Evaporation Innovation

YEAR 5 AND 7
CHEMICAL SCIENCES
EARTH AND SPACE SCIENCES
DESIGN AND TECHNOLOGIES

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK | Queensland Government

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

QUEENSLAND MUSEUM NETWORK

Queensland Government

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

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EXPLORE – EXPLAIN – ELABORATE – EVALUATE

Evaporation Innovation

Teacher Resource

Australia is the world's driest populated continent, receiving low average annual rainfall that is both unevenly distributed across the continent and highly variable. The conservation of water is therefore an important strategy to ensure the effective and sustainable management of water now and into the future.

Design Challenge

In this activity, students are engineers tasked with developing an innovative solution that will reduce the rate of evaporation experienced by a local dam, reservoir or weir. Evaporation can result in the loss of large volumes of water. For instance, Brisbane's three main water supply reservoirs (Wivenhoe, North Pine, Somerset) can lose 248 GL/year to evaporation[1]; this is equivalent to 99,200 Olympic sized swimming pools!

Students may develop their solution for a real or imagined dam, reservoir or weir. Information related to the surface area, depth, evaporation rate and residential water use of various operational dams, reservoirs and weirs across Queensland is provided on page 43.

Students then calculate when the chosen site will run out of water, if the water supply source is currently at capacity and there is no rainfall from this day forward. An example of how students could complete this question is shown on page 44. After students design and test their solution, they complete this calculation again to determine if their solution is effective in reducing evaporation.

Innovation Analysis

Following the completion of the design challenge, students may explore how people in design and technologies fields have responded to similar issues. Students may read about and then analyse one of the following designed solutions using the Innovation Analysis worksheet:

- Those 96 million black balls in LA's reservoir are not just there to save water
- Using recycled plastic bottles to reduce evaporation
- Floating discs have evaporation covered

1 Burn, S. (2011). Future urban water supplies. In Prosser, I (Ed.), *Water* (pp. 89-104). Australia: CSIRO Publishing. Retrieved from: https://www.publish.csiro.au/ebook/download/pdf/6557

Curriculum Links

Science

YEAR 5

Science Understanding

Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE081)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

Science Inquiry Skills

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS086)

Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS087)

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS090)

Compare data with predictions and use as evidence in developing explanations (ACSIS218)

Reflect on and suggest improvements to scientific investigations (ACSIS091)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS093)

YEAR 7

Science Understanding

Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)

Science as a Human Endeavour

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE223)

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE121)

Science Inquiry Skills

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)

Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126)

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)

Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

Design and Technologies

YEAR 5 & 6

Design and Technologies Knowledge and Understanding

Examine how people in design and technologies occupations address competing considerations, including sustainability in the design of products, services, and environments for current and future use (ACTDEK019)

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use (ACTDEK023)

Design and Technologies Processes and Production Skills

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)

Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions (ACTDEP026)

Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions (ACTDEP027)

Curriculum Links

YEAR 7 & 8

Design and Technologies Knowledge and Understanding

Investigate the ways in which products, services and environments evolve locally, regionally and globally and how competing factors including social, ethical and sustainability considerations are prioritised in the development of technologies and designed solutions for preferred futures (ACTDEK029)

Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (ACTDEK034)

Design and Technologies Processes and Production Skills

Critique needs or opportunities for designing and investigate, analyse and select from a range of materials, components, tools, equipment and processes to develop design ideas (ACTDEP035)

Generate, develop, test and communicate design ideas, plans and processes for various audiences using appropriate technical terms and technologies including graphical representation techniques (ACTDEP036)

Select and justify choices of materials, components, tools, equipment and techniques to effectively and safely make designed solutions (ACTDEP037)

Independently develop criteria for success to evaluate design ideas, processes and solutions and their sustainability (ACTDEP038)

General Capabilities

Literacy

Comprehending through listening, reading and viewing

Composing texts through speaking, writing and creating

Numeracy

Estimating and calculating with whole numbers

Using measurement

ICT Capability

Investigating with ICT

Creating with ICT

Critical and Creative Thinking

Inquiring – Identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Social awareness

Social management

Cross Curriculum Priorities

Sustainability

Sustainable futures result from actions designed to preserve and/or restore the quality and uniqueness of environments (OI.9)

Evaporation Innovation

Teacher Resource

Queensland Dams, Reservoirs and Weirs

Note: Approximate figures are used for surface area, depth and residential water use.

Name	City	Surface Area[1] (m^2)	Depth[1] (m)	Evaporation Rate[2] (mm/year)	Residential water use (per person, per day)
Wivenhoe Dam	Brisbane	108,000,000	59	1600	150L[3]
Copperlode Falls Dam	Cairns	3,327,000	45	1800	200L[3]
Chinchilla Weir	Chinchilla	3,580,000	9.2	1800	264L[4]
Fairbairn Dam	Emerald	150,000,000	46	2000	533L[4]
Awoonga Dam	Gladstone	67,800,000	53	2000	267L[4]
Hinze Dam	Gold Coast	9,720,000	62	1600	175L[3]
Borumba Dam	Gympie	4,800,00	43	1600	184L[4]
Lenthalls Dam	Hervey Bay	7,000,000	32	1600	200L[4]
Wivenhoe Dam	Ipswich	108,000,000	59	1400	150L[3]
Wivenhoe Dam	Logan	108,000,000	59	1600	150L[3]
Dumbleton Weir	Mackay	1,510,000	15	2000	200L[3]
North Pine Dam	Moreton Bay	21,800,000	45	1600	150L[3]
Moondarra Dam	Mount Isa	21,900,000	27.5	2800	576L[4]
Peter Faust Dam	Proserpine	43,250,000	51	1800	670L[4]
Fitzroy River Barrage	Rockhampton	16,120,000	10	2000	330L[4]
Storm King	Stanthorpe	830,000	10	1400	213L[4]
Ewen Maddock Dam	Sunshine Coast	3,710,000	11.4	1600	165L[3]
Baroon Pocket Dam	Sunshine Coast	3,820,000	58	1600	165L[3]
Cressbrook Dam	Toowoomba	5,170,000	59	1600	170L[3]
Cooby Creek	Toowoomba	3,014,000	30	1600	170L[3]
Perseverance Dam	Toowoomba	2,200,000	53	1600	170L[3]
Ross River Dam	Townsville	82,000,000	34.4	2400	300L[3]
Leslie Dam	Warwick	12,880,000	33	1600	239L[4]

1 Australian National Committee on Large Dams Incorporated. (2010). Register of large dams in Australia. Retrieved from https://www.ancold.org.au/wp-content/uploads/2012/10/Dams-Australia-2010-v1.xls
2 Bureau of Meteorology. (2003). Average evaporation map – Annual. Retrieved from http://www.bom.gov.au/climate/map/evaporation/evap_ann.shtml
3 RACQ. (2016). Cost of living: Utilities. Retrieved from https://www.racq.com.au/-/media/racq/pdf/loans/racq---cost-of-living---utilities.pdf
4 Queensland Government. (2020). Regional water supply security assessments. Retrieved from https://www.business.qld.gov.au/industries/mining-energy-water/water/industry-infrastructure/supply-planning/security/security-assessments

Evaporation Innovation

Teacher Resource

Calculating Water Loss

To calculate when the dam will run out of water, you will need to:

1. Calculate the total capacity of the dam using the formula:

   Dam Capacity = Surface Area x Depth x 0.4

   Note: 0.4 is a conversion factor that takes into account the slopes of a side of a dam.
2. Calculate the evaporation experienced by the dam each day using the formula:

   Dam Evaporation = Surface Area x Evaporation Rate

   Hint: Be sure to use the same unit of measurement for surface area and evaporation rate.
3. Calculate how much water the town's population uses per day in litres.

   Convert this amount from litres to mega litres.
4. Calculate total water loss/day based on population use and evaporation rate.
5. Calculate how long it will take for the dam to run out of water using the formula:

   Time taken to run out of water = Dam Capacity ÷ Total Water Loss/day

Example Response

1. Calculate the total capacity of the dam.

   Molong Reservoir, Orange

   Dam Capacity = Surface Area x Depth x 0.4
   = 300,000 m^2 x 16 m x 0.4
   = 1,920,000 m^3
   = 1920 ML

2. Calculate the evaporation experienced by the dam each day.

   Average Evaporation Rate = 1400 mm/year
   = 1400 mm ÷ 365
   = 3.8 mm/day

   Dam Evaporation = Surface Area x Evaporation Rate
   = 300,000 m^2 x 0.0038 m
   = 1140 m^3
   = 1.14 ML

3. Calculate how much water the town's population uses per day in litres.

   Convert this amount from litres to mega litres.

   Molong population = 1674 people

   Total Molong residential water use/day = 133 L x 1674
   = 222,642 L
   = 0.22 ML

4. Calculate total water loss/day based on population use and evaporation rate.

   Total water loss/day = 0.22 ML + 1.14 ML
   = 1.36 ML

5. Calculate how long it will take for the dam to run out of water.

   Time taken to run out of water = Dam Capacity ÷ Total Water Loss/day
   = 1920 ML ÷ 1.36 ML
   = 1411.76 days
   = 3.87 years

Evaporation Innovation: Design Challenge

Student Activity

Task:

A regional council has selected your engineering company to design a solution that will reduce the rate of evaporation currently experienced by their local dam. The regional council is located in a drought prone area, and by engaging your engineering company they hope to conserve the amount of water available for use by the community and local industry. You will present your final solution to representatives from the regional council (your class and teacher).

You must:

- **Investigate** the local context and factors that may influence the rate of evaporation. Develop criteria that solutions would need to meet to successfully address the problem (success criteria).
- **Design** an innovative solution that will reduce the rate of evaporation experienced by the dam. During the design process, you should consider:
  - Success criteria
  - Materials, systems, components, tools and equipment, including their characteristics, properties and cost
  - The impacts your solution will have in relation to sustainability and the environment
- **Create** a prototype of your designed solution.
- **Test** your designed solution by conducting a scientific investigation. How well does your design reduce evaporation? Evaluate your results against the success criteria.
- **Refine** your designed solution to further reduce the rate of evaporation. Repeat your scientific investigation to determine the impacts of any changes made to your design.
- **Evaluate** your designed solution continuously against the success criteria, and make changes to improve the design.
- **Collaborate** in teams of two or three and pitch your final designed solution to the regional council. You may also be required to evaluate social interactions to effectively work in a team.

Investigate

The regional council (your teacher) has supplied the following information about the local dam.

Dam name	
Surface area (m^2)	
Depth (m)	
Evaporation rate (mm/year)	
Residential water use (per person, per day)	

Use this information to calculate when the dam will run out of water, if the dam is currently at capacity and there is no rainfall from this day forward. Remember to include your working out, as this will help to explain your thinking and support your conclusion.

Keep in mind: Your designed solution should increase this amount of time by decreasing the rate of evaporation experienced by the dam.

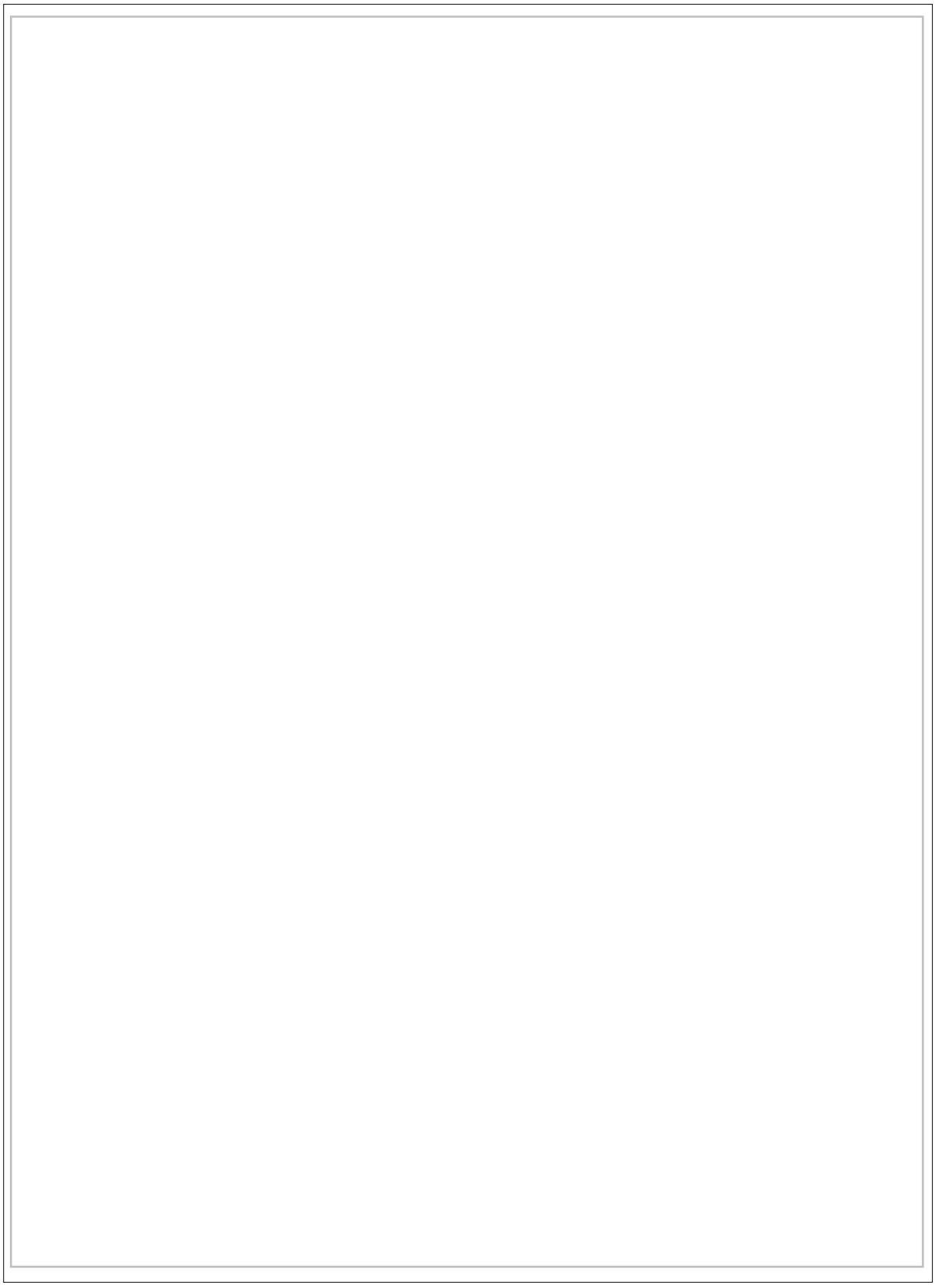
What other factors may influence the rate of evaporation experienced by the local dam? Identify these factors and explain how they may increase or decrease the rate of evaporation.

Factor	Effect on rate of evaporation

Develop criteria your designed solution would need to meet to successfully address the problem (success criteria).

Design

Draw a labelled diagram of your designed solution. Make sure you identify and justify the materials you will use to create the solution, and explain and justify reasons for your design.



Create

Create a prototype of your designed solution.

Test

Conduct a scientific investigation to test the effectiveness of your designed solution.

Aim

To investigate how effective the designed solution is in reducing the rate of evaporation.

Materials

List all of the equipment you will use in the experiment. Remember to include numbers and amounts.

Method

List the steps you will take to conduct the experiment.

Risk Assessment

What safety considerations must be made before, during and after this experiment? Identify at least five hazards and how to minimise them.

Hazard	How to minimise hazard

Results

1. Record your results in a table (you may wish to use Excel for the table and graph).
2. Present your results in a graph.
3. Calculate the average rate of evaporation per day for the control test and your designed solution.

Control Test	Designed Solution

4. Use the average rate of evaporation per day for your designed solution to recalculate when the dam will run out of water, if the dam is currently at capacity and there is no rainfall from this day forward.

Discussion

1. Explain the results.

2. Justify the effectiveness of your designed solution in reducing the rate of evaporation. Consider your previous calculations and success criteria in your response.

3. Explain any challenges you experienced when completing this investigation, and how you did or could overcome them.

4. Determine how you could improve the investigation.

5. Discuss how you could refine your designed solution to increase its effectiveness.

Refine

Modify your designed solution based on the ideas discussed in the previous question. Repeat the scientific investigation to determine the impacts of any changes made to your design.

Explain and evaluate the impact of these modifications.

Present your final designed solution to the regional council.

Evaluate

Reflect on your actions with your team or class after you have completed the design challenge. You might like to think about the following questions to assist with your reflection:

- What scientific knowledge helped you make decisions about your designed solution?
- What aspects of your designed solution are you very satisfied with and why?
- Describe any further changes you could make to improve the designed solution.
- What were the main challenges you experienced during the design process? How did you overcome these challenges?
- What have you learnt about evaporation and the design process from this activity?
- How could you apply this knowledge and understanding to your learning in other contexts?
- What more would we like to know about evaporation?

Evaporation Innovation: Innovation Analysis

Student Activity

Innovation Analysis

Research and select an innovation that has been designed to reduce evaporation. Describe the innovation. Include in your description what the innovation is, how it is made and how or where it is likely to be used by people.

Explain how the innovation reduces evaporation.

Evaluate the sustainability implications of the innovation. Consider the materials, techniques and technologies used to make the innovation.

Evaluate the impacts of the innovation on society. Consider any ethical impacts, as well as impacts at a local, regional and global scale.