
WASTEWISE
Schools Program
MATHS
MATHS
MATHS

MATHS: BAN THE BOTTLE
Background Information for teachers

Curriculum focus

Mathematics: Number and Algebra, Measurement, Statistics and Probability

See list of curriculum links at the end of the maths activity instructions for more information.

Aim: **Students compare bottled water and tap water in terms of unit cost and waste. They develop and conduct a survey to investigate if the school community would support the ban of selling bottled water.**

Summary of activities:
There are nine activities in this package.

1. Set the scene: How does the class feel about banning bottled water?
2. Compare the cost of tap water to the cost of bottled water.
3. Compare the distance travelled by bottled water and tap water.
4. Calculate the waste produced from Polyethylene terephthalate (PET) plastics waste production.
5. Recycling plastics at school.
6. Did your learning impact on your feelings?
7. Conduct a survey about bottled water.
8. Conduct a fundraising activity (optional).
9. Conversions for other plastics.

Suitable for: Years 7 – 10.

Duration: About two weeks (8 lessons) plus homework time for students to gather responses to the surveys.

Background information

For more information and statistics on bottled water in Australia please see the bottled water background information in the introduction to this guide.

Cross-curriculum links

This guide is designed to be used as a cross-curriculum unit with many subject areas looking at the topic of bottled water from different angles. This creates opportunities for sharing across subject areas and year levels. You could invite:

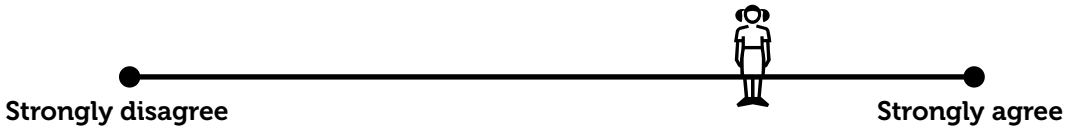
- an English class to debate which is more persuasive, statistics or language, in convincing people to drink tap water
- a science class to share their results and have your class produce graphs (on taste and odour preferences)
- a geography class to share their research on cost of bottled water and where it comes from (Inquiry question 1) or to share graphs and statistics on bottled water (e.g. How much PET plastic is recycled?).

You might also like to share the school survey results in the newsletter or at an assembly.

MATHS: BAN THE BOTTLE
Activity Instructions

Activity 1. Set the scene: How does the class feel about banning bottled water?

1. Share this statement with students:
   Our school canteen (or community) should stop selling bottled water.
2. Tell students that they will be standing somewhere along the 'line', according to how they feel about the statement. Point out which side of the room is 'strongly agree' and which side is 'strongly disagree'. Ask students to choose a place to stand on the line. Give the students a few minutes to talk to the people near them and discuss why they have placed themselves where they are. Ask several students to explain to the class why they are standing where they are.
3. Ask students to return to their seats and to record their position, and reason for choosing this position, in their books.



This activity will be repeated in Activity 6 to see if students' opinions have changed after learning more about the topic.

Activity 2. Compare the cost of tap water to the cost of bottled water

For this activity you will need: A projector and screen to display the tables and questions in Exercise 1. Exercise 1 can be found at the back of the maths section on page 46.

1. Ask students:
   a. True or False? Some brands of bottled water come from the tap.

      It's true, some brands of bottled water are from natural springs while others are purified tap water.

   b. True or False? Australian consumers pay almost 2000 times more than the cost of tap water to drink from a bottle.

      Students will find out the answer to this in Exercise 1.

2. Have students complete Exercise 1 (page 46) comparing the cost of bottled water and tap water. To avoid printing, please try to put the questions and tables on display.

   There are two options for Exercise 1.

   - Option 1 is unstructured for advanced students.
   - Option 2 is scaffolded for those who need step-by-step instructions.

3. Discuss with students:
   a. Which 'average' (mean, median or mode) did you use for comparing tap water and bottled water?
   b. Does bottled water cost 2000 times the cost of tap water? Why do we buy bottled water when we can get water from the tap for free? What are we paying for when we buy a bottle of water?

Student research option:

We have provided costs of different bottled water brands in Exercise 1. Alternatively, you could ask students to research the cost of different brands of bottled water and compile them in a table. If a geography class is also doing the bottled water curriculum, they could share their research into the costs of different brands.

Filling up with tap water saves money.

Activity 3. Compare the distance travelled by bottled water and tap water

For this activity you will need:

- A projector and screen to display the tables and questions in Exercise 2. Exercise 2 can be found at the back of the maths section on page 49.
- Computer access for each student to calculate distances using a mapping program on the internet (such as Google Maps).

1. Have students complete Exercise 2 (page 49) comparing the distance travelled by bottled water and tap water. To avoid printing, please try to put the questions and tables on display.

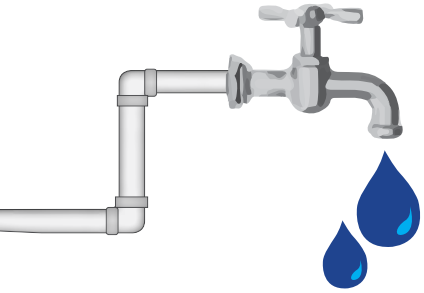
   There are two options for Exercise 1.

   - Option 1 uses the mean, mode, median and range (suitable for Year 7 to 9).
   - Option 2 uses box-and-whisker plots (suitable for Year 10).

2. Discuss with students:

   a. What impact do the large distances have on the mean? Did you use the maximum distance or the mean distance when comparing how far bottled water and tap water travel?

   b. How is tap water transported to your home? How is bottled water transported and stored before it is sold? What environmental impacts are associated with the transport and storage of bottled water?



If your school is not in Perth, you could tailor this activity to your region by using the water supply maps provided on the Water Corporation Education page (posters)

www.watercorporation.com.au/Home/Teachers/Lesson%20plans%20and%20teaching%20resources/Videos%20music%20and%20posters.

Activity 4. Calculate the waste produced from PET plastics waste production

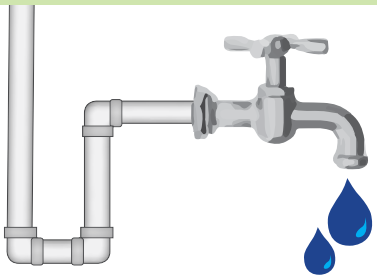
For this activity you will need: A plastic water bottle, scales to weigh the bottle, a projector, screen and speakers to show a short clip and to display the tables and questions in Exercise. Exercise 3 can be found at the back of the maths section on page 53.

1. Watch the following clips:
   a. Visual display of recycling rates in America
   www.youtube.com/watch?v=OZbTXDkrD1o
   b. Discussion about where recycling goes
   www.dailymotion.com/video/xvn9up_where-does-recycled-plastic-go-to-china-and-back_news
2. Show students a plastic water bottle and ask them to identify the recycling symbol and number on the bottom of the bottle.
3. Use Table 1 in Exercise 3 (page 53) to determine the type of plastic that the bottle is made from.
4. Weigh the bottle and record the weight to use in Exercise 3.
5. Ask students to complete Exercise 3.

Bales of plastic ready for recycling from a Materials Recovery Facility in Bunbury.

Activity 5. Recycling plastics at school

For this activity you will need: A projector, screen, speakers and an internet connection to show a short clip and to display the tables and questions in Exercise 4. Exercise 4 can be found at the back of the maths section on page 55. You will also need to know the number of students in your school, whether you have a co-mingled recycling system and how much an empty bottle of water weighs (from Exercise 3).



The lightest 600mL water bottle produced in Australia weighs just 12.8grams (according to Mount Franklin, 2011). Students could use this figure if you don't have a water bottle to weigh.

1. Ask students:

   a. True or False? The local council picks up my waste at school.

   It depends on your school. Some school's waste is picked up by a contractor while others is picked up by the local council. In Perth, public schools' waste is usually collected by SITA, Perth Waste or VEOLIA.

   b. True or False? It costs money to have waste collected at the school.

   It's true, schools are allocated money to pay for waste collection services.

   c. True or False? PET plastic from water bottles can be recycled into clothing and pens.

   It's true. Watch the clip www.youtube.com/watch?v=zyF9MxlcItw to find out how PET is recycled into polyester.

2. Discuss with students: Do we have co-mingled recycling bins at our school? These bins usually have a yellow lid and are marked with recycling symbols.

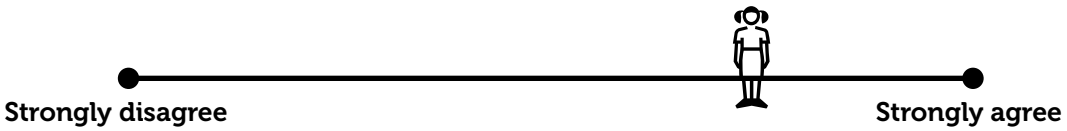
3. Complete Exercise 4 (page 55) with the students. You will need to help the students create a table to collect the class data in Question 2.

Activity 6. Did your learning impact on your feelings?

1. Ask students to summarise their learning in the following table:

	Bottled water	Tap water
Cost of water (average) (from Exercise 1)		
Distance travelled (average) (from Exercise 2)		
Waste produced at your school per year (estimated) (from Exercise 4)		
Cost of waste disposal to landfill at your school (estimated) (from Exercise 4)		

2. Rewrite this statement up on the board:
   Our school canteen (or community) should stop selling bottled water.
3. Remind the students that they will be standing somewhere along the 'line', according to how they feel about the statement. Point out which side of the room is 'strongly agree' and which side is 'strongly disagree'. Ask students to choose a place to stand on the line. Give the students a few minutes to talk to the people near them and discuss why they have placed themselves where they are and if their feelings have changed.
4. Ask several students to report back and explain to the class why they are standing where they are.
5. Ask students to return to their seats and to record their new position in their books. Ask them to write one or two sentences about any change in their opinion and what was most significant in changing their opinion.



Activity 7. Conduct a survey about bottled water

For this activity you will need: A projector, screen, speakers and an internet connection to show a short clip and to display Exercise 5. Exercise 5 can be found at the back of the maths section on page 58.

1. Watch clip about how Monte Sant' Angelo Mercy College banned bottled water www.youtube.com/watch?v=yYUmAvo4Ank&list=PLA7E0B83332F6D76F#t=185.

2. Discuss with students:

a. Why do you think the school only targeted bottled water and not the other drinks in plastic PET bottles?

b. Do we sell bottled water at school?

c. Could our school reduce the number of drinks we buy in PET plastic bottles by encouraging students to swap some of their bottled water, juice and soft drinks with tap water?

d. What other alternatives are there to bottled water in schools?

e. Would it be possible to ban bottled water at our school or in our community?

Did you know the City of Perth have installed drinking fountains with chilled sparkling tap water?

www.perth.wa.gov.au/newsroom/featured-news/australian-first-perth-trials-public-drinking-fountain-alternative

3. **Design the survey (optional)**

Use the survey on page 58 or ask the students to design their own survey on bottled water to answer the following questions:

- What type of water do students/teachers consume and which do they prefer (tap, bottle, filtered)?
- Do students/teachers buy bottled water and why?
- What are the students'/teachers' opinions on bottled water and tap water? Do they think one is cleaner, safer, tastier or healthier?
- Do the students/teachers support the banning of bottled water sales?

Jigsaw opportunity: Put the students in groups of 3 or 4. Give each group one of the questions above and ask them to write survey questions for it. Bring the groups together and create a survey.

No time to design a survey? Use the one in Exercise 5.

4. **Conduct the survey:**

a. Discuss with students:
   - Should we survey everyone in the school or take a sample?
   - If we take a sample, how big should the sample be?
   - Will different samples give different results? How important are those differences?

b. Have the students conduct the survey and return to class with their results ready to analyse the results.

5. **Analyse the survey:** Ask students to analyse the survey results. This will vary depending on the survey questions but could include:
   - Produce a pie chart to show the types of water people drink
   - Calculate the mean number of water bottles students purchase in a week
   - Use the mean to compare the number of water bottles purchased with other drinks (this could include mean, mode, median and range or a back-to-back stem and leaf plot)
   - Calculate how much waste from bottles is produced by students at the school in a week (students will need to know the weight of a bottle and the number of students at the school)
   - What percentage of the school supports the banning of bottled water sales?
   - Produce a graph to show how students felt about the alternatives to bottled water. Which is the preferred alternative?
   - Produce a two-way table or a column graph to compare the support the banning of bottled water by males and females (or teachers to students)
   - Use a dot plot to compare the number of bottles of water purchased by different groups (e.g. compare teachers and students or compare younger students with older students).

6. Report (optional): Students could collate their results and produce a report on bottled water at school. The report could include cost, distance and waste calculations from earlier exercises as well as survey results. The best reports could be presented to the principal.

Activity 8. Conduct a fundraising activity (optional)

1. Plan and conduct a fundraising event. Students could sell an alternative to bottled water (e.g. fresh juice or chilled cordial) to students who bring refillable bottles. Alternatively they could sell reusable bottles to students who don't own one.

2. As a class, ask students to plan for the fundraiser. Ask students to:

   a. Use their survey results to determine the best product to sell
   b. Discuss the number of items they think they can sell – think about the best / worst scenario
   c. Make a list of items they will need to purchase and calculate their costs
   d. Estimate the cost price of each product they are selling (you may like to discuss with students how this may vary depending on the number sold)
   e. Decide on a selling price
   f. Ask students to write an equation for the revenue (R = SP x n, Revenue = selling price x number of items sold). Students may also like to graph this
   g. Ask students to calculate how many items need to be sold to break even
   h. Ask students to calculate how many items need to be sold to make a 20% profit.

3. Ask students to discuss and decide on roles, develop a marketing campaign, implement their fundraiser as a one off or ongoing business and then celebrate their achievements.

Monte Sant' Angelo Mercy College in NSW raised funds to install cold filtered water stations similar to these ones found at Curtin University.

Activity 9. Conversions for other plastics

For this activity you will need: A projector, screen, speakers and an internet connection to show a short clip and to display Exercise 6. Exercise 6 can be found at the back of the maths section on page 60.

1. Watch the clip on plastic bags from the *Bag It* movie www.youtube.com/watch?v=MRjPkl_4lmM
2. Complete Exercise 6 (page 60).

Extension or Assessment

- Examine the profit and loss statements of the school canteen. How much of the profit is from the sale of water? What percentage is this? How else could the canteen earn this amount without the sale of plastic bottled drinks?
- Investigate where plastics are sent for recycling. They could also analyse the environmental impact of exporting plastics for recycling in China.
  - How far do plastics travel to the recycling plant?
  - How much plastic is exported for recycling?
  - Is there an environmental impact of transporting recyclables to China or other overseas locations? How can you quantify it? You might like to consider both sides of the journey. Would the ships have returned empty if it wasn't for recyclables? www.recyclenow.com/why_recycling_matters/isnt_plastic_export.html

    The following graphs, from the 2011–12 *National Plastics Recycling Survey* (Australian) may also be useful.
    - Figure 23 (page 32): Plastics recyclate export from 1997 to 2011-12 (column graph).
    - Figure 46 (page 58): Destination of plastics reprocessed in Australia (pie chart).
    - Table 10 (page 33): Waste plastics exported overseas by polymer and state (two-way table).

    www.pacia.org.au/Library/PageContentVersionAttachment/b32ecc28-36a3-4087-bd68-33a889cf9aef/r02_05_a10802_nprs_2011_12_report.pdf

Student leadership

Inspired students might like to participate in, or organise, an event to encourage other students to join them in giving up plastic bottles for a day, a week or month. The details of this campaign are outlined in the student leadership section of this document.

References for this lesson

These links were used in the lesson and may provide further background information:

- Source for graphs: *2011/12 National Plastics Recycling Survey (Australia)*
  www.pacia.org.au/Library/PageContentVersionAttachment/b32ecc28-36a3-4087-bd68-33a889cf9aef/r02_05_a10802_nprs_2011_12_report.pdf
- Source for bottled water costs: *Good Food Australia*
  www.goodfood.com.au/good-food/drink/bottled-water-put-to-the-taste-test-20130513-2jh9k.html
- Where does my water come from: *Drinking Water Quality Annual Report 2011/12, Water Corporation*
  www.watercorporation.com.au/-/media/files/about%20us/our%20performance/drinking%20water%20quality/annual-report-2012.pdf

EXERCISE 1: The cost of water

Table 1. The price of water supplied to homes in WA

The *Water Corporation* in WA has a tiered pricing structure for the water supplied to our homes. The pricing structure for annual water use is shown in the table below.

Water use (kL)	Price per kilolitre
0 - 150 kL	$1.381 /kL
151 - 500 kL	$1.841 /kL
Over 500 kL	$2.607 /kL

Water Corporation (2014) www.watercorporation.com.au/my-account/rates-and-charges.

Table 2. Water use per household in WA

In 2008/09 the *Department of Water* conducted a survey on water use. The results are shown below.

Number of people in the house	Water use per year (L per household)
1	106 000
2	212 000
3	318 000
4	424 000
5	530 000
6	636 000

Department of Water (2013) www.water.wa.gov.au/PublicationStore/first/98576.pdf.

Table 3. Cost of bottled water

The Waste Wise team visited a supermarket and recorded the cost of different brands of bottled water. The costs are the standard shelf price and do not include any discounts offered at the time.

Brand	Size of bottle	Cost	Cost per Litre
Fiji	500mL	$1.69	
Deep Spring	600mL	$1.75	
Aqua Pura	1.25L	$1.60	
Mount Franklin	1L	$2.10	
Evian	1.5L	$4.09	
Thank You Water	1.5L	$2.00	
Frantelle	1.5L	$1.45	
Snowy Mountain	1L	$1.29	
Woolworths Select	1L	$1.19	
Pump	750mL	$2.79	
Yaru	500mL	$1.50	
Coles brand	600mL	99c	
Coolridge	1L	$2.40	
Pureau	2L	$2.99	
Waiwera	1L	$3.60	

Prices sourced from a Perth supermarket in October 2014.

Complete one of the following options:

Option 1.

Elise Dalley from *Choice* (2013) claimed that 'Australian consumers pay almost 2000 times more than the cost of tap water to drink from a bottle'. Use the information provided in Table 1, 2 and 3 to determine if this claim is correct.

Option 2.

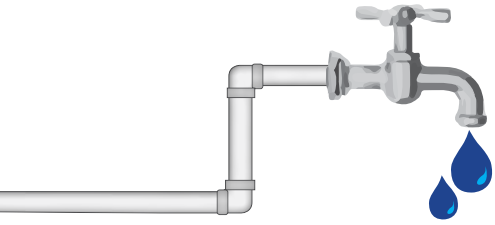
Elise Dalley from *Choice* (2013) claimed that 'Australian consumers pay almost 2000 times more than the cost of tap water to drink from a bottle'. Use Table 1, Table 2 and Table 3 to answer the following questions to determine if this claim is correct.

Part 1. Calculate the cost of water supplied to your household by following the following steps:

1. How many people are in your house, including you?
2. What is your water use per annum (per year)?
3. Convert your household's water use to kilolitres per annum (hint: 1000L = 1kL).
4. Calculate the total cost of your water per annum using these steps
   a. Calculate the cost of the first 150kL.
   b. Calculate the cost of the water from 151 – 500kL.
   c. Calculate the cost of any water over 500kL.
   d. Add these together to calculate the total cost of water per annum for your household.
5. Calculate the cost of water per litre for your household (Hint: you will need to use Question 1 and Question 3d).
6. Other students in your class may have a slightly different cost. Write down their cost. Why is it different?
7. What is the range in costs in your class?

Part 2. Calculate the mean (average) cost of bottled water

8. Look at each brand of bottled water in Table 3 and convert each to a cost per litre.
9. Use your answers from Question 8 to calculate mean cost of bottled water per litre.
10. Calculate the median, mode and range in the cost of bottled water per litre.



Alternatively, you could find out the costs of different brands at your local shop and use these.

Part 3.

11. Which is more expensive? Tap water or bottled water?

12. Use your answers to Part 1 and Part 2 to complete this sentence

    'On average, bottled water is _____ times more expensive than tap water'.

13. Was the statement by Elise Dalley correct? Does water from a bottle cost 2000 times more than tap water?

Extension:

How long would it take you to recoup the cost of a bottle of water by refilling the bottle with tap water? You will need to make an assumption about the amount of water you drink in a day.

Filling up with tap water saves money.

Answers based on four people in a household

1. 4
2. 424 000L
3. 424kL
4. a) $207.15 b) $504.43 c) 0 d) $711.58
5. $0.0017 per Litre(4 decimal places)
6. See teacher
7. See teacher
8. See teacher
9. $2.10 per Litre
10. Median = $2.10, Mode = none, range = $2.76
11. Bottled water
12. 1235 times more expensive (based on 4 person household)
13. See teacher

EXERCISE 2: How far does water travel?

Water supply in Perth

The Perth, South West, Goldfields and agricultural regions share a water supply system that draws on surface sources, groundwater and seawater desalination. This is known as the Integrated Water Supply System (IWSS) which provides fresh, clean drinking water to more than 1.7 million people. Surface water comes from eight dams in the Darling Range: South and North Dandalup, Serpentine, Wungong, Churchman Brook, Canning, Victoria dams and Mundaring Weir. Water is also supplied from Stirling and Samson Dams in the South West Region. Groundwater is drawn from the Yarragadee, Leederville and shallow aquifers (Water Corporation, 2012). The desalination plant is located in Kwinana. *Figure 1* shows the proportion of water supplied by surface water, groundwater and desalination.

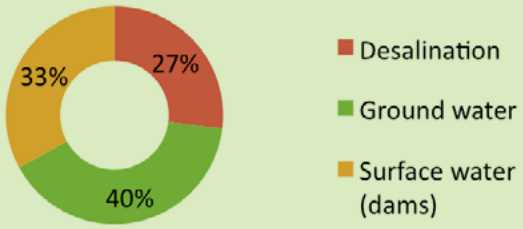


Figure 1. Current Water Sources in Perth (Water Corporation, 2014)

Table 1. Source of bottled water

Brand	Type of water source	Source of water or location of bottling	Cost
Fiji	Artesian	Yaqura, Fiji	$1.69
Deep Spring	Spring	Not supplied	$1.75
Aqua Pura	Purified (tap water)	Salisbury South, SA	$1.60
Mount Franklin	Spring	Bottled in Kewdale, Perth. Water sourced within two hours drive.	$2.10
Evian	Spring	Evian-Les-Bains, France	$4.09
Thank You Water	Spring	Mt Tamborine, QLD	$2.00
Frantelle	Spring	Bottled in Welshpool, Perth (sourced from springs in WA, NSW or VIC)	$1.45
Snowy Mountain	Spring	Daylesford, VIC	$1.29
Woolworths Select	Spring	Gingin, WA	$1.19
Pump	Purified (spring)	Bottled in Kewdale, Perth. Water sourced within two hours drive.	$2.79
Yaru	Spring	Mount Warning, NSW	$1.50
Coles brand	Spring	Not supplied	99c
Coolridge	Spring	Bottled in Welshpool, Perth (sourced from springs in WA, NSW or VIC)	$2.40
Pureau	Purified (Sydney water, tap)	Sydney	$2.99
Waiwera	Artesian	Auckland, New Zealand	$3.60

Option 1. Comparison using means

Suitable for Years 7 - 9

Part 1. Calculate the mean distance travelled by tap water

1. Surface water comes from eight dams in the Darling Range: South and North Dandalup, Serpentine, Wungong, Churchman Brook, Canning, Victoria dams and Mundaring Weir. Calculate the mean distance from your home to each of the surface water sources (dams) listed above.
2. Groundwater is drawn from the Yarragadee, Leederville and shallow aquifers. Calculate the mean (average) distance from your home to each of the two known groundwater sources.
3. The desalination plant is located in Kwinana. How far is this from your home?
4. Use the percentages in Figure 1 to calculate a weighted average for the water supplied to the tap in your home using the formula below.

$$\textbf{Weighted average} = \frac{(27\times D + 40\times G + 33\times S)}{100}$$

where,
D = desalination distance
G = groundwater distance
S = surface water (dam) distance}

Part 2. Calculate the mean (average) distance travelled by bottled water

5. Use Table 1 to calculate the distance travelled by each bottled water brand to your home.
6. What is the maximum distance travelled by bottled water?
7. What is the range?
8. What is the mean (average) distance travelled by bottled water?
9. What would happen to the mean if we removed one or two of the largest distances travelled?
10. How does the distance travelled by bottled water compare to the distance travelled by tap water to your home?

Alternatively, you could find out where the brands at your local shop come from and use these for the calculation in question 5

11. Research: How is tap water transported to your home? How is bottled water transported and stored before it is sold. What environmental impacts are associated with the transport and storage of bottled water? Why is tap water a more sustainable choice?

Answers based on Scarborough

1. Mean = 64km
(Distance to each dam: 112km, 99.2km, 88.7km, 51.5km, 49.9km, 28.2km, 28.2km, 55km)
2. 22.55km (Distance to each known groundwater source: 33.3km, 11.8km)
3. 55.9km
4. 45.23km
5. Distance travelled: 6385km, 2689km, 22.2km, 14 239km, 4353km, 24.5km, 3353km, 76.9km, 22.2km, 4360km, 24.5km, 3948km, 5343km
6. 14 239km
7. 14 216.8km
8. Mean = 3449km
9. It would decrease
10. Bottled water travels 314 times further
11. Tap water travels along pipes while bottled water travels by ships, trains and trucks. The bottled water travels much greater distances and uses more energy and fossil fuels than tap water. Burning fossil fuels for transport also creates pollution and greenhouse gases. Often bottled water is refrigerated prior to sale, consuming more electricity and fossil fuels. Tap water is a more sustainable choice because it uses less energy and resources.

'One hundred percent of FIJI Water is from a single source in the pristine, tropical Fiji Islands, an archipelago of over 300 islands nestled in the South Pacific, more than 1600 miles from the nearest industrialized country. It is bottled at the source in the remote Yaqara Valley on the island of Viti Levu.' www.fijiwater.com/faqs

Option 2. Comparison using box-and-whisker plot

Suitable for Year 10

Part 1. Draw a box-and-whisker plot for the distance travelled by tap water by following these steps:

1. Calculate the distance from each of the 11 known water sources to your home. The water sources are listed in the paragraph about the water supply to Perth.
2. Calculate the mean distance travelled by water to get to your tap.
3. Calculate the standard deviation (Year 10A only).
4. Which water source is the closest to your home?
5. What water source is the furthest from your home?
6. What is the median distance of the water sources from your home?
7. Draw a box-and-whisker for this data (the distance water travels to your tap at home).

Part 2. Draw a box-and-whisker plot for the distance travelled by bottled water by following these steps:

8. Use Table 1 to calculate the distance travelled by each bottled water brand to your home
9. Calculate the mean distance travelled by water to get to your tap.
10. Calculate the standard deviation (Year 10A only).
11. What is the minimum distance travelled by bottled water to your home?
12. What is the maximum distance travelled by bottled water to your home?
13. What is the median distance travelled by bottled water to your home?
14. Draw a box-and-whisker plot showing the distance water travels to your tap at home.

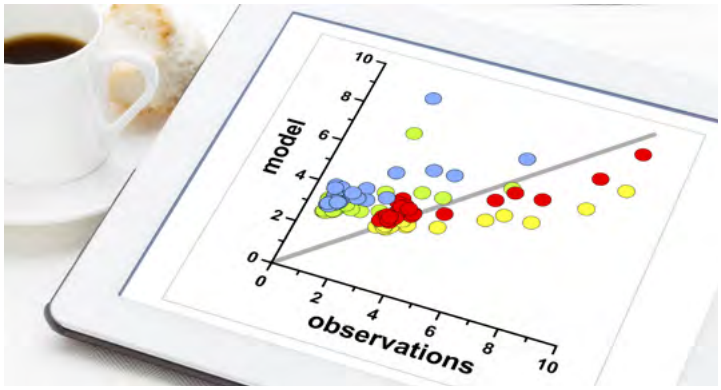
Part 3. Compare the distances travelled

15. Compare the mean distance travelled by tap and bottled water (Q2 and Q9).

16. Which data has the greatest variation? How can you tell?

17. Use the box-and-whisker plots to describe the differences between tap and bottled water.

18. Research: How is tap water transported to your home? How is bottled water transported? What environmental impacts are associated with the transport and storage (refrigeration) of bottled water? Why is tap water a more sustainable choice?



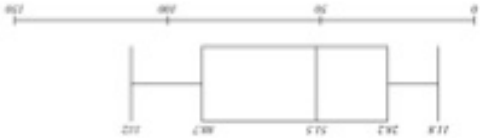
Extension:

Draw a scatterplot of the distance travelled by bottled water and the cost. Is there a relationship? If so, describe how distance and cost are related.

Answers based on Scarborough

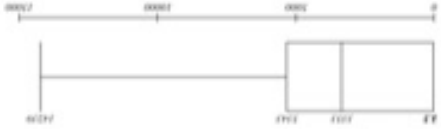
1. Distance to each water source: 112km, 99.2km, 88.7km, 51.5km, 49.9km, 28.2km, 28.2km, 55km, 33.3km, 11.8km, 55.9km
2. 55.8km
3. 31.8km
4. 112km, South Dandalup
5. 11.8km, Leederville
6. 51.5km
7. Five point summary; 11.8, 28.2, 51.5, 88.7, 112

Distance tap water travels



8. Distance travelled (km): 6385, 2689, 22.2, 14239, 4353, 24.5, 3353, 76.9, 22.2, 4360, 24.5, 3948, 5343
9. 3449km
10. 3973km
11. 22.2km
12. 14 239km
13. 3353km
14. Five point summary: 22.2, 24.5, 3353, 5343, 14239

Distance bottled water travels



15. Bottled water travels 62 times further than tap water (on average)
16. Bottled water has the greatest variation (as shown by the larger standard deviation)
17. The bottled water distances are much larger and have much greater variation (especially in the top half of brands).
18. Tap water travels along pipes while bottled water travels by ships, trains and trucks. The bottled water travels much greater distances and uses more energy and fossil fuels than tap water. Burning fossil fuels for transport also creates pollution and greenhouse gases. Often bottled water is refrigerated prior to sale, consuming more electricity and fossil fuels. Tap water is a more sustainable choice because it uses less energy and resources.

EXERCISE 3: How much plastic is recycled and where does it go?

Table 1. Total consumption and recycling of plastics in Australia, 2011/12 (by polymer).

Polymer	Plastics Identification Code	Consumption (tonnes)	Domestic recycling (tonnes)	Export for recycling (tonnes)	Total recycling (tonnes)
PET	1	116 838	15 101	47 043	62 144
HDPE	2	405 977	33 668	59 535	93 203
PVC	3	209 465	6 222	2 212	8 434
L/LLDPE	4	212 525	33 658	34 036	67 694
PP	5	216 347	20 323	18 817	39 140
PS	6	23 630	2 994	4 896	7 889
EPS	6	40 335	2 712	64	2 775
ABS/SAN	7	20 619	5 312	0	5 312
PU	7	56 523	6 993	0	6 993
Nylon	7	15 871	860	0	860
Other	7	158 560	8 189	0	8 189
Totals	**-**	**1 476 690**	**136 032**	**166 604**	**302 635**

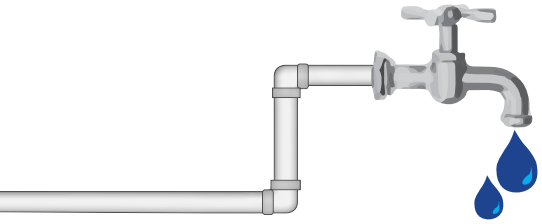
Source: 2011/12 National Plastics Recycling Survey, PACIA

Bottles that don't get recycled end up in landfills.

Recycling plastics in Australia

1. In 2011/12, how many tonnes of PET were consumed in Australia?
2. How many tonnes of PET plastic were not recycled? Where would these go?
3. What percentage of PET plastic is recycled?
4. Of the PET plastics that are recycled, what percentage is exported for recycling?
5. Research: What kind of environmental impacts might be associated with sending plastic overseas for recycling? Where does the plastic go? How far does it travel? What mode of transport is used to get the plastic overseas?
6. How much does an empty bottle of water weigh?
7. In Australia, 15,253.79 tonnes of PET was used in the packaging of bottled water in 2009/10 (Source: www.gotap.com.au/Did%20you%20know/Facts.aspx).
   a. Use the weight of an empty bottle to estimate how many PET bottles were used in 2009/10?

      Hint: convert both the weight of the bottle and the weight of PET into kilograms before calculating the number of PET bottles used in a year.
   b. What percentage of PET plastic goes to landfill each year?
   c. How many PET water bottles end up in landfill per minute?
   d. How does this compare to the rate in America (840 bottles per second)?
   e. What assumption have you made in this calculation?



The lightest 600mL water bottle produced in Australia weighs just 12.8grams (according to Mount Franklin, 2011). Students could use this figure if you don't have a water bottle to weigh.

Answers

1. 116 838 tonnes
2. 54 694 tonnes, these would go to landfill
3. 53%
4. 76%
5. Most of the plastics exported for recycling go to Asian countries (more than 7000km away). A lot of energy and fuel is used to transport plastics for recycling.
6. See teacher (lightest bottle is 12.8g)
7. a) 1,191,702,344 bottles (using 12.8g per bottle)
   Challenge: 1.2 billion bottles
   b) 47% go to landfill (from Table 1)
   c) 1066 per minute
   d) Less (Australians throw out 18 bottles per second)
   e) All bottles are the same size and weigh 12.8g.

EXERCISE 4:
Recycling plastics at school

Table 1. Cost of waste removal at school

Waste Stream	Bin Type	Bin Size	Frequency	Unit	All prices are GST Inclusive		
					PERTHWASTE effective 01/01/2015	SITA effective 01/01/2015	VEOLIA effective 01/04/2013
Co-mingled Recycling	Mobile Garbage Bins	240 Litre	3 or more times/week	per bin	$5.05	$4.96	$6.05
	Mobile Garbage Bins	240 Litre	Weekly	per bin	$5.05	$4.96	$6.05
	Mobile Garbage Bins	240 Litre	Fortnightly	per bin	$5.05	$4.96	$6.33
	Mobile Garbage Bins	240 Litre	Monthly	per bin	$5.05	$4.96	$6.60
	Mobile Garbage Bins	240 Litre	Ad hoc	per bin	$5.05	$4.96	$6.05
	Mobile Garbage Bins	660 Litre	3 or more times/week	per bin	$10.80	$9.22	$9.90
	Mobile Garbage Bins	660 Litre	Weekly	per bin	$10.80	$9.22	$9.90
	Mobile Garbage Bins	660 Litre	Fortnightly	per bin	$10.80	$9.22	$10.45
	Mobile Garbage Bins	660 Litre	Monthly	per bin	$10.80	$9.22	$10.45
	Mobile Garbage Bins	660 Litre	Ad hoc	per bin	$10.80	$9.22	$9.90
	Mobile Garbage Bins	1100 Litre	3 or more times/week	per bin	$14.08	$12.69	$12.10
	Mobile Garbage Bins	1100 Litre	Weekly	per bin	$14.08	$12.69	$12.10
	Mobile Garbage Bins	1100 Litre	Fortnightly	per bin	$14.08	$12.69	$12.65
	Mobile Garbage Bins	1100 Litre	Monthly	per bin	$14.08	$12.69	$12.65
	Mobile Garbage Bins	1100 Litre	Ad hoc	per bin	$14.08	$12.69	$12.10
	Front Lift Bins	1.5 Cubic Metre	Ad hoc	per bin	$27.51	N/A	$26.40
	Front Lift Bins	3.0 Cubic Metre	Ad hoc	per bin	$44.20	N/A	$39.60
	Front Lift Bins	4.5 Cubic Metre	Ad hoc	per bin	$52.24	N/A	$59.40
General waste	Mobile Garbage Bins	240 Litre	3 or more times/week	per bin	$6.38	$7.42	$6.82
	Mobile Garbage Bins	240 Litre	Weekly	per bin	$6.38	$7.42	$6.82
	Mobile Garbage Bins	240 Litre	Fortnightly	per bin	$6.38	$7.42	$7.15
	Mobile Garbage Bins	240 Litre	Monthly	per bin	$6.38	$7.42	$7.37
	Mobile Garbage Bins	240 Litre	Ad hoc	per bin	$8.86	$7.42	$6.82
	Mobile Garbage Bins	660 Litre	3 or more times/week	per bin	$16.70	$14.84	$11.88
	Mobile Garbage Bins	660 Litre	Weekly	per bin	$16.70	$14.84	$11.88
	Mobile Garbage Bins	660 Litre	Fortnightly	per bin	$18.93	$14.84	$16.28
	Mobile Garbage Bins	660 Litre	Monthly	per bin	$18.93	$14.84	$20.68
	Mobile Garbage Bins	660 Litre	Ad hoc	per bin	$18.93	$14.84	$11.88
	Mobile Garbage Bins	1100 Litre	3 or more times/week	per bin	$21.14	$18.89	$15.62
	Mobile Garbage Bins	1100 Litre	Weekly	per bin	$21.14	$18.89	$15.62
	Mobile Garbage Bins	1100 Litre	Fortnightly	per bin	$21.14	$18.89	$21.78
	Mobile Garbage Bins	1100 Litre	Monthly	per bin	$21.14	$18.89	$27.94
	Mobile Garbage Bins	1100 Litre	Ad hoc	per bin	$21.14	$18.89	$15.62
	Front Lift Bins	1.5 Cubic Metre	Ad hoc	per bin	$30.88	$26.32	$26.40
	Front Lift Bins	3 Cubic Metre	Ad hoc	per bin	$51.82	$45.55	$36.96
	Front Lift Bins	4.5 Cubic Metre	Ad hoc	per bin	$69.31	$66.80	$50.99

Source: General Waste Disposal and Recycling Services Price Schedule, CUA36309
http://infopage.gem.wa.gov.au/docs/Buying_Guide_-_36309.pdf

Bales of plastic ready for recycling from a Materials Recovery Facility in Bunbury.

Swan Christian College collect plastics and other recyclables.

Recycling plastics at your school

1. How many plastic bottles of drink (water, soft drink, juice, other) have you purchased at school in the last week? How many of these did you recycle?
2. Create a table in your book to collect the class data on the number of 'purchased' plastic bottles. Your teacher will show you how to do this.
3. Use the table from Question 2 to calculate the average number of plastic bottles purchased per student in your class.
4. How many students attend your school?
5. Use the class average to calculate the total number of plastic bottles purchased by students at your school:
   a. in one week.
   b. one school year (40 weeks).
6. How much does a plastic bottle weigh? How many tonnes of plastic does your school produce each year from drink containers?
7. According to Keep Australia Beautiful, a standard 240L bin can hold 170 containers (http://kab.org.au/wp-content/uploads/2012/07/3_recycling_trade_flyer_pack.pdf). How many 240L bins would your school fill each week with the plastic bottles from drinks consumed?

8. Assume your school has 1.5 cubic metre front-lift general waste bins (skip bin)

   a. Convert 240L to cubic metres.
   b. How many 240L bins could fit in a 1.5 cubic metre bin?
   c. Use the Keep Australia Beautiful figure in Question 7 to calculate how many containers fit in a 1.5 cubic metre bin.
   d. Calculate how many 1.5 cubic metre bins your school would fill each week.
   e. How much would it cost to have these bins collected by PERTHWASTE if:
      i. they all went to landfill (general waste)?
      ii. they all were recycled (co-mingled)?
      iii. 53% of the containers were recycled?
   f. Use your answer to Question 8e (iii) to calculate how much money your school could save in a year if 53% of plastic containers were recycled.

9. Extension: How much money could your school save in one year if students at your school reduced the purchase of drinks in plastic containers by 10% by drinking tap water instead? List your assumptions with your calculation.

Some questions to consider:

- Does your school currently recycle plastic containers?
- What kind of bins does your school have?
- Who collects the bins? How much are the collection costs?

  If you don't know the answer, you could investigate by looking around the school for clues or you could ask staff. Alternatively, you could make assumptions and list these with your answer.

Dowerin DHS collect milk bottles, clear plastic bottles and aluminium cans for recycling.

Answers

8. a) 0.24m3 b) 6.25 bins c) 1063 containers
   d) See teacher e) See teacher f) See teacher

EXERCISE 5: Bottled water survey

1. Please tick: Male ☐ Female ☐
2. Tick one. I am a
   - ☐ Student
   - ☐ Staff member (principal, teacher, librarian etc)
   - ☐ Other, please specify _____

Please answer the following questions about your water drinking habits. Tick one option for each question.

3. What kind of water do you drink most often?
   - ☐ Tap
   - ☐ Bottled
   - ☐ Filtered (e.g. using household filter)
4. How often do you drink water from the water fountains (bubblers) at school?
   - ☐ Never
   - ☐ Sometimes
   - ☐ Often
   - ☐ Always
5. How often do you carry a refillable water bottle with you at school?
   - ☐ Never
   - ☐ Sometimes
   - ☐ Often
   - ☐ Always
6. How many bottles of water did you purchase at school in the last week? _____
7. If you buy bottled water at school, why do you buy it instead of drinking from the tap?
   - ☐ I prefer cold water from the fridge
   - ☐ I prefer the taste of bottled water to tap water
   - ☐ I think bottled water is 'cooler' (more fashionable) than tap water
   - ☐ It's more convenient than tap water
   - ☐ Other, please describe:_____

Please answer the following questions about your opinions on bottled water. Tick one option for each question.

8. I think bottled water tastes better than tap water.
   - ☐ Agree
   - ☐ Disagree
   - ☐ Unsure

9. I think bottled water is safer and cleaner than tap water.

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

10. I think bottled water is a waste of money.

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

11. Some bottled water that you buy in shops is filtered tap water.

- ☐ True
- ☐ False
- ☐ Unsure

12. I am concerned about the cleanliness or safety of water fountains (bubblers) at school.

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

13. There are enough water fountains (bubblers) available at school.

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

14. If more water fountains (bubblers) were available at school, I would use them more.

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

15. If the water fountains (bubblers) were of better quality, I would use them more.

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

16. I am concerned about the environmental impact of bottled water (e.g. litter, plastic doesn't break down).

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

17. We should ban the sale of bottled water at the canteen.

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

EXERCISE 6: Plastic bag conversions

1. One million plastic grocery bags are used every minute.
   a. How many bags are used per hour?
   b. How many bags are used per day?
   c. What would the impact be per year?
2. Forty billion (40,000,000,000) plastic bags were eliminated in China after one year of not using them.
   a. How many bags did China save per day?
   b. What are ways that we can reduce the number of plastic bags used each time we visit the grocery store?
3. It costs 22 cents per bag in Ireland at the market.
   a. If you went to the store and used 3 bags to take home your groceries, how much money would you spend on plastic bags each visit?
   b. How much would you spend if you did the same shopping every week for a year?
   c. If you purchase one reusable bag at the grocery store for $1.50 and bring it each time you go to the grocery store, how much money would you save over the course of a month?
4. Three hundred million take-away coffee cups are consumed in one day in the US.
   a. How many coffee cups are used per hour?
   b. How many coffee cups are used per second?
5. The average person in the US contributes 800 pounds of packaging per year to the waste stream:
   a. How many kilograms is this?
   b. How much is this per person, per day?
6. What steps can YOU take to reduce the amount of waste in the form of packaging that you contribute to the waste stream?
7. One million plastic cups are used on US airline flights every 6 hours
   a. How many plastic cups are used each minute?
   b. How many plastic cups are used in one day?
   c. Are there ways you can decrease this number the next time you are flying on an airplane?

By converting these units, you may find yourself converting your ways!

These conversion questions were modified from the Bag It curriculum document available at http://bagitmovie.com/downloads/EducationPacket_7.pdf

Answers

1. a) 60 million b) 1440 million c) 525 600 million
2. a) 109 589 041 bags per day b) Take your own bags
3. a) $0.66 b) $34.32 c) $2.86
4. a) 12.5 million (12 500 000)b) 3472
5. a) 362.8kg b) 1kg per day
6. Buy less packaged food (and more fresh food), buy second hand products, fix things instead of buying new things, borrow or hire items
7. a) 2778 b) 4 million c) Take your own cup

MATHS: CURRICULUM LINKS

Year 7:

NUMBER AND ALGEBRA	**Number and Algebra; Real numbers** Find percentages of quantities and express one quantity as a percentage of another, with and without digital technologies (ACMNA158). Recognise and solve problems involving simple ratios (ACMNA173). **Number and Algebra; Money and financial mathematics** Investigate and calculate 'best buys', with and without digital technologies (ACMNA174).	Activity 4, 5 Activity 2, 5, 9 Activity 2
STATISTICS AND PROBABILITY	**Statistics and Probability; Data representation and interpretation** Identify and investigate issues involving numerical data collected from primary and secondary sources (ACMSP169). Construct and compare a range of data displays including stem-and-leaf plots and dot plots (ACMSP170). Calculate mean, median, mode and range for sets of data. Interpret these statistics in the context of data (ACMSP171).	Activity 7 Activity 7 Activity 2, 7

Year 8:

NUMBER AND ALGEBRA	**Number and Algebra; Number and place value** Carry out the four operations with rational numbers and integers, using efficient mental and written strategies and appropriate digital technologies (ACMNA183). **Number and Algebra; Real numbers** Solve problems involving the use of percentages, including percentage increases and decreases, with and without digital technologies (ACMNA187). Solve a range of problems involving rates and ratios, with and without digital technologies (ACMNA188).	Activity 2, 3, 4, 5 Activity 5 Activity 2, 5
MEASURE-MENT	**Measurement; Using units of measurement** Choose appropriate units of measurement for area and volume and convert from one unit to another(ACMMG195).	Activity 5
STATISTICS AND PROBABILITY	**Statistics and Probability; Data representation and interpretation** Investigate techniques for collecting data, including census, sampling and observation (ACMSP284). Explore the practicalities and implications of obtaining data through sampling using a variety of investigative processes (ACMSP206). Explore the variation of means and proportions of random samples drawn from the same population (ACMSP293).	Activity 7 Activity 7 Activity 7

Year 9:

NUMBER AND ALGEBRA	**Number and Algebra; Real numbers** Solve problems involving direct proportion. Explore the relationship between graphs and equations corresponding to simple rate problems (ACMNA208). Express numbers in scientific notation (ACMNA210).	Activity 2, 5, 9 Activity 5
STATISTICS AND PROBABILITY	**Statistics and Probability; Data representation and interpretation** Identify everyday questions and issues involving at least one numerical and at least one categorical variable, and collect data directly and from secondary sources (ACMSP228).	Activity 7

Year 10:

STATISTICS AND PROBABILITY	**Statistics and Probability; Data representation and interpretation** Construct and interpret box plots and use them to compare data sets (ACMSP249).	Activity 3

Year 10A:

STATISTICS AND PROBABILITY	**Statistics and Probability; Data representation and interpretation** Calculate and interpret the mean and standard deviation of data and use these to compare datasets (ACMSP278).	Activity 3