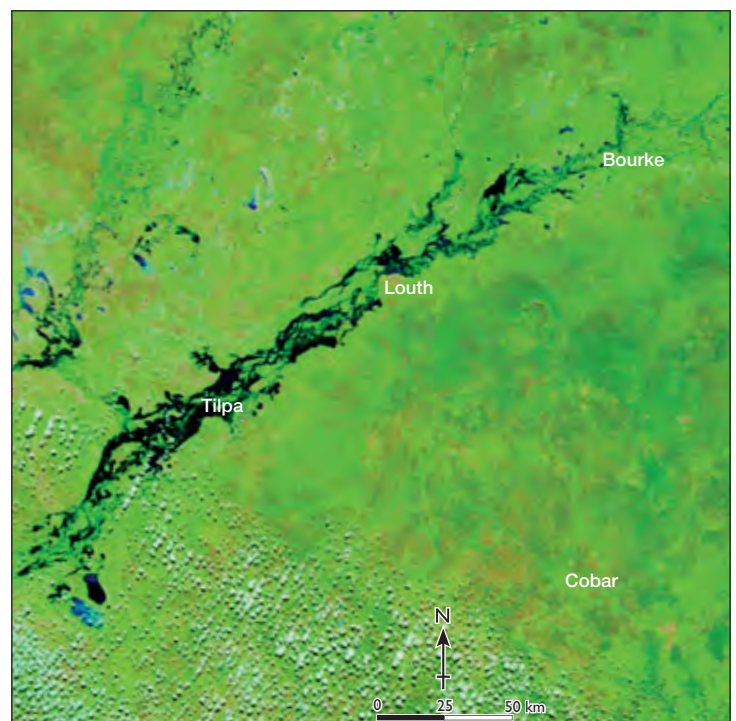
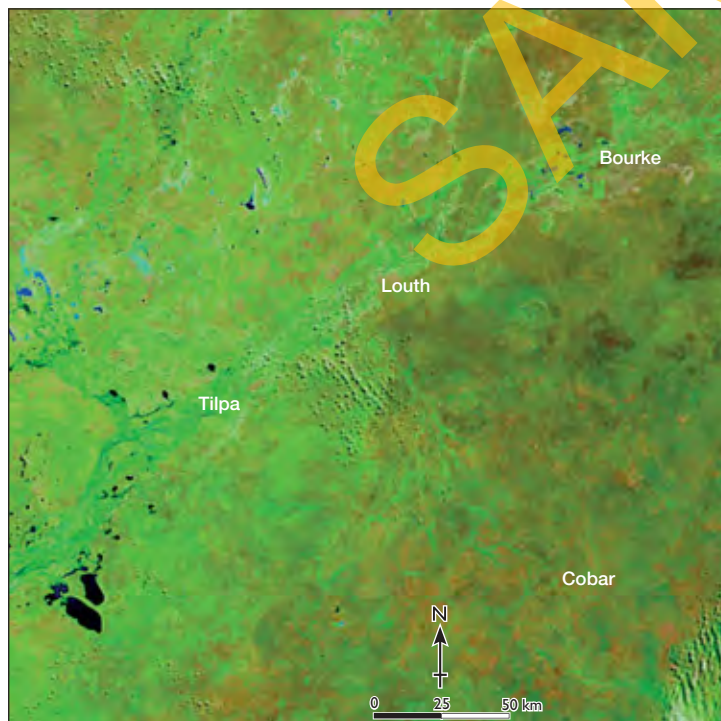
The Darling is Australia's third-longest river, flowing 1390 kilometres from Brewarrina until it joins the Murray River at the town of Wentworth. The Murray and Darling are the main rivers in the Murray–Darling River Basin, where 40 per cent of Australia's food is produced.

The flow of water in the Darling River varies greatly

due to drought and water that is taken to supply farms for irrigation. The Darling can be a small trickle or a raging torrent – it can even dry up completely. The Darling River stopped flowing at the town of Menindee, near Broken Hill in New South Wales, 48 times between 1885 and 1960.

Climate change

Australians have come to see drought as part of the natural cycle of rainfall patterns, but a new threat now faces us – and it is one we do not fully understand. For years scientists have been warning us about the possibility that our climate is changing. While the vast majority of the world's scientific community now accepts that the planet is warming due to the effects of greenhouse gases, these experts are much less sure how this will affect specific places and specific climates. It appears that climate change will mean less water for many Australians in the future, putting even greater pressure on our current supplies.



Source 1.34 These satellite images of the Darling River show the river affected by drought in 2011 (left), and flooded in March 2012 (right). These images use a photographic technique to help geographers distinguish between water and land. The colours used in the image are blue for water, bright green for vegetation, and an earth-tone for bare ground.

Much of Australia's fresh water comes from water collected in rivers, lakes and dams. This water will evaporate more quickly in the future, meaning that there will be less available for use in cities and rural areas. Source 1.37 shows the trends in annual rainfall over the last four decades. The green areas have had an increase in rainfall while the yellow and brown areas have had a decrease.

Source 1.35 Part of the poem 'My Country' by Dorothea Mackellar (1908)

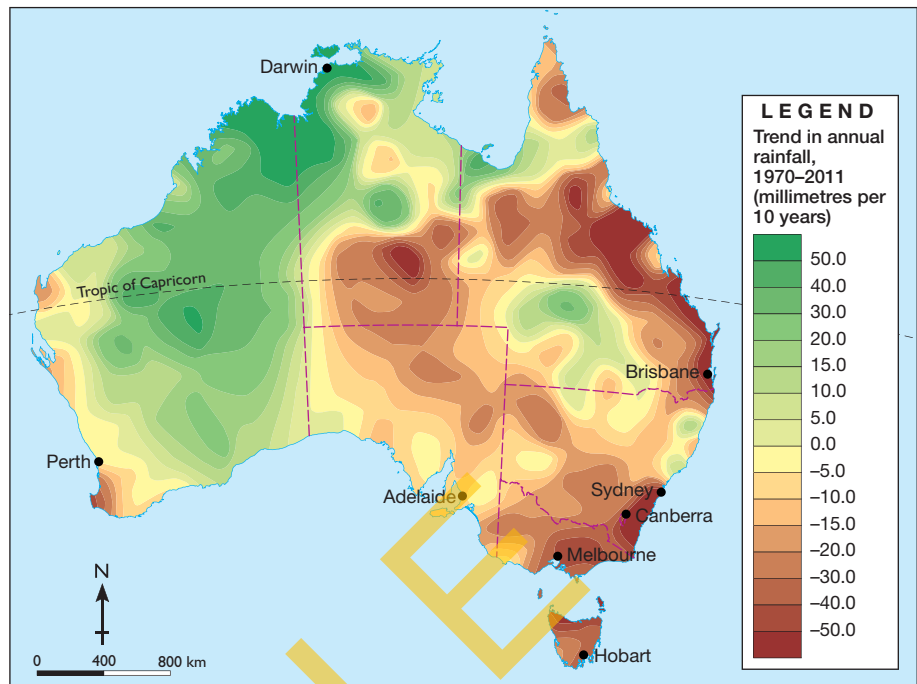
I love a sunburnt country,
A land of sweeping plains,
Of ragged mountain ranges,
Of droughts and flooding rains,
I love her far horizons,
I love her jewel-sea,
Her beauty and her terror –
The wide brown land for me! ...

Core of my heart, my country!
Her pitiless blue sky,
When sick at heart, around us,
We see the cattle die –
But then the grey clouds gather,
And we can bless again
The drumming of an army,
The steady, soaking rain...

Source 1.36 A young girl from Wentworth in New South Wales jumps over the Darling River in 2006 (top) and swims in it during a flood in 2008 (bottom).



AUSTRALIA: RAINFALL TRENDS, 1970–2011



Source 1.37

Source: Oxford University Press

Check your learning 1.10

Remember and understand

- Which part of Australia is the most water poor?
- Read the poem 'My Country' in Source 1.35.
 - Decide if you think the poem accurately describes the part of Australia you live in.
 - Which line in the poem best sums up Australia's variable water supply?
- Why might a warmer future lead to less water being available in Australia?
- Look at Source 1.34. How and why did the flow of water along the Darling River change between 2011 and March 2012?

Apply and analyse

- Look carefully at Source 1.37.
 - Between 1970 and 2011, which parts of Australia experienced significant decreases in annual rainfall?
 - Which capital cities have been most affected?
 - How has the Murray–Darling River Basin been affected?

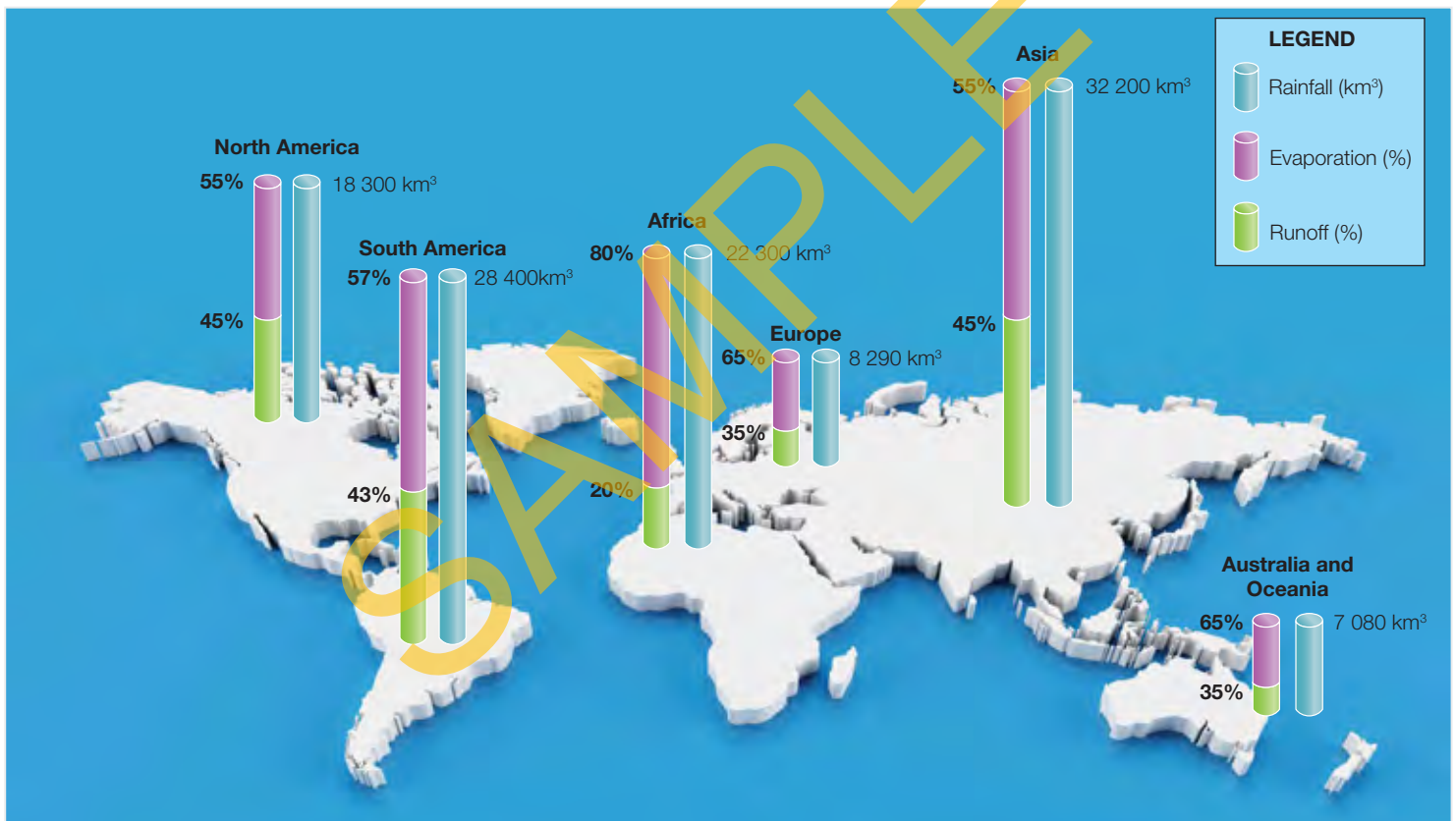
Water in the world

In an average year, 577000 km³ of rain falls on Earth. Of this, 458000 km³ fall, on the oceans and 119000 km³ on land.

When water falls to earth as rain, most of it **evaporates** back into the atmosphere. Of the annual rainfall that falls on land 74000 km³ (or 62 per cent) evaporates. In Australia, around 65 per cent of our total rainfall each year evaporates. The remaining 35 per cent runs off the land, and of this, only about 12 per cent ends up in our rivers. Only Africa has a higher

evaporation rate than Australia.

The amount of water in Australian rivers is the smallest of all inhabited continents, with South America experiencing the highest volumes of water in its rivers. For example, the Amazon River (the second-longest river in the world) carries more water than any other river on Earth with an average discharge (volume of water flowing through it) greater than the next seven largest rivers combined. Nearly 20 per cent of all the fresh water entering the oceans comes from the Amazon River.

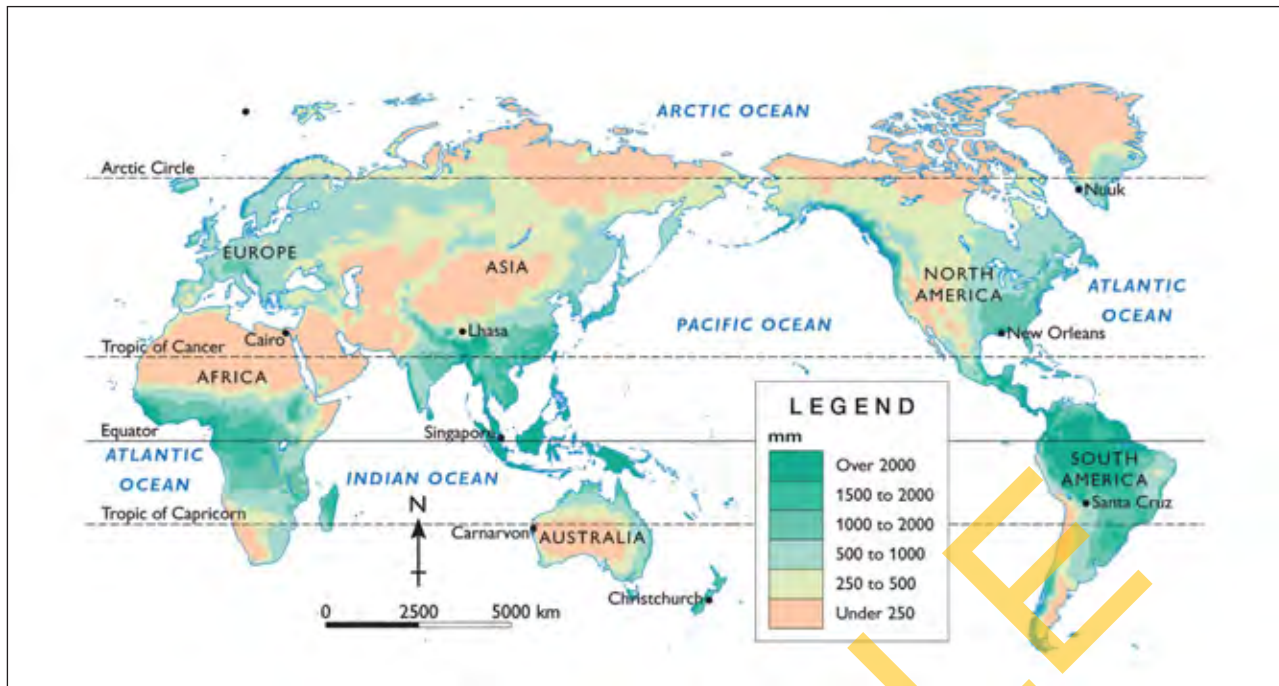


Source 1.38 Average volume of yearly rainfall (km³), evaporation and runoff by world region

Source: FAO Aquastat

Source 1.39 Some of Australia's driest regions are in the desert.





Source 1.40

Source: Oxford Atlas



Source 1.41 South America's high rainfall has contributed to the creation of the Igazu Falls, which is 80 metres high and 3 kilometres wide.

Check your learning 1.11

Remember and understand

- 1 Use Source 1.38 to rank the six inhabited continents from the continent with the most runoff to the continent with the least.
- 2 Which river carries the most water and how does it compare to other rivers?

Apply and analyse

- 3 Look carefully at Source 1.40.
 - a Which region of the world is the wettest? Why do you think this is the case?
 - b Which part of Africa experiences the lowest rainfall? What type of landscape would you expect to find here?
 - c Which part of Asia is the wettest? What are some of the advantages and disadvantages of high rainfall?
 - d Does the region north of the Arctic Circle have low or high rainfall? How might much of the water in this region be stored?

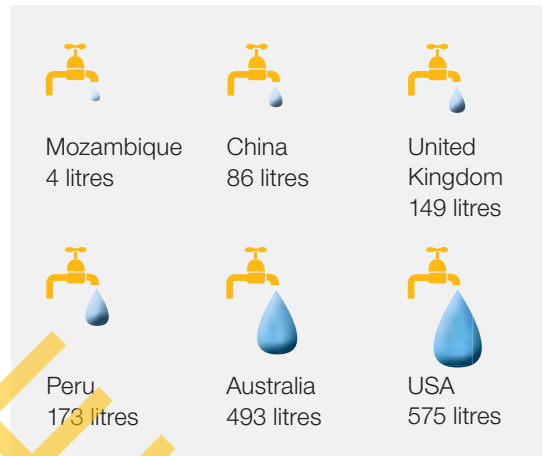
The world's drinking water

Drinking water, sometimes called potable water, is water that is safe to drink and use for cooking and washing. In Australia, most water undergoes some form of treatment to make it safe to drink. Water treatment removes sediments, pollutants and microorganisms that can make us sick. Australians are among the world's biggest water users, using almost 500 litres of water per person per day. This figure is for all water use, including water used in agriculture and industry. While this amount has declined in recent years, it still ranks among the highest in the world. Experts estimate that each Australian will need to use 12 per cent less water by 2030 in order to stay within the limits imposed by our rainfall. Some households have started to use a number of strategies to save water, while many others continue to waste large amounts.

Access to safe drinking water

In Australia, we take for granted that we have flush toilets, running water from taps and clean, safe drinking water. However, millions of people around the world get sick or die each year from drinking contaminated water. The United Nations estimates that half the world's population has problems caused by lack of access to clean water. More than 1 billion people do not have access to a reliable freshwater supply, and 2.6 billion do not have basic sanitation, such as running water to clean their hands or flush their toilets.

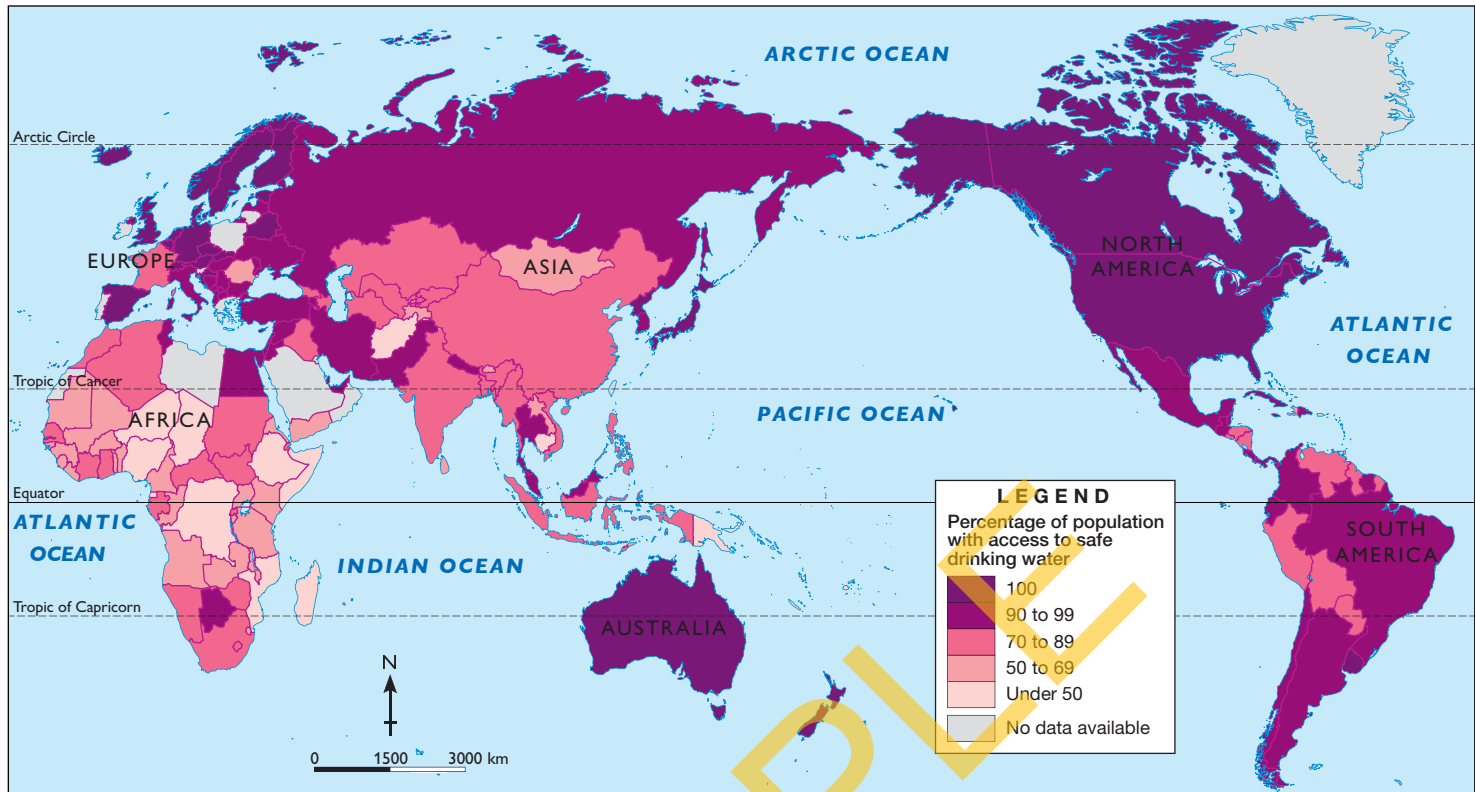
It is estimated that, at any one time, almost half the people in poorer countries are suffering from health problems due to a lack of safe water. Each year, millions of people die from diseases carried in their water. Millions of women and children around the world, particularly in Africa, spend several hours a day collecting and carrying enough water to keep their families alive for another day.



Source 1.42 Water use per person per day. Mozambique has the lowest daily water use per capita while the United States has the highest. Source: United Nations 2006

Source 1.43 In Chad, as in many African countries, each day begins with a walk to the village well.





Source 1.44

Source: Oxford Atlas

keyconcept: environment

Serah's story

Serah and her six children live in Ethiopia in Africa. The scarcest resource in her region is water. Before dawn, she makes her first journey to the village pump. Once there were three wells, but the 8-metre well has dried up. The 9-metre well has a little salty water at the bottom. The flow from the pump of the 25-metre well has slowed to a painful trickle. There is just barely enough for everyone to drink.

While it takes her 25 minutes to walk down the hill to the pump, it will take her 40 minutes to make the return journey with the 10-litre jar balanced on her head. She makes this trip at least twice a day. She tends not to drink as much as the others as she believes she should look after her children before herself. This means that she cannot produce enough milk for her baby, so he is often ill. The water contains parasites that make her other children sick, but Serah has little choice.

For more information on the key concept of environment, refer to section GT.1 of 'The geographer's toolkit'.

Check your learning 1.12

Remember and understand

- 1 What is potable water?
- 2 How many people in the world do not have access to a reliable supply of fresh water?
- 3 Describe the differences in the drinking water available in most Australian homes and in Serah's village.

Apply and analyse

- 4 Using Source 1.44 and the world map on the inside front cover of this book, identify two countries with excellent access to safe water and two countries with poor access to safe water. Which continent has the worst access to safe water?
- 5 Read Serah's story.
 - a How much water will Serah collect in two trips to the pump?
 - b How many people depend on her trips to the pump?
 - c How much will each person receive?
 - d The average toilet in Australia uses 8 litres per flush. Write a statement about the way water is used in Australia compared to Ethiopia.

1.3 bigideas: broadsheet

Windhoek, Namibia

Namibia is the driest country in Africa south of the Sahara Desert. Its capital, Windhoek, receives about 360 millimetres of rainfall a year and its 250 000 people rely on three dams for most of their water. These dams, however, are built on rivers that do not always flow and are therefore unreliable for city water use.

In 1969 the government decided to mix water from traditional sources, such as dams and wells, with recycled water from the city's sewage-treatment plant in order to supplement Windhoek's fresh water. As the city's population continued to grow rapidly, in the 1990s it was decided to build another treatment plant to convert sewage into drinking water. This was completed in 2002. Now more than one-third of Windhoek's drinking water comes from this unlikely source, making the city the world leader in turning waste-water into drinking water.



Source 1.45 Water is a scarce and precious resource in Namibia.

Source 1.46 Climate data: Windhoek, monthly averages

Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall (mm)	76	74	79	41	8	0	0	0	3	10	23	48
Temperature (°C)	29	28	27	25	22	20	20	23	25	29	29	30

skilldrill

Drawing climate graphs

Climate graphs combine bar graphs and line graphs to help us interpret the climate in a specific location. In order to draw a climate graph, geographers gather climate data – the monthly average rainfall and temperature – for the location they are investigating.

Step 1 Look carefully at the climate data to find the lowest and highest temperature figures that you will need to show on your graph. In this example, Windhoek's temperature varies from 20 to 30 degrees Celsius. Decide on a scale that shows this range of data, then place it on the left-hand axis of your climate graph.

Step 2 Using graph paper, plot the temperature data on your graph by placing a small, neat dot in the centre of each month at the correct height. Join the dots with a smooth red line and continue the line to the edges of the graph.

Step 3 Look carefully at the climate data to find the lowest and highest rainfall figures that you will need to show on your graph. In this example, Windhoek's rainfall varies from 0 to 79 millimetres a month. Decide on a scale that shows this range of data, then place it on the right-hand axis of your climate graph.

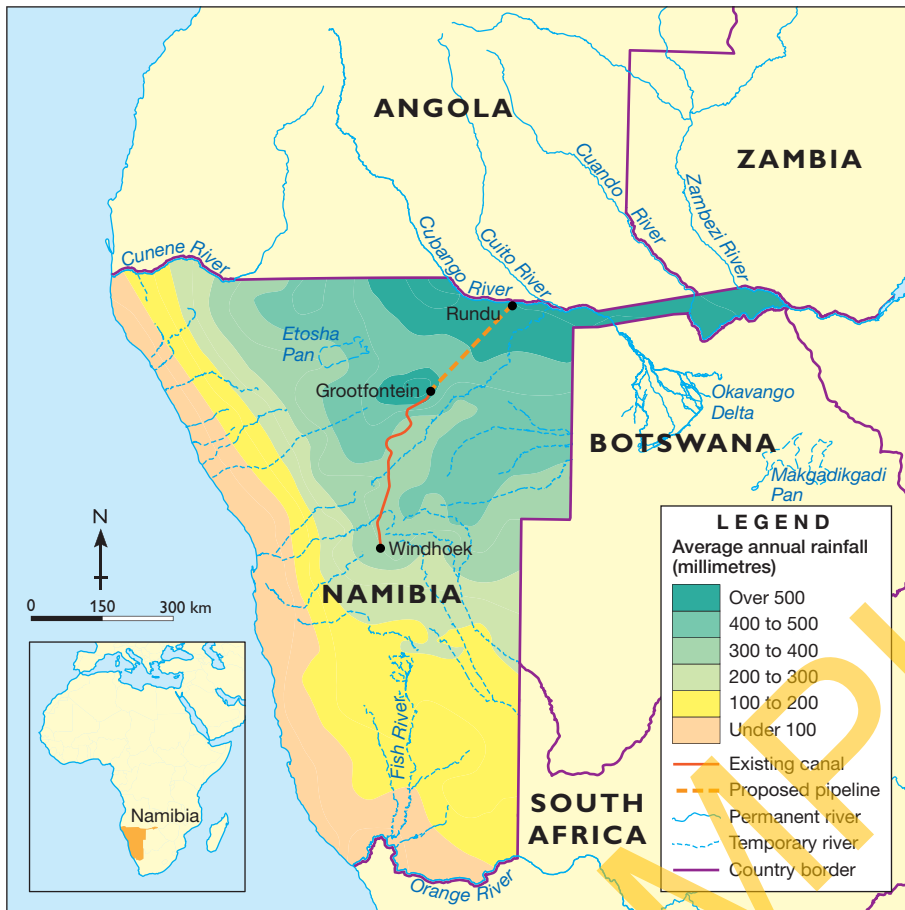
Step 4 Plot the rainfall on your graph by drawing a blue bar to the correct height for each month. You may like to very lightly shade the bars with a blue pencil.

Step 5 Complete your graph with a suitable title and a label for each of the three axes.

Apply the skill

1 Using the steps shown above and the data in Source 1.46 and referring to the Alice Springs climate graph (Source 1.32), construct a climate graph for Windhoek.

NAMIBIA: AVERAGE ANNUAL RAINFALL



Source 1.47

Source: Oxford University Press

Source 1.48 Many Namibian rivers are only temporary, meaning they are dry for most of the year.

Extend your understanding

- Describe the annual pattern of rainfall in Windhoek.
- Explain how this annual pattern makes dams and reservoirs an unreliable water resource.
- Describe the annual pattern of temperature and explain the impact of these temperatures on the evaporation of water held in dams.
- Compare the climates of Windhoek and Alice Springs (Source 1.32).
- Examine the map of Namibia. Identify three water resources on this map.
- What have the people of Windhoek done to make their water supply more sustainable and safe?
 - What problems does lack of access to safe water cause?
- Use the information on the map (Source 1.47) to explain why a pipeline is proposed to be built from the Cubango River to Grootfontein.
- Why would the people of Botswana be concerned about this proposed pipeline?

