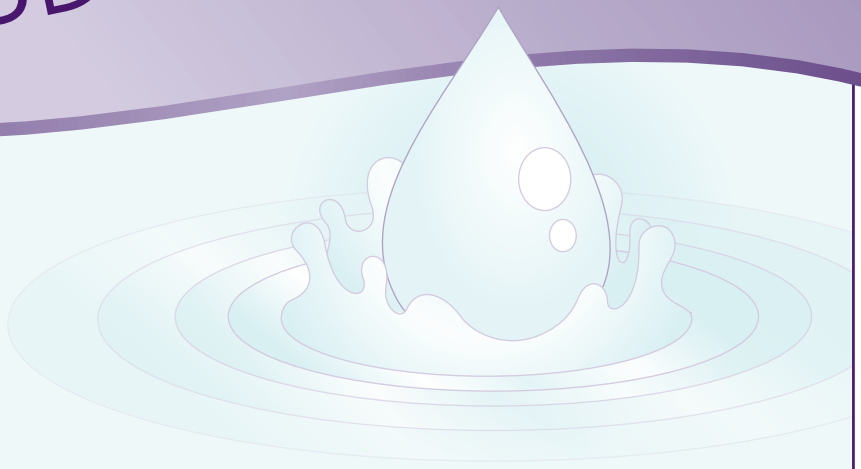
QCATs
Queensland Comparable Assessment Tasks

9

2009

MATHEMATICS

STUDENT BOOKLET



Rainwater

Given name: .....

Family name: .....

School: .....

Queensland Government

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Partnership and innovation

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Setting the scene: Group discussion

Water supply

Water availability affects us all — whether we live in the city, in a small town, on a farm or in an isolated community.

Many of us use water supplied by the local council, but with uncertain rainfall and a growing population, some councils are finding it increasingly difficult to meet demand. Governments encourage us to use less water for showering and to use water-efficient washing machines. Water restrictions are common, with councils limiting the watering of gardens and the washing of houses and cars.

Image: State Library of Queensland

Many householders are looking to supplement the council water supply with rainwater. State and local governments are encouraging us to install rainwater tanks.

The use of rainwater is not a new idea, and there was a time when almost all houses had a rainwater tank as the only water supply. Tanks are making a comeback and are now available in shapes and sizes to fit even the smallest of spaces.

If your household was thinking of installing a rainwater tank to supplement your water needs, what issues would need to be considered?

The problem

In this assessment task you are required to plan how to make the best use of available rainwater, using mathematical reasoning to:

- determine how to use past rainfall data to predict rainfall patterns
- analyse how rainfall is measured
- predict how much rainwater could be collected from a roof each month using local rainfall data
- develop an appropriate rainwater-use plan and choose a suitable rainwater tank.

Image: Queensland Studies Authority

Section 1: How much rain?

In Queensland, rainfall varies a lot from place to place, with Innisfail on the north tropical coast receiving an average (mean) rainfall of over 3500 mm of rain per year and Birdsville in the far south-west averaging less than 200 mm per year.

In all locations there are monthly variations, with wetter and drier periods during the year.

Analysis of rainfall records allows us to make reasonable predictions of future rainfall.

Table 1 below shows April rainfall records at Birdsville Police Station from 1997 to 2006.

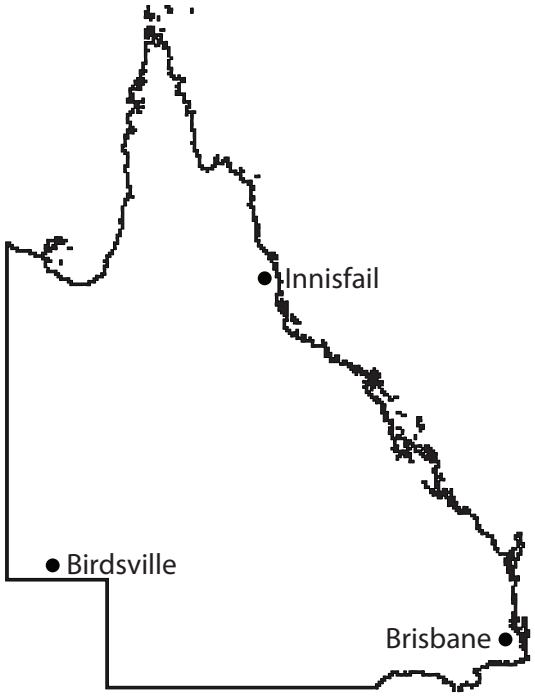

Table 1

April rainfall data for Birdsville Police Station, 1997 to 2006										
Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
April rainfall (mm)	0.0	52.8	2.0	86.6	1.0	0.0	6.7	1.0	0.0	0.0

Source: Commonwealth of Australia 2009, Bureau of Meteorology, <www.bom.gov.au>

1. Calculate Birdsville's mean and median April rainfall for the period 1997 to 2006.

Show all working

Mean April rainfall = ...

Show all working

Median April rainfall = ...

2. The median is a more useful predictor of typical monthly rainfall than the mean. Use the April data for Birdsville to explain why.

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STOP HERE: WAIT FOR YOUR TEACHER'S DIRECTIONS

Measuring rainfall

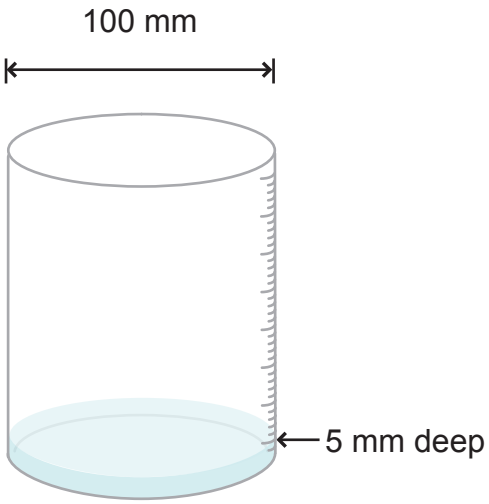
A rain gauge is used to measure rainfall (usually in millimetres).

The level in the gauge represents the depth of rainwater that would build up on a flat horizontal surface if it didn't run off or soak in.

Any open container with straight vertical sides can be used as a simple rain gauge. The depth of water collected is a measure of the amount of rain.

Rain gauges A and B both measure the same amount of rainfall, even though A collects a greater volume of water because of its larger opening.

3. If 5 mm of rain falls and is collected in a 100 mm diameter rain gauge, calculate the volume of rainwater in the gauge.



Volume of a cylinder
$= \pi r^2 h$

Show all working

Volume of rainwater = ... mm^3

To improve the accuracy of rainfall measurement, the collected rainwater can be poured into a narrower cylinder.

4. How is the accuracy of rainfall measurements improved by pouring the collected rainwater into a narrower cylinder?

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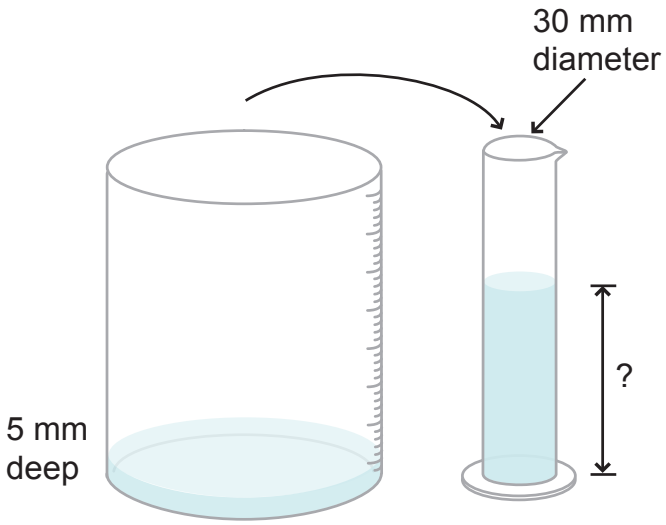


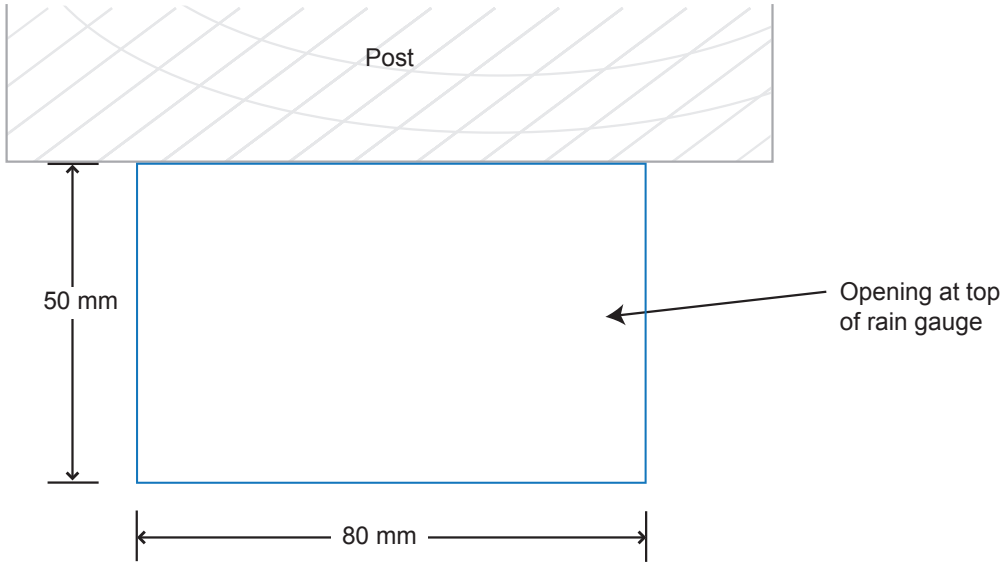
5. Calculate the depth of the rainwater collected in Question 3 after it is poured into a narrow, 30 mm diameter cylinder.

Show all working

Depth of water in the narrow cylinder = ... mm

Not all rain gauges are cylinders.

The diagram below shows the top view of a rain gauge attached to a post.



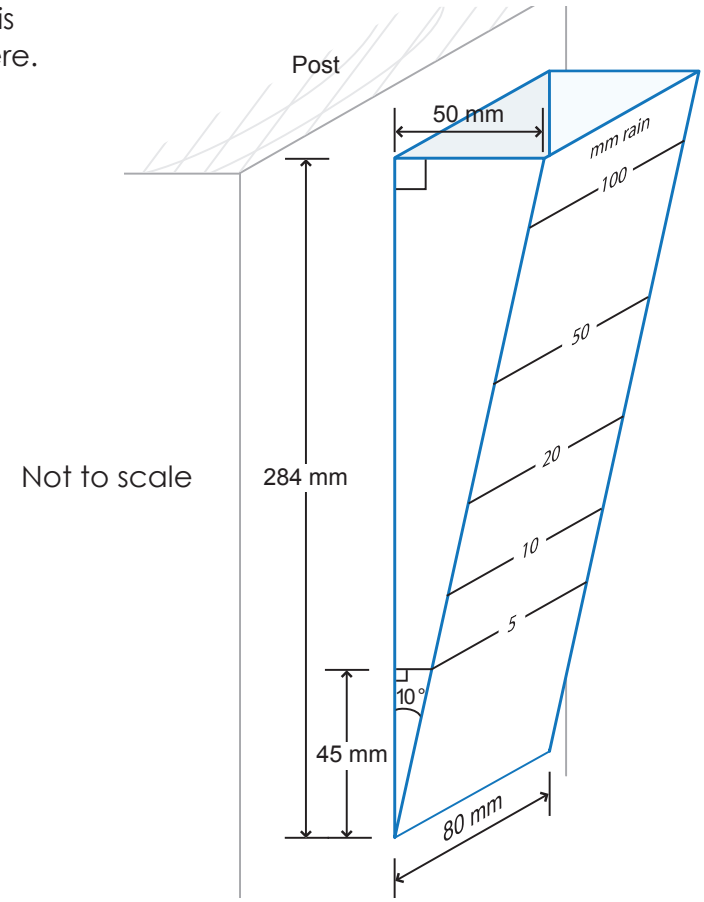
Not to scale

6. If 5 mm of rain falls, calculate the volume of water collected in the rain gauge above.

Show all working

Volume of rainwater collected = ... mm^3

The rain gauge from page 8 is wedge-shaped, as shown here.



7. Use the volume calculated in Question 6 to check if the 5 mm graduation on the rain gauge is in the correct place.

Show all working

Tick the correct answer.

The 5 mm graduation is:

- ☐ in the correct place
- ☐ too high
- ☐ too low.

STOP HERE: WAIT FOR YOUR TEACHER'S DIRECTIONS

Section 2: Planning a rainwater supply

Table 2 below shows typical roof areas for homes of different sizes.

Table 2

Typical roof areas	
Home type	**Roof area (m^2)**
2 bedroom home	100
3 bedroom home	150
4 bedroom home	200
5 bedroom home	250

Assume the roof is flat.

(This makes little difference to the amount of rain collected.)

From the table, choose a home that most closely matches the one you live in (or would like to live in).

My choice of home: .....

8. Calculate the amount of rainwater in litres (L) collected by the roof of your chosen home when one millimetre (1 mm) of rain falls.

Show all working

1 mm = 0.001 m
1 m^3 holds 1000 L

Amount of rainwater collected by the roof when 1 mm of rain falls = ... L

Your teacher has supplied you with median monthly rainfall data for:

…… (location).

9 a. Copy the median rainfall values for each month into column A of Table 3.

b. Using your answer to Question 8, calculate the expected amount of rainwater collected from your chosen roof during each month.
Write these values in column B of Table 3.

Table 3

Expected rainwater collected		
Month	**A** Median rainfall (mm)	**B** Rainwater collected by the roof (L)
Jan		
Feb		
Mar		
Apr		
May		
Jun		
Jul		
Aug		
Sep		
Oct		
Nov		
Dec		

10. Explain how you could make the best use of the collected rainwater (Table 3) to reduce your need to use water from the local supply.

In your answer:

- ☐ record the number of people living in the house
- ☐ work out approximately how much water your household uses each month (refer to Table 4 below)
- ☐ compare the expected amount of rainwater collected (Table 3) to your monthly usage
- ☐ explain how you could use the collected rainwater to supply some or all of your needs
- ☐ select an appropriately sized tank to store rainwater for use in drier months (refer to Table 5 below)
- ☐ justify all your reasoning and show all calculations.

Answer on the following pages.
Check the box next to each point above as you complete it.

Table 4

Careful water use (using water wisely)	
Use	**Litres *per person* per month**
Drinking, cooking	**300**
Dish washing	**150**
Bathroom and toilet	**2500**
Washing clothes	**200**
A garden hose uses about 700 litres ***per hour***	

Table 5

Rainwater tank sizes and prices										
Tank capacity (litres)	500	1000	1500	2000	2500	3000	5000	10000	20000	50000
Installed cost	$500	$700	$750	$800	$1000	$1100	$1400	$2000	$3000	$7000

Have you checked all the boxes in Question 10?
Continue your answer over the page if necessary.

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Continue your answer over the page if necessary.

Have you checked all the boxes in Question 10?

Guide to making judgments — Year 9 Mathematics

Student .....

Purpose: To use mathematical reasoning to develop an appropriate local plan for storage and use of rainwater.

Knowledge and understanding	Thinking and reasoning	Thinking and reasoning	Communicating	
Selection and manipulation of formulas to calculate lengths, volumes and statistical measures of central tendency. *Questions 1, 3, 5, 6, 8, 9*	Choice of strategies and procedures to generate solutions. *Questions 7, 10*	Generalisation and justification of reasoning. *Questions 2, 4, 10*	Use of mathematical language and representations to communicate thinking and to justify reasoning. *Questions 1–10*	
Demonstrates consistent success in selecting, manipulating and applying appropriate formulas.	Successfully applies a multi-step procedure to check the rain gauge graduation. Chooses a tank size which accurately meets the needs of the rainwater-use plan.	Justifies choice of tank size with an accurate analysis of water use and rainfall availability. Makes perceptive generalisations about accuracy of rainfall measurements and predictors of rainfall.	Clearly communicates procedures, reasoning and justification using mathematical representations, language, working, rounding and units.	**A**
	Demonstrates significant progress in applying a multi-step procedure to check the rain gauge graduation. Determines a realistic plan for rainwater use.	Bases rainwater-use plan on a well-reasoned comparison of water needs and available rainwater. Justifies choice of tank size with a partial analysis of water use and rainwater availability.		**B**
Demonstrates proficiency in selecting and applying appropriate formulas.	Chooses an appropriate strategy to plan rainwater use and storage, with some success. Links choice of tank size to rainwater-use plan.	Makes a plausible generalisation about accuracy of rainfall measurements or predictors of rainfall. Bases rainwater-use plan on a comparison of water needs and available rainwater.	Shows working and units in calculations. Communication of explanations and justifications is variable.	**C**
Demonstrates variable success in selecting and applying formulas.	Demonstrates some success in developing a plan to make use of available rainwater.			**D**
		Some calculation of expected rainfall or water use evident.	Occasionally shows working and uses everyday language.	**E**

Feedback .....

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