UNIT 1 WATER IN THE WORLD

TOPIC 4
Too much, too little

4.1 Overview
Numerous videos and interactivities are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

4.1.1 Introduction
Every person on the planet interacts with the weather on a daily basis. Sometimes we feel hot, sometimes we feel cold. The constant change in the weather also affects the environment.

Weather influences the level of precipitation experienced in different places. If there is too little rain, drought can develop, sometimes producing heatwaves — days of dry, hot weather. If there is too much rain, flooding will occur. These extreme weather events have many effects, which can be more severe in certain parts of the world. While we cannot control these events, we can learn from the past and plan to minimise their impact in the future.

<table>
<thead>
<tr>
<th>Starter questions</th>
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<tbody>
<tr>
<td>1. Describe how the weather affects your everyday life.</td>
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<tr>
<td>2. List three things you would expect to happen if an area did not get its usual rainfall for a long time.</td>
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<tr>
<td>3. List three things you would expect to happen if an area suddenly got much more than its usual rainfall.</td>
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<tr>
<td>4. Think of an extreme weather event you have experienced or heard about in your life. Explain what happened and the effects this event had on you or others and the surrounding environment.</td>
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Flooding along Cooper Creek, Queensland.
4.2 What is weather?

4.2.1 How does weather change?

Our Earth is surrounded by a band of gases called the atmosphere. It protects our planet from the extremes of the sun’s heat and the chill of space, making conditions just right for supporting life. The atmosphere has five different layers. The layer that starts at ground level and ends about 16 kilometres above Earth is called the troposphere. Our weather is the result of constant changes to the air in the troposphere. These changes sometimes cause extreme weather events.

Droughts, floods, cyclones, tornadoes, heatwaves and snowfalls — even cloudless days with gentle breezes — all begin with changes to the air in the troposphere. The five main layers in the Earth’s atmosphere all differ from one another. For example, the troposphere contains most of the water vapour in the atmosphere. As a result, this layer has an important link to precipitation.

All weather conditions result from different combinations of three factors:

• air temperature
• air movement
• the amount of water in the air.

The sun influences all three.

FIGURE 1 Australia experiences a diversity of weather, which has a major effect on how we live.
First, the sun heats the air. It also heats the Earth’s surface, which in turn heats the air even more. How hot the Earth’s surface becomes depends on the season and the amount of cloud cover.

Second, the sun causes air to move. This is because the sun heats land surfaces more than it heats the oceans. As the warm air over land gets even warmer, it expands and rises. When hot air rises, colder air moves in to take its place.

Third, the sun creates moisture in the air. The heat of the sun causes water on the Earth’s surface to evaporate, forming water vapour. As this water vapour cools, it condenses, forming clouds. It may return to Earth as rain, dew, fog, snow or hail.

At times these three factors — temperature, air movement and water vapour — can create extreme weather events. Very high air temperatures influence heatwaves; rapidly rising air plays a part in the formation of cyclones; and excess rain can create flooding.

4.2.2 Weather and climate: what is the difference?

Weather is the day-to-day, short-term change in the atmosphere at a particular location. Extreme weather events are often described as unexpected, rare or not fitting the usual pattern experienced at a location.

Climate is the average of weather conditions that are measured over a long time. Places that share the same type of weather are said to lie in the same climatic zone. Because of the size of the Australian continent, its climate varies considerably from one region to another.
4.2 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What is the name of the layer of the atmosphere where all Earth’s weather happens?
2. Define the term troposphere.
3. In which levels of the atmosphere are the following features found?
   (a) Most passenger planes
   (b) Orbiting satellites
   (c) Burning meteors
   (d) The Aurora lights

Explain
4. Explain the difference between weather and climate.
5. Draw three diagrams to help you explain the factors that influence the following weather conditions:
   (a) air temperature
   (b) air movement
   (c) the amount of water in the air.
Discover
6. In a magazine or newspaper or online, find a photograph that shows an example of one type of weather. Paste the picture in the centre of a page and add labels about the impact of that weather on the environment (for example, creating puddles) and on what we do (such as the clothes people wear).

Predict
7. Look carefully at the map of Australia’s climatic zones in figure 3. Predict which two settlements, or places, might be at risk of flood. Make sure you explain why you chose them.
8. Look at the environment outside the window.
   (a) What is the weather like? Do you think it matches the climatic zone in which you live? Explain.
   (b) Now check to see you climatic zone, using figure 3. If your answers are different, explain why this may have occurred.

Think
9. Look carefully at the photographs in figure 1.
   (a) Describe the weather event in each photograph.
   (b) How would each weather event affect people’s lives?
10. Describe how the weather affected you yesterday.

4.3 SkillBuilder: Reading a weather map

WHAT ARE WEATHER MAPS?
Weather maps, or synoptic charts, show weather conditions over a larger area at any given time. They appear every day in newspapers and on television news. Being able to read a weather map is a useful skill because weather affects our everyday life.

Go online to access:
• a clear step-by-step explanation to help you master the skill
• a model of what you are aiming for
• a checklist of key aspects of the skill
• a series of questions to help you apply the skill and to check your understanding.

FIGURE 1 MAPgraphics Pty Ltd, Brisbane

The main influences on Melbourne’s weather are the low pressure system south of it, the high pressure system to the north-west, and the cold fronts to the west and east.

Low pressure system. Note how the isobar is joining points with an atmospheric pressure of 992 (lower than the 1013 average).

The cold front has just passed over Melbourne and has brought unsettled, rainy weather behind it. More rainy weather is likely for Melbourne when the cold front coming towards it from the west gets closer.

Warm front advancing from west to east behind the cold front. Note the lower atmospheric readings on the isobars.

Warm front advancing from west to east — towards southern Australia. Note how the isobars behind it are close together, indicating strong winds.

Shading indicates rain fell in the previous 24 hours.

Greater distance between isobars indicates wind is weaker in these regions.

TROUGH

MELBOURNE
NOON
9 OCTOBER 1992

Rainfall in previous 24 hours

Isobar (value in hectopascal)

Gaps in the isobars indicate strong winds until lately.

Source: MAPgraphics Pty Ltd, Brisbane

Watch this eLesson: Watch this video to learn how to read a weather map.
Searchlight ID: eles-1637

Try out this interactivity: Use this interactivity to learn how to read a weather map.
Searchlight ID: int-3133
4.4 How is a natural hazard different from a natural disaster?

4.4.1 What are natural hazards?

Australia is prone to a wide variety of natural hazards, which range from drought and bushfire to flooding. Many of these events are part of the weather’s natural cycle. However, human actions such as overgrazing, deforestation and the alteration of natural waterways have sometimes increased the impact of these hazards. So why do people continue to live in areas that are at risk of experiencing these hazards?

There is a difference between natural hazards and natural disasters. A hazard is an event that is a potential source of harm to a community. A disaster occurs as the result of a hazardous event that dramatically affects a community. There are four broad types of natural hazard:

1. **atmospheric** — for example, cyclones, hailstorms, blizzards and bushfires
2. **hydrological** — for example, flooding, wave action and glaciers
3. **geological** — for example, earthquakes and volcanoes
4. **biological** — for example, disease epidemics and plagues.

Clearly natural hazards that are linked to the weather are categorised into the atmospheric and hydrological types. Hazards such as flooding and cyclones could also be termed extreme weather events.

Some natural hazards are influenced by the actions of people and where they choose to locate themselves. For example, the severity of a flood depends not only on the amount and duration of rainfall that occurs. Humans can influence floods by building on floodplains and not planning well for disaster. Environmental degradation and poor urban planning can also turn natural hazards into natural disasters.

**Five of Australia’s costliest natural disasters**

- **Flood**, Queensland, New South Wales and Victoria 2010–2011: 35 deaths, 20,000 homes destroyed in Brisbane alone, $5.6 billion cost
- **Cyclone**, Cyclone Tracy, Darwin 1974: 65 deaths, 10,800 buildings destroyed, $4.18 billion cost
- **Earthquake**, Newcastle 1989: 13 deaths, 50,000 buildings damaged, more than $4 billion cost
- **Hailstorm**, Sydney 1999: 1 death, 24,800 buildings damaged, $2 billion cost
- **Bushfire**, Black Saturday, Victoria 2009: 173 deaths, 3500 buildings destroyed, $1.5 billion cost

**Top five casualty rate natural disasters worldwide in the last 15 years**

- **Earthquake**, Haiti, 2010: estimated range 85,000–316,000 deaths
- **Tsunami**, Indian Ocean 2004: approximately 230,000 deaths
- **Cyclone**, Cyclone Nargis, Myanmar, 2008: at least 146,000 deaths
- **Earthquake**, Sichuan, China, 2008: approximately 87,400 deaths
- **Earthquake**, Kashmir, Pakistan, 2005: approximately 79,000 deaths

4.4.2 Why do people live in areas at risk from natural hazards?

Risk is the possibility of negative effects caused by a natural hazard. Therefore, the type of hazard experienced, along with the vulnerability of the people affected, will determine the risk faced. The poorest people in the world are vulnerable because their ability to recover from the impact of a hazard is hampered by their lack of resources. In an event such as a flood or earthquake, people lose their personal belongings, homes and livestock, which are often linked to their incomes, continuing the cycle of poverty. However, in regions that are adequately prepared, and where there is support to cope and rebuild, people recover more quickly.
### FIGURE 2 Australia’s natural hazards and disasters

#### Source: MAPgraphics Pty Ltd, Brisbane

<table>
<thead>
<tr>
<th>Natural Hazard</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cyclones</strong></td>
<td>Approximate number of coastal crossings since 1959</td>
</tr>
<tr>
<td><strong>Severe storms</strong></td>
<td>At least one recorded severe thunderstorm (non-tornado)</td>
</tr>
<tr>
<td><strong>Bushfires</strong></td>
<td>Areas subject to forest, grass and scrub fires of moderate risk to people</td>
</tr>
<tr>
<td><strong>Earthquakes</strong></td>
<td>Major earthquake</td>
</tr>
<tr>
<td><strong>Floods</strong></td>
<td>Potential flash flooding</td>
</tr>
</tbody>
</table>

#### 4.4 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Remember**

1. How do natural hazards and natural disasters differ?

**Explain**

2. Explain how a flood is both a natural and human hazard.
3. Explain why the risk of experiencing a natural disaster depends on the geographical location of a community.
4. Describe key changes that natural hazards and natural disasters can cause to an environment.
4.5 Why does Australia experience droughts?

4.5.1 What is a drought?

Australia is the driest inhabited continent on Earth. As a result, Australia has had many droughts. The main reason Australia is so dry is that much of the continent lies in an area dominated by high atmospheric pressure for most of the year, which brings dry, stable, sinking air to the country. Australia also experiences great variation in its rainfall due to the Southern Oscillation and El Niño.

Low average rainfall and extended dry spells are a normal part of life throughout most of Australia. The continent is located in a zone of high pressure that creates conditions of clear skies and low rainfall. Drought conditions occur when the high pressure systems are more extensive than usual, creating long or severe rainfall shortages. A drought is a long period of below-average rainfall, when there is not enough water to supply our normal needs. Because people use water in so many different ways and in such different quantities, there is no universal amount of rainfall that defines a drought.

The term drought should not be confused with low rainfall. Sydney could experience a drought and have more rainfall during that period than Alice Springs, which could be experiencing above average rainfall. If low rainfall meant drought, then much of Australia would be in drought most of the time.

FIGURE 1 Australian rainfall patterns, 2008

Source: MAPgraphics Pty Ltd, Brisbane
Droughts affect all parts of Australia over a period of time. Intervals between severe droughts have varied from four to 38 years. Some droughts can be localised while other parts of the country receive good rain. Others, such as the drought of 1982–83, can affect more than half the country. Droughts can be short and intense, such as the drought that lasted from April 1982 to February 1983; or they can be long-lived, such as the drought from 2002–2009.

Different weather systems affect different parts of Australia, so there is little chance that all of Australia would be in drought at the same time.

### 4.5.2 El Niño

Australia’s drought of 2002 and beyond, like many before, was caused by what meteorologists call an El Niño event. In a normal year, warm surface water is blown west across the Pacific Ocean towards Australia. This brings heavy rain to northern Australia, Papua New Guinea and Indonesia. On the other side of the Pacific, South America experiences drought. When there is an El Niño event, these winds and surface ocean currents reverse their direction. The warm, moist air is pushed towards South America. This produces rain in South America and drought in Australia.

### 4.5.3 Southern oscillation

Fluctuations in rainfall have several causes that are not fully understood. Probably the main cause of major rainfall fluctuations in Australia is the southern oscillation, which is a major air pressure shift between the Asian and east Pacific regions. The strength and direction of the southern oscillation is measured by a simple index called the southern oscillation index (SOI). The SOI is calculated from monthly or seasonal fluctuations in air pressure between Tahiti and Darwin.
In an average rainfall year with ‘typical’ pressure patterns, the SOI is between −10 and +10. If the SOI is strongly negative (below −10), this means that the air pressure at sea level in Darwin is higher than in Tahiti, and an El Niño event occurs.

During an El Niño event, there is less than average rainfall over much of Australia. During this period, drought will occur. If the SOI becomes strongly positive (above +10), this means that the air pressure in Darwin is much lower than normal and a La Niña event occurs. During this period, above average rainfall will occur.

In recent years, scientists have made great advances in understanding and forecasting El Niño and southern oscillation events. The National Climate Centre in Australia produces outlooks on rainfall three months ahead. These outlooks are proving to be of great value to farmers and especially valuable for ecologically sustainable development in rural areas.

4.5 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What is drought?
2. Refer to figure 2, which compares conditions during a typical year and an El Niño year, and study the text. Use the following words to complete the sentences below: stable, moist, cooler, east, drought, Tahiti, dry, warm, north, Darwin.
   During an El Niño event, the normally ______ sea in the oceans to the ______ and ______ of Australia are replaced by much ______ water. The air pressure in ______ begins to fall relative to the air pressure in ______. The normal ______ easterly trade winds change their direction. The result is ______ and ______ air and severe______.
### Explain

3. Why is Australia so dry?

4. What is the SOI and how is it calculated?

5. What do the following SOIs indicate?
   (a) Between +10 and −10
   (b) >+10
   (c) <-10

6. Why is there little chance that all of Australia would be affected by drought at the same time?

7. Refer to figure 3 showing the areas affected by El Niño. Describe the areas that become (a) wetter, (b) drier and (c) warmer during an El Niño event.

### Think

8. List some of the short-term effects that drought can have on Australia. Once you have listed these, try to come up with some long-term impacts that Australia and its people would experience if these short-term impacts continued for up to 10 years.

9. Why is El Niño the result of the interconnection that occurs between Australia and South America?

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4.6 What are the impacts of drought?

#### 4.6.1 Beyond reasonable drought: Australia, 2002–2009

Around the world, droughts often develop due to similar weather conditions. However, their impacts on different communities that live around the world can be diverse. Often, developed countries find themselves economically worse off during a drought period. In contrast, developing countries usually face devastating social consequences as a result of an extremely dry weather period.

Droughts can last for many years. They may be widespread or confined to small areas. The drought that started in 2002 affected large areas of Australia by 2005 (see figure 1). When Australia experiences a drought, agriculture suffers first and most severely, but eventually everyone feels the impact.

Due to the severe lack of water caused by the drought, many farmers...
faced production losses because they were not able to sustain their crops or sufficiently feed their livestock. This had negative economic impacts.

- By 2004, dairy farmers had experienced a 4.5 per cent drop in their incomes.
- Cotton crops were devastated by the shortage of water.
- Up to 20 cotton communities and approximately 10,000 people in the industry were affected.
- Some communities had to cut production by 60 to 100 per cent.
- Cattle and sheep farmers found it hard to find stockfeed, and prices increased. As a result, herds grew smaller.

In rural towns, jobs were lost and many businesses failed. Some people found themselves forced to leave drought-affected areas in search of other work. Many never returned. Very long droughts cause country people much heartache, and this can result in the break-up of families. It can also lead to severe depression in some individuals. However, the Australian Government set up a fund that farmers and people in agricultural businesses can apply to for financial relief when their incomes are disrupted by drought. Counselling hotlines are also available to offer support.

Along with these economic and social impacts, the Australian environment suffers in drought. Droughts have a bad effect on topsoil in Australia. During drought conditions, millions of tonnes of topsoil are blown away (see figure 2). This loss takes many years to replace naturally, if it is ever replaced. The loss of topsoil can make many regions far less productive, making it harder for farmers to recover once the drought has broken.

Use the News report: dust storms weblink in the Resources tab to watch a news report on dust storms in Sydney and Brisbane.

4.6.2 The Horn of Africa, 2011

Drought in the Horn of Africa (see figure 3) is becoming a recurring event. Unfortunately, such droughts are occurring in shorter and shorter cycles. As a result, the people who live in this region do not have time to recover.
before they are faced with another dry period. Recently, the Horn of Africa experienced drought in 2005–2006, 2009 and most recently 2011–2013. The last disaster is said to be the worst drought in 60 years. These droughts have had terrible social effects.

It is believed that over 10 million people were affected by the drought in 2011. Most people in Ethiopia, Kenya and Somalia are subsistence farmers, and rely on agriculture to sustain them. With crop failure and animal losses, a severe food shortage developed, leading to malnutrition. One in three children suffered from malnutrition. The potential for loss of life on a massive scale is a distinct possibility. Tens of thousands are believed to have died in Somalia where famine was declared.

The situation in Somalia is made worse by continuing civil unrest. Many of the starving are fleeing to refugee camps in bordering Ethiopia and Kenya. As many as 1500 refugees arrive at these camps every day, many having walked up to six weeks to get there. Due to the extreme poverty of the region, health services are in short supply, adding to these people’s problems.

4.6 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Why aren’t the people living in the Horn of Africa able to recover from drought?
2. What makes the drought situation worse in Somalia?
3. Identify three key changes drought brings to the environment.

Explain
4. Why are some drought outcomes in Australia different from those in the Horn of Africa?

Think
6. List all the environmental, economic and social impacts of drought. Using this list, create a flow diagram to illustrate how these three impact groups relate to, connect to and influence each other. Use this flow diagram to get you started. You can add more boxes and arrows to show how elements are connected.

learnON RESOURCES — ONLINE ONLY
Explore more with this weblink: News report: dust storms

4.7 Why does Australia experience bushfires?
Access this subtopic at www.jacplus.com.au

4.8 What happened on Black Saturday?
Access this subtopic at www.jacplus.com.au
4.9 How can dry periods be managed to reduce the impact of drought?

4.9.1 Options for managing dry periods

During times of extreme water shortages, governments, communities and individuals often attempt to ensure there is a reliable water supply. The 2002–2009 drought in Australia sparked many different water-saving actions. However, in an environment prone to drought, with increasing demand for water, it is vital to protect and manage water resources at all times — not only during dry periods.

4.9.2 Option 1: government action

The Queensland Government developed the South-East Queensland (SEQ) water grid in order to secure alternative sources of water in an environment that seemed to be growing drier. This strategy aimed to connect the water sources of the region through a pipe network that could move water to different areas and thus meet the needs of local communities. The grid includes existing dams, three water treatment plants and a desalination plant, all connected by approximately 450 kilometres of pipes.

In 2008, the Western Corridor Recycled Project was completed at a cost of $2.5 billion. This project is part of the SEQ water grid and is the largest recycled water scheme in Australia. The project will supply up to 230 megalitres per day of recycled water to industry and power plants. The water also has the potential to be used by farmers and to top up drinking supplies. However, these last two uses of recycled water have created wide debate among communities.

The desalination plant at Tugun on the Gold Coast can provide up to 133 megalitres of drinking water per day. Essentially this project produces drinking water by removing salts and other minerals from sea water. This technology is very successful and has been used in other regions of Australia for years, including Perth, Coober Pedy, Hamilton Island and the Torres Strait islands. Internationally, there are approximately 7500 plants in operation. These desalination plants enable safe drinking water to be produced without having to rely on rainfall.

**FIGURE 1** The desalination plant at Tugun produces drinking water for south-east Queensland.

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**Water measurements**
- 1 ML = 1 megalitre
- 1 megalitre = 1 000 000 litres
- 10 megalitres = 4 Olympic-size swimming pools

**Stages of the desalination process**
1. Sea water is piped from the ocean into a submerged inlet tunnel to the plant.
2. At the pre-treatment stage, particles in the sea water are micro-filtered, the pH is adjusted, and an inhibitor is added to control the build-up of scale in pipelines and tanks.
3. The sea water is forced through layers of membrane to remove salt and minerals. Concentrated salt water is separated and returned to the ocean.
4. During post-treatment, small amounts of lime and carbon dioxide are added to the water, along with chlorine for disinfection.
5. The desalinated water is blended with other Gold Coast water supplies and joins south-east Queensland’s water grid to supply homes and industry.

Based on information from www.watersecure.com.au
FIGURE 2 The SEQ water grid
In times of drought, governments may introduce water restrictions to limit the pressure placed on water supplies by individual households and businesses. They may also introduce incentive schemes that provide a rebate on water-saving devices, such as water tanks, which help relieve the strain on the water supply.

4.9.3 Option 2: You and me — personal action

Owing to government action, more and more people are becoming open to the idea of using recycled water in their homes. In Adelaide, 500 homes have been plumbed into the Southern Urban Reuse Project, which allows them to use recycled waste water for toilet flushing and watering their gardens. This project has the capacity to supply up to 8000 homes in the future.

The global leader in the use of reclaimed, or recycled, water is Singapore. This small island nation used to obtain 50 per cent of its water from Malaysia. However, its goal is to be 100 per cent water independent by 2061. Singapore treats its waste water to a drinkable standard. This method is gaining public acceptance, and will supply up to 50 per cent of the nation’s water in future.

Many of our day-to-day actions require us to use water. There are ways we can all use this water more effectively to ensure it is not wasted. By looking at our actions carefully, we can save water in the kitchen, laundry, bathroom and garden (figure 4). Some ideas may include:

- putting aerators on taps
- using a hose with a shut-off nozzle
- cleaning driveways and paths with a broom rather than a hose.

4.9 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What is the SEQ water grid made up of?
2. How many litres are there in 230 megalitres?

Explain
3. What is the aim of a desalination plant? How does it achieve this?
4. Will the SEQ water grid be effective in managing water during a drought period? Why or why not?

Think
5. Why do you think the topic of using recycled water can create debate in the community? Create a list of pros and cons for the use of recycled water.
6. Talk to your family about saving water as individuals or as a household. Come up with a list of other ideas that could save water around the home. With this information, create a poster that could be used to educate others.
7. Describe what you believe are the two most sustainable ways of reducing the impacts of drought. Give reasons for your choices.
FIGURE 4 Personal action

Ensure your next washing machine has lots of water-efficiency stars.

Ensure you completely fill your dishwasher before using it.

Don’t keep the tap running when washing fruit and vegetables. Wash them in a bowl instead.

Install a dual-flush toilet.

Dispose of tissues in the bin — don’t flush them down the toilet.

Have short showers. Try for four minutes!

Don’t run the tap when brushing your teeth.

Use a water-saving showerhead and keep a bucket in the shower for excess water to use on the garden.

Cover soil in mulch to retain moisture in soil. Grow drought-tolerant plants.

Water the garden in the early morning or evening to reduce evaporation.
4.10 Why does it flood?

4.10.1 Types of floods

Even though Australia is the driest of all the world’s inhabited continents, there are periods of very heavy rainfall and flood. Flood disasters in Australia damage property, kill livestock and cause the loss of human life. Since 1788 more than 2000 people have died in floods, equalling the number of deaths from cyclones. In some cases, entire sections of a town have been washed away, as in 1852, when one-third of the town of Gundagai disappeared.

There are three main types of flood:

1. *Slow-onset floods*. These occur along the floodplains of inland rivers, such as the Darling and Namoi, and may last for weeks or months. They are caused by heavy rain and run-off upstream. The water can take days or weeks to affect farms and towns downstream.

2. *Rapid-onset floods*. These occur in mountain headwaters of larger inland rivers or rivers flowing to the coast. The rivers are steeper and the water flows more rapidly. Rapid-onset floods are often more damaging because there is less time to prepare.

3. *Flash floods*. These are caused by heavy rainfall that does not last long, as occurs in a severe thunderstorm. This type of flooding causes the greatest risk to property and human life because it can happen so quickly. It can be a serious problem in urban areas where drainage systems are inadequate.

![Figure 1: Flash flood in Toowoomba, Queensland, 2011](image1)

![Figure 2: Damage left in Toowoomba after the flash flood](image2)
4.10.2 Floods and floodplains

Floods are a natural occurrence, but they are a natural hazard to humans, who tend to build farms, towns and transport routes in areas such as floodplains. A floodplain (figure 3) is an area of relatively flat land that borders a river and is covered by water during a flood. Floodplains are formed when the water in a river slows down in flat areas. The river begins to meander and gradually deposits alluvium, which builds up the floodplain and other landforms such as deltas.

These fertile, flat areas are used for farming and settlement around the world. In Australia, many of our richest farmlands are on floodplains, and towns are often built on them, close to rivers. Such towns are subject to flooding. The possibility of flood is also increased when vegetation in catchment areas has been cleared or modified. Native vegetation can slow down run-off and reduce the chance of flooding.

4.10.3 La Niña and floods

A La Niña event in Australia is often associated with floods. La Niña is virtually the opposite of El Niño. Very cold waters dominate the eastern Pacific, and the oceans off Australia are warmer than normal. Large areas of low pressure extend over much of Australia; warm, moist air moves in, and above-average rainfall occurs. There can also be torrential rain and widespread floods.

Recent La Niña events in Australia occurred in 2010–2011, when many parts of Queensland, New South Wales and Victoria were flooded (figure 4).
4.11 What are the impacts of floods?

4.11.1 The Brisbane floods, 2011

When the Brisbane River broke its banks on 11 January 2011, Australians were shocked and saddened by the devastation left in its wake. Thankfully those affected were able to gain some comfort from the assistance they received from the community as they began the slow process of recovery. However, this is not always an option for those affected by floods in other regions of the world. On the same day on the other side of the world, Brazil was also experiencing a flood. This flood would have a tragic human cost.
CASE STUDY
Queensland, Australia 2010–2011

Country background
Australia is considered a developed nation with a strong economy. Australians earn on average $38,200 per person. Approximately 24 million people reside in Australia, with 4.8 million of those living in Queensland. About 84 per cent of all Australians are located within 50 kilometres of the coast.

Why?
The flooding that affected this region was due to a strong La Niña event. Long periods of heavy rain over Queensland catchments caused rivers to burst their banks.

Effects
- Three-quarters of the state was declared a disaster zone.
- At least 70 towns and over 200,000 people were affected.
- There were 35 deaths.
- It cost the Australian economy at least $10 billion.
- Up to 300 roads were closed, including nine major highways.
- Over 20,000 homes were flooded in Brisbane alone.
- There was massive damage and loss of property.

Assistance and recovery
- $1.725 billion is being raised by the Federal Government via a flood levy in the tax system.
- $281.5 million is in the Disaster Relief Appeal set up by the then Premier, Anna Bligh.
- Over $20 million was donated to aid agencies such as the St Vincent de Paul Society to help those suffering.
- About $1.2 million was raised through charity sporting events such as Rally for Relief, Legends of Origin and Twenty20 cricket.
- The Australian Defence Force was mobilised to help with the clean-up.
- The Mud Army was formed: 55,000 volunteers registered to help clean up the streets, and thousands more unregistered people joined them.
- Improvements will be made to dam manuals to help manage the release of water from dams during floods.

**FIGURE 1** Anatomy of a flood

1. Floodwaters from **Lockyer Creek**, which flows into **Brisbane River**. The Lockyer Valley was hit by more than 200 mm of rain.
2. More than 490,000 million litres were released from **Wivenhoe Dam** into Brisbane River.
3. Floodwaters from the **Bremer River**, which is also fed by the **Lockyer Valley**. After passing Ipswich, where it burst its banks, the Bremer River flows into the Brisbane River.

**Town heights above sea level in metres:** Toowoomba 700 m Murphys Creek 704 m Withcott 262 m Helidon 143 m Grantham 110 m Gatton 111 m Forest Hill 95 m Laidley 135 m Ipswich 54.8 m Brisbane 28.4 m
CASE STUDY

State of Rio de Janeiro, Brazil, 2011

Country background
Brazilians earn on average $10 200 per person per year. Approximately 209 million people reside in Brazil, with 650 000 living in the three towns worst affected by the flooding.

Why?
Due to the equivalent of a month’s rain falling in 24 hours, flash flooding occurred in a mountainous region in Rio de Janeiro State and São Paulo State. Hillsides and riverbanks collapsed due to landslides. It is believed that illegal construction and deforestation may have contributed to the instability of the land.

Effects
• Approximately 900 people died — most of them in poverty-stricken areas with poor housing conditions and no building policies.
• Forty per cent of the vegetable supply for the city of Rio de Janeiro was destroyed.
• Around 17 000 people were left homeless.
• There was widespread property damage, most of it to homes built riskily at the base of steep hills.

Assistance and recovery
• $460 million was set aside by the President for emergency aid and reconstruction.
• Troops were deployed to help.
• There were donations of clothes and food to the area from other Brazilians.
• About $450 million was loaned by the World Bank.
• Support was given by internal and international charities.

FIGURE 2 Areas affected by the floods in Brazil, 13 January 2011

FIGURE 3 Hills collapsed after the heavy rains, destroying homes.
4.12 How do different places manage floods?

Floods occur in many countries around the world. It is important for these countries to learn how to effectively live with this natural hazard. Managing the effects of floods is important if the amount of damage caused is to be minimised. Unfortunately, not all countries have the same resources to tackle this problem. Those countries that are able to invest in flood-prevention infrastructure have a greater chance of reducing the risk of flood.

The most common form of flood management is to build a barrier that prevents excess water from reaching areas that would suffer major damage. Levees (see figure 2), weirs and dams are a few examples of structures that are built to contain floodwaters. Dams that are used to stop flooding need to be kept below a certain level to allow space for floodwater to fill. Wivenhoe Dam in south-east Queensland was built in response to the floods in 1974 (see figure 1). However, there was some debate about whether this dam could have been used more effectively during the 2010–2011 floods.

![FIGURE 1 Lake Wivenhoe, Queensland, at 190 per cent capacity, January 2011](image-url)
Levee bank; can be built from earth, sandbags or concrete

The levee contains the water of the river if it rises above the natural height of its banks during a flood event.

FIGURE 2 An artificial levee

To prevent London being flooded during unusually high tides and storm surges, the city constructed the Thames Barrier, a system of floodgates that stretch across the width of the river (see figure 3). The barrier is triggered if predicted water levels are above a certain height. If this happens, the gates rise to stop the incoming water. Once the water recedes, the danger has passed and the gates are lowered.

Another way to manage the risk of damage from floods is to stop building on low-lying land that is guaranteed to flood. Unfortunately, in many urban areas this land has been developed, which increases the chance of property damage in a flood.

Since 2006, the Brisbane City Council has offered a residential property buy-back scheme. This scheme gives people the opportunity to sell their property to the council if they live in a low-lying area that has a 50 per cent chance of flooding every year. People will not be allowed to build on this land again. For this initiative to be successful, it is essential that the price offered by the council is similar to what the owners would get in a private sale; otherwise there is no incentive to use it.

Another way to prepare the population for the arrival of floods, Bangladesh has developed a flood forecasting and warning system that can be broadcast via newspapers, television, radio, the internet and email. Regrettably, due to the growing population in the capital of Dhaka, building is now occurring on low-lying land that was previously used to store floodwater (see figure 4). As a result, many people are still being affected by flooding. In 1998, 65 per cent of Bangladesh was inundated. Twenty million people needed shelter and food aid for two months.

Unfortunately not all countries have the finances to fund property buy-backs or large-scale barrier building. Bangladesh, for example, experiences annual flooding during the monsoon season. In response to this, homes are usually built on raised land above flood levels or on stilts.
FIGURE 4 In Dhaka, homes are built on stilts to avoid the floodwaters.

### 4.12 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Remember**
1. What flood management techniques are being used in Brisbane?
2. Where are you at most risk from flood when building?

**Explain**
3. Look at figure 2 and use it to help write a definition for the term levee.
4. How can an early warning system reduce the risk of a flood disaster?
5. Explain the **interconnection** between population growth and the risk posed by floods.

**Discover**
6. Use the Bureau of Meteorology weblink in the Resources tab to find out more about flood warnings.
   Prepare an information sheet that could be released to a rural community about to be affected by a major flood event. It should include tips on what to do before, during and after the event. Search for the area you live in and check any flood warnings it has had in the past.

**Think**
7. What do you think would happen if a dam, built to prevent floods, was already full to capacity and the area received more heavy rainfall? What might be some of the consequences?

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**learnon**

**RESOURCES — ONLINE ONLY**

- **Try out this interactivity**: Responding to floods
  Use this interactivity to learn more about common flood control measures.
  Searchlight ID: int-3085

- **Explore more with this weblink**: Bureau of Meteorology
**4.13 SkillBuilder: Interpreting diagrams**

**WHAT ARE DIAGRAMS?**

A diagram is a graphic representation of something. In geography, it is often a simple way of showing the arrangement of elements in a landscape and the relationships between those elements. Diagrams also have annotations: labels that explain aspects of the illustration.

**Go online to access:**
- a clear step-by-step explanation to help you master the skill
- a model of what you are aiming for
- a checklist of key aspects of the skill
- a series of questions to help you apply the skill and to check your understanding.

**FIGURE 1 The water cycle**

- A, The sun’s heat provides the energy for the water cycle.
- B, The warm air that absorbs evaporated moisture expands and rises into the atmosphere.
- C, As warm, moist air rises, it cools. Water vapour that cannot be held in the air condenses into tiny water droplets or ice crystals. As more of these form, clouds appear. This process is known as condensation.
- D, The sun evaporates water from oceans, damp soil, leaves and people’s skin, turning it into water vapour.
- E, When the droplets or crystals become too heavy to overcome the pull of gravity, they fall to Earth as precipitation.

**RESOURCES — ONLINE ONLY**

- Watch this eLesson: Watch this video to learn how to interpret diagrams. Searchlight ID: eles-1636
- Try out this interactivity: Use this interactivity to learn how to interpret diagrams. Searchlight ID: int-3132

**4.14 Review**

**4.14.1 Review**

The Review section contains a range of different questions and activities to help you revise and recall what you have learned, especially prior to a topic test.

**4.14.2 Reflect**

The Reflect section provides you with an opportunity to apply and extend your learning.

Access this subtopic at www.jacplus.com.au

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