5. Water Quality Activities

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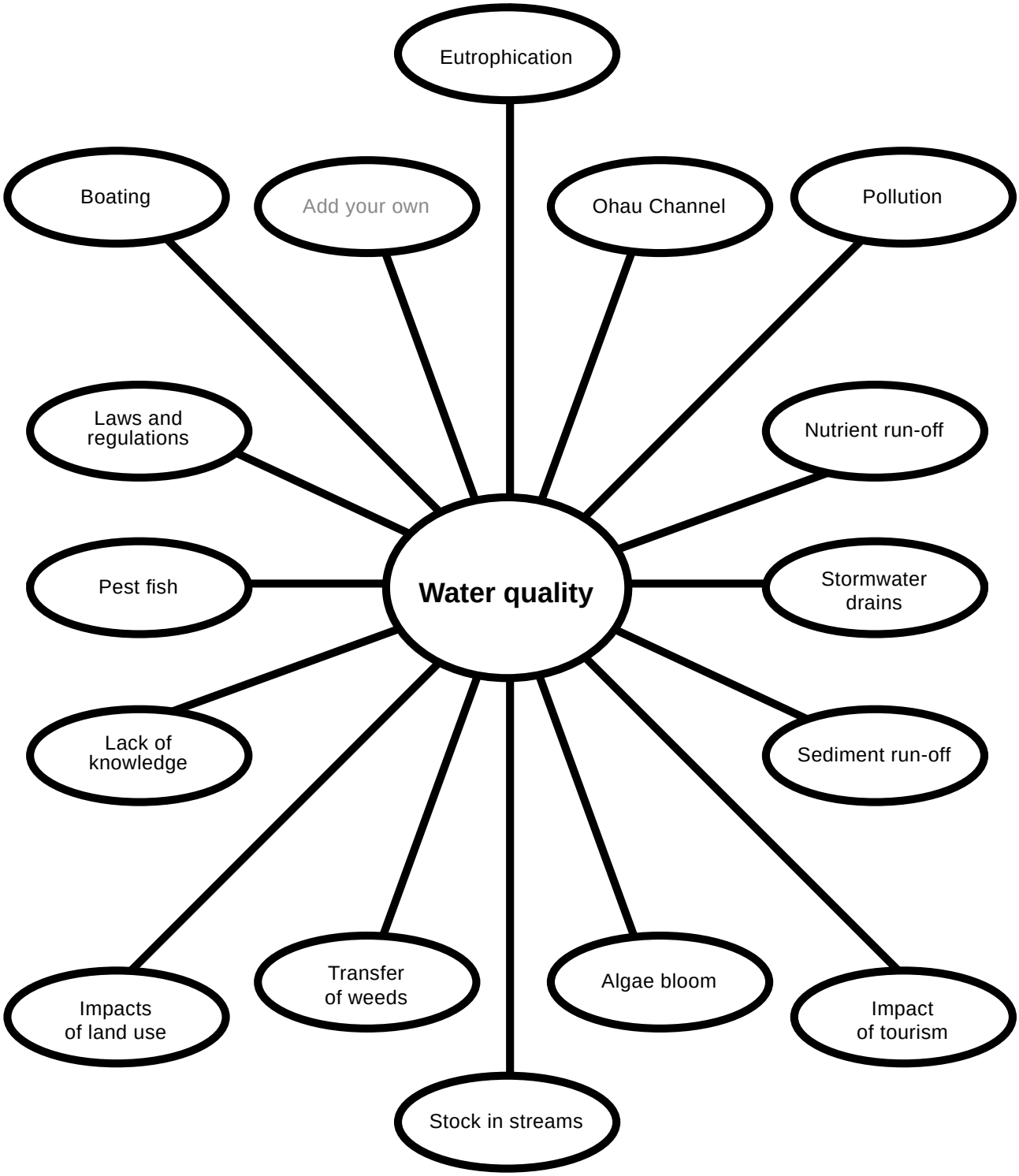
Relevant resources:

- www.teara.govt.nz
- www.niwa.cri.nz
- www.niwascience.co.nz/edu/resources/
- www.niwascience.co.nz/edu/students/faq/hydro-terms
- www.tki.org.nz/r/environ_ed
- www.tki.org.nz/r/environ_ed/primary_units/streams_water_e.php
- www.tki.org.nz/r/hot_topics/freshwater_e.php
- http://nwp.rsnz.org/content/Pollution_Detectives/projects_pollutiondetective.htm
- www.ew.govt.nz/enviroinfo/water/wetlands/index.htm
- www.protectyourwaters.net/prevention/prevention_generic.php
- www.habitattitude.net/impacts/degrade.php
- www.scienceclarified.com
- www.wateryear2003.org
- www.waitakere.govt.nz go to the education section – an excellent site.
- Waiora – Environment Bay of Plenty teachers resource
- Saving Our Wetlands – video 163 – DoC Conservancy Office
- Kaituna Wildlife Management Reserve – video 191 – DoC Conservancy Office
- ‘Take Action For Water’, Greater Wellington Regional Council, teachers resource
- RSNZ – Alpha Series – www.rsnz.org/education/alpha
  - » Alpha 117 – NZ Streams & Rivers
- RSNZ – Gamma Series – www.rsnz.org/education/gamma
  - » Gamma Series – May 2004, The Business of Drinking Water
- Learning Media – Building Science Concepts – www.learningmedia.co.nz
  - » Book 1: Levels 2–3 Waterways: How Rivers and Streams Work
  - » Book 15: Levels: 1–2 Where’s the Water?: Water’s Forms and Changes
  - » Book 31: Levels: 3–4 Water and Weather

- Learning Media – Connected series – www.learningmedia.co.nz
  - » Connected 3, 2004 – Item 30054 – Year 4–8, testing the water quality and ecology of local streams. Teachers' notes item 30055
  - » Connected 2, 2002 – Item 24733 – Year 3–6, includes changes in the physical state of water; the water cycle. Teachers' notes item 24734
- Learning Media – reader – www.learningmedia.co.nz
  - » From Sky to Sea, Joy Cowley, ISBN 0478214189, follows water as it falls from the clouds and journeys to the sea.
  - » Lake Life, Sharon Holt, ISBN 0790310104 shows support plants, animals, bacteria – and even people. This text examines the importance of lakes an explores some of the potential threats to this precious resources.
  - » The World of Water, Susan Paris, ISBN 0 7903 0458 9 Water is one of the most important resources on Earth. This book explains where water comes from and how it gets to our homes. It also explores pollution and the importance of water conservation.
  - » A Fishy Mystery, Anna MacKenzie, Item No. 30444 A group of children discover some dead fish floating in the local river and they are determined to find out what's killing them. They started by asking their teacher for help, then they conduct some research of their own.
- Pollution Busters newsletter # 7 Stormwater
- Pollution Busters newsletter # 12 Water
- Pollution Busters newsletter # 14 Lakes
- Pollution Busters newsletter # 16 Weeds
- Pollution Busters newsletter # 24 Wetlands
- NIWA – The Environment Watch CDs provide a series of environmental education resources intended for use by community groups, environmental educators, and secondary schools. NIWA has produced the series based on Environment Watch items from the TV3 programme No8 Wired, produced by the Gibson Group and sponsored by Sustanza

Water Quality - Issues

This brainstorm highlights some of the issues relating to Water Quality; you may find others as you work through your selected activities. Many also link to other sections.



Templates 4–10 are useful tools for guiding students from the issues through to action.

Water Quality - Action Ideas (see page 12)

- Riparian planting with local iwi/community/care group/farmers
- Wetland creation/restoration or enhancement
- Identification of stormwater drains e.g. I only drain rain/fish icon
- Cleaning stormwater grates
- Wash cars/bikes etc on the grass
- Monitor water quality and publicise results
- Lobby Board of Trustees, local or regional council about using permeable surfaces rather than tarseal or concrete
- Greywater recycling – investigate, trial, advocate
- Roofwater recycling– investigate, trial, advocate
- Design and install stormwater filters
- Apply for funding to use for actions such as the one above
- Approach your local or regional council, Department of Conservation, Fish & Game etc for help
- Litter collection
- Pamphlets, brochures, posters etc highlighting an issue
- Signs
- Letter writing/lobbying
- Advertising
- Slogans
- Surveys - advertise results in school foyer, newsletter, local library etc
- Public awareness raising
- Boat cleaning days
- Radio – advertising/item/reporting or newspaper article
- Stalls and displays at local events
- Organise a community event around an issue

Activity 5a Lakes Research

Curriculum links **Social studies**

Science

English

Any level

5

Social Studies/
Science/
English

Resources required

- Large scale map of the lakes

Prior learning

In groups, discuss the following questions:

- What do we already know about the Rotorua Lakes?
- What else do we want to find out? (You could use the chart created in 1a What We Know Now)
- Where could we look to get information?

Method

1 Use the following as a quiz or for group discussion

- Name the cleanest lake – Why did you say this?
- Name the dirtiest lake and explain your choice.
- Where do you get your drinking water from? Is it clean and how do you know this?

2 Divide into groups to research a chosen lake using the internet. Find statistics and information relevant to that particular lake (lake area, maximum lake depth, catchment area, land uses percentages and Trophic Level Index – TLI).

Use websites:

http://cber.bio.waikato.ac.nz/research_lakes.shtml

www.envbop.govt.nz/Water/Lakes/Lakes.asp

3 Present research on a large scale map of the lakes (may want to use OHT line drawing to enlarge). Discuss the meaning of the different TLIs and the relationship between that and land use types i.e. Compare the TLI pasture and forest/scrub percentages. What is the relationship?

4 In pairs students choose a lake to research in greater depth.
Research could include the following:

- What are the legends associated with the lake?
- What are activities of the catchment area around the lake?
- Which streams run into or out of the lake?
- What is the water quality of the lake? What is the reason for this?

5 Reflection

- Go back to Method 1, have any of your answers changed? Have your views and perceptions of the lakes changed?
- What can we do with the information we have gained? Can we help in the improvement of water quality for this lake? How?

Possible next steps

Use reference material from the websites to discuss in groups what:

- Long term strategies could be used to improve or maintain the quality of the water in that lake?
- Is being done to improve the water quality of this lake?

Activity 5b Jack and Jill

Curriculum links

Social Studies

English

Science

Environment Education – about

Any level

5

Social Studies/ English/ Science

Method

1 Class discussion – pose the following questions to the class. Don't provide them with the answers but keep providing them with the next question to prompt their thinking.

- What is a catchment?
- Which way does water run?
- Why do rivers form where they do?
- Why do lakes form where they do?

2 Once students have identified the features of a catchment, pose the following question:

Why did Jack and Jill go up the hill to fetch a pail of water?

Again, allow the ideas and deeper thinking to occur, prompt with additional questions, encouraging discussion. Initial answers tend to be that:

- They were going to a well.
- The well was up there to catch the maximum amount of rain.
- The water was cleaner up there etc.

Eventual outcome: For students to consider that perhaps the rhyme is illogical, they would not go up hill to fetch water from a well.

3 Reflection

- Find other rhymes/myths/fairy tales that involve water and perhaps an untruth.

Related concepts

- Water Cycle, catchment (Wairoa sections 1 & 2)

Possible next steps

- Surface and groundwater – divide the class and give one group surface water, the other groundwater. They research and present to the class.
- Through discussion the class then links the two using diagrams and or role modelling.
- Discuss what happens to rainwater using a cross-sectional diagram. Discuss the length of time that water can be under the ground before it appears in a stream or lake or spring.

Activity 5c Journey of a Water Drop

Curriculum links **Science**

Environmental Education – about

Any level
5
Science

Resources required

- "An Interview with a glass of water" Jeffy James, Connected 2 2002
- Waiora – Activity 1.2 "Follow the Water droplet", page 47 with Photocopy Master 2, page 107

Prior learning

In groups, students draw a large water drop on paper.

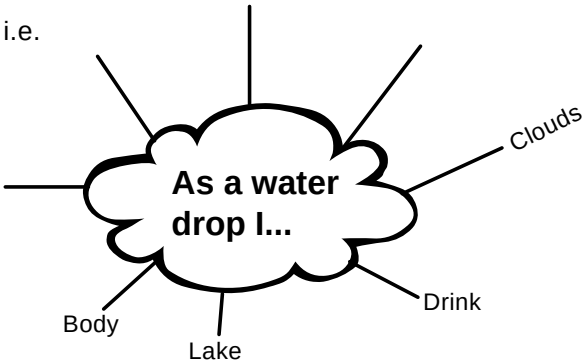
- Brainstorm your group's idea of what is water?
- Brainstorm all places water is found. How does it get there?

Method

1 Read the story "An Interview with a Glass of Water"

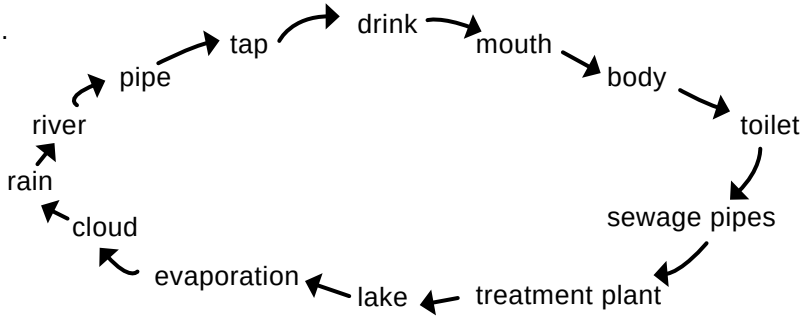
2 Create a brainstorm 'As a water drop I…'. Include all the places water goes or is found and the different things water can do.

i.e.



3 Take one idea and consider where the water drop was before and after. Create a visual representation,

i.e.



4 Research the water cycle and explore processes related to water, i.e. evaporation, condensation, precipitation, freezing/melting, sedimentation (group could be assigned a process to research).

5 Reflection

- What happens to the water drop at each stage of its journey?
- How can we improve the quality of the water drop before it completes its cycle?
- At what stages of the water cycle do you have an input? List your effects.
- How can you make a positive effect?

Possible next steps

- What do we use water for?
- How do we use the water?
- How much water is there?
- Waiora (Section 1)

Related Concepts

- Activity 1.1 “ The Water Cycle” page 45, Waiora, Photocopy Masters, pages 102–106

Activity 5d Rotorua's Catchment

Curriculum links **Social Studies**

Environmental Education – in and about

Level 3–5
5
Social Studies

Resources required

- Topographic map of catchment
- Land use maps
- MTS (Tumonz) CD if available in your school

Method

A catchment is an area of land, bounded by hills or mountains. Surface and groundwater flows from the hills or mountains into streams that join, and ultimately have the same outlet to the sea.

1 Catchment

a Look at a topographic map to find the edge of the catchment (ridgelines). Go outside and look at the surrounding landscape – where would the highest point of the catchment be? This will be clearer in some places than others. What catchment are we in?

b Look carefully at the map.

- How does the map tell you the location of hills and mountains?
- How can you identify stream?

c List the streams surrounding:

- Lake Rotorua
- Lake Okataina
- Lake Tarawera

d Follow each stream flow from the start to the lake. Briefly describe the path i.e. down hill/ through native/planted bush/surrounded by pastures/farms/through urban rural areas/human population.

e Summarise the water input for each lake based on your above descriptions.

2 Land use

a Go outside and look at the surrounding landscape. Discuss the various land uses you can see and in what sort of proportions.

b Compare the land use of two different lakes e.g. Lake Rotoma and Lake Okataina. Use a chart (example on the next page) to summarise your finding.

	Lake 1	Lake 2
Surrounding environment		
Human activity		
Streams – number – environment		

3 Reflection

- Are all of Rotorua's lakes equal?
- What makes them different?
- What factors do we (humans) input?
- How can we have a positive impact?
- What changes do we need to initiate to see a change for the better?

Related concepts

- Keywords – catchment, land use, water quality, nutrients, trophic level index, surface water flow, groundwater flow, water cycle. These keywords are important and meanings could be written on cards and used as a matching game or placed on a large wall map of Rotorua in the relevant places, e.g. land use goes well on farmland etc.
- Waiora (Section 2)

Possible next steps

- Waiora (Section 2)

Extension Activities

- Rotorua is particularly rich in Maori history and tangata whenua relationships with streams and lakes.

  Research

  - By asking whanau members
  - Using the computer
  - Using books i.e. Land of Te Arawa by Don Stafford
  - Reading articles from local papers
- Locate significant history attached to a Rotorua water feature such as a stream, lake or river. Include names and stories and how it was used by local hapu/marae.

Activity 5e Just Passing Through

Curriculum links Science

Any level
5
Science

Resources

- Photos of eroded areas (see www.envbop.govt.nz or Waiora)
- Wool or rope
- A slope
- A watch with a second hand or stopwatch
- Something to represent sediment e.g. leaves or sand

Method

1 If you know of an area that is eroded, go there and walk around it. Let students think about what is or isn't in that area. If you don't know of an area, source photos of eroded areas. Brainstorm with students what erosion is, why they think it might happen and what we can do about it. Encourage discussion on the bareness of most eroded areas i.e. often stream banks with no planting whatsoever, or areas of heavy stock concentration on farmland.

2 After some discussion explain to the students that this activity simulates the difference in the flow of water from areas that have no trees or plants to areas that have.

3 Create a catchment with students taking different roles. Have two students as fish, two as wetland birds, and five as wetland plants. Divide the rest of the class in half. The first half 'become' trees, the other half raindrops. The 'tree' students position themselves near the top of the hill (the beginning of the wool – which is laid out to represent a stream with a circle near the bottom to represent the wetland). The wetland plants and birds can position themselves in and around the wetland. Fish can move upstream and downstream. The raindrops position themselves at the top of the hill.

Part one – How does vegetation affect water movement?

1 The ‘rain’ starts. (If you want to you can create rain noises). At the height of the rainstorm, the raindrops make their way down to the stream, walking swiftly. This represents water falling on and flowing over the land’s surface. Start timing their movement.

2 Vegetation on the slope slows the flow of water. To show this, students representing vegetation try to tag the raindrops. Vegetation must keep one foot in place, but can pivot and stretch their arms (representing leaves and roots intercepting water).

3 If a raindrop is tagged, the student simulates filtering into the ground by circling five times around the vegetation. To represent water moving underground toward the stream and passing through spaces among soil particles, tagged raindrops should crawl towards the stream (wool).

4 Once raindrops reach the stream, they stand up and walk the length of the wool. In the rapids, (wiggly sections of the wool) they can spin around or do forward rolls to represent water spilling over the rocks.

5 At the end of the stream, raindrops remain in the wetland shaking hands with as many of the wetland plants as they can, they can only move out when there are four other raindrops in the wetland. Then they move off slowly downstream, one at a time.

6 Note the time taken for the raindrops to have passed through the wetland.

7 Discuss the activity and describe the movement of the water, and how vegetation and wetlands slow the water down.

Part two – what happens to water when forest is cleared?

1 ‘Raindrops’ reposition themselves. (Students could swap roles). This time the ‘trees’ are cows and sheep. Water moves around them but is not slowed by them. The ‘fish’ stay in the wetland, because there is no cover upstream.

2 Time the ‘raindrops’, from start to finish.

3 Compare the time required for the water to flow through sites with and without plant cover. Discuss what this means. Find out how the fish felt when they could no longer move upstream.

Part three – How do vegetation and wetlands help keep water clean?

1 Set up the field as in part one. Scatter leaves or sand to represent dirt and sediment. As ‘raindrops’ flow through the site they pick up the sediment. If tagged they filter into the ground, dropping all their sediment (symbolising the filtering power of soil). They circle around the ‘trees’ as in part one and move downstream (crawling). If any ‘raindrops’ reach the wetland, they leave their dirt there (symbolising the filtering effect of wetlands).

2 Discuss how vegetation and wetlands help to slow and filter water.

Part four – What happens to water when wetlands are drained?

1 'Raindrops' reposition themselves again and more dirt is placed on the field. This time the wetland is drained, by moving the wool inwards into a smaller circle. Any plants outside the new circle must wilt and die. Wetland fish and birds must go downstream and look for a new habitat. Raindrops at the top of the slope come down, picking up sediment, no longer slowed down by either vegetation or the wetland. Only the first two raindrops must stop in the wetland. The rest go round the small wetland and move on carrying their dirt. They can pass this dirt to the fish, who start to swim slower, representing the detrimental effect of sediment on fish.

2 Discuss how the draining of the wetland affected the fish and wetland plants. How did they feel? Discuss the speed of the water and the dirt that was carried through when there was no wetland to act as a sponge and a filter.

Part five – What can we do to help restore catchments?

1 Some 'trees' are replanted next to the stream and some other students link hands to represent a fence that separates the cows from the stream. The 'trees' lean over and form an arch over the 'stream', representing cooling and shading. The 'fish' come back. The 'trees' 'hold' the stream bank together, represented by keeping small heaps of sediment between their feet. 'Raindrops' cannot take this sediment, and also have to leave half of the sediment that they have picked up as they move through the stream bank 'trees', representing their filtering function.

2 Further 'restoration' can occur by planting 'trees' at the slip site (though some students should remain as cows). 'Raindrops' travelling over this replanted area can no longer pick up the dirt. A wetland can be recreated (wool extended back to a bigger circle). Water slows down again, fish and plants are established again.

Activity 5f Calligrams

Curriculum links **English**

Social Studies

Environmental Education – about

Any level
5
English

Resources required

- Pictures/illustrations relating to the lakes (see brochures etc. in file box)

Prior learning

- Find examples of good calligrams for reference

- Create criteria for an effective calligram – what does it need to do/have?

Method

Part A

1 Calligrams – words written to demonstrate their meaning

2 Brainstorm words to do with lake pollution: 10 words (neat), 15 words (wow), 20 words (amazing!)

3 Choose four of your words to write as calligrams – draft ideas

4 Choose your favourite calligram to publish for displaying on the wall

Part B

5 Choose a Rotorua Lake e.g. Rotoiti, Rotoma, and design a calligram based on your research in 5a Lakes Research.

6 Reflection

- Which words make the most interesting calligrams? Why is this?

Possible next steps

- Research and explore differing styles of expressing words/visuals
- Students may want to express themselves through poetry – acrostic, haiku etc.

Activity 5g Watery quiz

Curriculum links English

Any level
5
English

Resources required

- Books
- Charts
- www.kidcrosswords.com/puzzle_makers/puzzle_makers.htm

Prior learning

- Investigate possible games and quiz formats that could be used to share information
- Survey others (children in same or different classes) to investigate commonly liked games

Method

1 Brainstorm 10 questions about lake pollution or lake issues.

2 Find possible solutions to your questions.

3 Create a quiz or game that another group of students can play
e.g. matching cards, dominoes, riddles etc, based on your questions and answers.

Related concepts

Consider using these and other quizzes to assist:

- Literacy and development
- English as a second language (ESOL) students
- Or as homework.

Activity 5h Puzzlemaker

Curriculum links **Social Studies**
Environmental Education – about

Any level
5
Social Studies

Resources required

- Internet access

Prior learning

- Students may need to work on descriptive language and asking questions – language purpose, being specific when asking questions/alluding to an answer.
- Investigate how a crossword works. In pairs, do crosswords and have a go at making a very simple crossword. Test your simple crossword on someone else.

Method

1 Brainstorm 20 words relating to the Rotorua Lakes. (Check all spelling.)

2 Think of a clue for each word so someone else can guess the word. (Thinking of how a crossword works.)

3 Log on to PUZZLEMAKER and type in your words and clues to make a crossword:
   - http://puzzlemaker.school.discovery.com/chooseapuzzle.html
   - or try www.kidcrosswords.com/puzzle_makers/puzzle_makers.htm

4 Share your crossword with a buddy or share with someone at home.

5 Reflection

   Swap your crossword with a buddy. Complete crossword and give feedback based on:
   - Was their crossword easy to do based on your current knowledge of the lakes?
   - Were the questions appropriate for the answer they needed?
   - Did you learn anything new about the lakes?

Related concepts

Consider using these and other puzzles to assist with:

- Literacy development
- English as a second language (ESOL) students
- Or as homework.

Possible next steps

- Brainstorm additional ways of testing and sharing information about the lakes, i.e. games, puzzles, word-finds. Choose another medium to test and share information.

Activity 5i Treasure Hunt

Curriculum links **Science**

Social studies

Environment Education – about

Any level

5

Science/
Social Studies

Resources required

- Maps with coordinates.

Prior learning

- Map discussion – What are maps used for? Where can you find them? What are the criteria of a map? How do we effectively read maps?
- Review map reading skills.

Method

1 The following activities require copies of maps. Teachers can also set this as an information technology hunt where the students must source their own maps.

The objectives of this activity are:

- To increase map reading skills
- Increase student knowledge of their local area
- Problem solving and co-operative work
- There is also an opportunity for students to contribute their personal knowledge

2 Reflection

- List five new features of the Rotorua area you have discovered.

Possible next steps

- Students access mapping tools and information from Environment Bay of Plenty's website: www.envbop.govt.nz/about-us/our-region

Treasure Hunt – Sheet 1

A Give the name and coordinates to the main stream that winds its way into eastern Lake Rotorua. Stream name: _____ Coordinates: _____	B This lake has no boat access, is not private and has a recreational point. Lake name: _____ Coordinates: _____
C Give the coordinates to a popular diving spot along the main western driving route. Name of lake: _____ Coordinates: _____	D This lake allows for seasonal duck shooting and has a boat ramp. Name of lake: _____ Coordinates: _____
E Name and coordinates for the point that is just north of the diving spot are... Name of point: _____ Coordinates: _____	F Camping on this lakeshore is allowed with the luxury of hot springs. Lake name: _____ Coordinates: _____
G Give the name and point of origin of the stream that joins the Green Lake and Lake Tarawera. Name of point: _____ Coordinates: _____	H The name and point where water from Lake Rotorua exits. Name of point: _____ Coordinates: _____
I This lake is private but has a recreational point along the lake shore. Name of lake: _____ Coordinates: _____	J The name of the river that transports lake water northwards out to the sea. Name of river: _____ Coordinates: _____

Treasure Hunt – Sheet 2

K Give the name and coordinates to the 'plug' of the Rotorua caldera. Name: _____ Coordinates: _____ Height: _____	L Give the name and coordinates to a lake south of Rotorua named after a kitchen utensil. Name of lake: _____ _____ Coordinates: _____
M The Pink and White Terraces were located here. Name of lake: _____ _____ Coordinates: _____	N Add your own feature and coordinates.
O A settlement here was destroyed in an 1886 eruption. Settlement name: _____ _____ Coordinates: _____	P Add your own feature and coordinates.
Q The coordinates for the area where the contents of flushing toilets get treated. Coordinates: _____	R Add your own feature and coordinates.

Activity 5j Household Water Use

Curriculum links **Science**

Social Studies

Environment Education – about

Level 2–5
5
Science/
Social Studies

Resources required

- Containers of different sizes – labelled 1, 2, 3 and 4
- Food colouring – blue and yellow
- Dropper
- Salt
- Measuring cylinder

Prior learning

- List ways you use water.
- List the ways your family uses water.
- How much water do you use in a day.
- Each person uses on average 480L/day (drinking, bathing, cleaning, toilet flushing, gardens etc). Show using a 2 L drink bottle.

Method

Where does the water you use come from and go to?

Personal water use activities

1 Practical demonstration of Earth's water resources

- Fill container 1 with 1000 ml of water. This represents all the water on Earth.
- Pour off 24 ml into container 2 with a drop of yellow food colouring in it. This represents all the ice water (the polar caps, snow, glaciers etc).
- Pour off 6 ml into container 3 with a drop of blue food colouring in it. This represents all the fresh water.
- The remaining 970 ml (container 1) represents all the salt water.
- Now using the 6 ml of fresh water (the blue dyed water in container 3) measure off 4 ml into container 4. Add dirt to this, this represents groundwater.
- The remaining 2 ml of freshwater in container 3 is surface water. Use a pipette to collect 1 drop (0.0003% of the original water). Put this into a petri dish. This represents all the drinkable water in the world!

2 Consider water use in the home.

- As a class, brainstorm all water use in homes.

3 Class discussion

- One pipe comes into the home so therefore all home water is drinkable water.

4 Refer back to the proportions of all Earth's water which is drinkable.

- Question: How could we conserve this drinkable water in our home?

5 Class discussion about solutions offered.

6 Introduce concept of grey water by suggesting which water use in homes could use 'used water'?

7 Look at the one drop of drinkable water in the petri dish.

8 Reflection

Consider

- Ways that your family can reduce water use
- Ways that your family can reuse water
- Decide on one action to trial – act on it!

Activity 5K Testing our Water - A

Curriculum links Science

Any level
5
Science

Resources required

- Glass or clear plastic containers e.g. peanut butter jars (two per group or pair)
- White vinegar (or lemon juice)
- Baking soda
- Red cabbage water or universal indicator solution (contact local secondary school)
- Eye droppers
- Iceblock sticks (one per child)

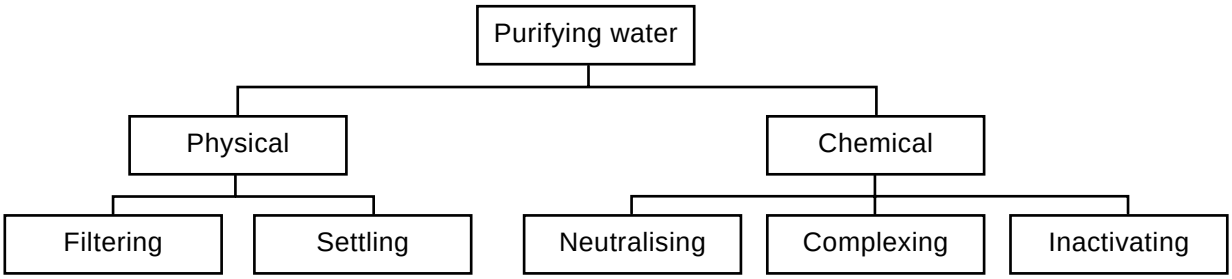
Method

1. Pour 1 or 2 cups of water into your clear containers (same in both).
   Label one container A and one B.
2. In container A put enough universal indicator or cabbage water to change the colour of the water.
3. Using an eyedropper, drop one drop of the acid (vinegar or lemon juice) into each container.
   - Do you see any difference?
4. Continue one drop at a time, discussing the changes observed along the way.
5. When the water in container has changed colour, stop.
6. Discussion:
   - Why hasn't the water changed colour in B?
   - Does that mean that there aren't any chemicals in B?
   - How can we check this?
   - Is it safe for us to test this by taste?
   - Remind students that we only ever taste something if we know that the chemicals added are safe.
7. Dip your iceblock stick into container B and taste.

- Is there some chemical in the water?
- How do you know?

Even though we can't see the chemical, it is still there. Scientists have lots of tests for our water to check what chemicals are in there.

- What can scientists do if they find chemicals that shouldn't be in our water? Brainstorm ways they might get rid of the chemicals/purify the water:



8 Reflection

- Because a lake looks clear does this meant it is clean?

Activity 51 Testing our Water – B

Curriculum links Science

Level 4–5
5
Science

Resources required

- Map showing Lake Rerewhakaaitu
- Background information
- Large beakers
- Weak acid (white vinegar)
- Weak base (baking soda)

Method

This could be done as a demonstration or in groups.

1 Activity:

a Into each of two large beakers, place 1 L of water. This represents the lake water. Add universal indicator which will be green showing the pH is neutral/7 into one beaker only. Everyone in the class has 2 ml of a weak acid e.g. Ethanoic Acid, Acetic Acid/Vinegar (0.1 mol/L) and one by one they come up and place their 2 ml into each beaker and stir.

Results:

- There is no 'observable' change for at least 10 students and then it changes colour to yellow – orange and then pink. The beaker with no indicator will show no change.
- This shows that even though we cannot **SEE** anything happening, chemicals can build up over time to cause a polluting effect.
- If the pH changes to acid it could harm aquatic life and leave the lake in a 'sad condition'.

Ask the students:

- **How could we solve/improve this problem?**

Possible solutions:

- Add a weak base – we could chemically dose the lake with a weak base to **neutralise** the acid.

b Now give the students 2 ml of a weak base e.g. ammonium hydroxide and have them come up one by one and add the base with stirring. After a number of students have added their base the colour of the water is restored to a neutral pH.

Ask the students – this is a good time for class discussion/debate:

- **Has this solved the pollution problem? Or presented/introduced new problems?**

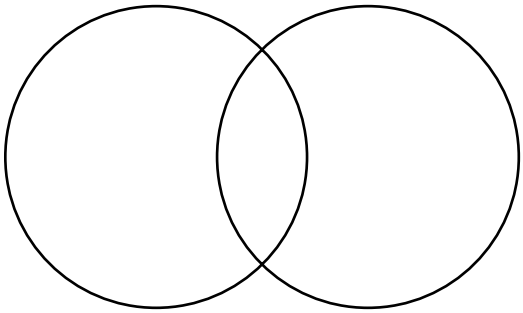
Acid + Base $\longrightarrow$ **Water + Ionic Compound**

Discussion at this point can revolve around invisibility of chemicals. Relate this to the lake and to treatment of water pollution.

Activity Worksheet

List three properties of acid	List three properties of bases

Fill in the diagram (or use Template 1), showing what acids and bases have in common (in the centre) and their differences.



Acids Bases

- In neutralisation, water and ANOTHER compound is formed.
- This compound may not be present naturally and could affect the lake water quality, aquatic life and lake health.

When dealing with a problem you must consider all sides of the solution NOT only removal of the pollutant.

Possible solutions

Treatment of the lake with ALUM:

- Lake Rerewhakaaitu has a problem with excessive phosphate levels.
- Use the maps to locate Lake Rerewhakaaitu. Write a short summary describing the location and surrounding environment. Are there any interesting geological features?
- What are the possible input sources?
- List any streams running into the lake. Are there any other possible inputs? Consider the uses to the lake. How is it used by the community?
- What does ALUM do to the pollutant?

- What are other effects of the chemical reaction?

Alum = The chemical formula for Alum is:

It reacts to remove the pollutant:

The reaction is one of binding and precipitation which means:

List the advantages of this sort of reaction:

List the disadvantages and possible effects on the aquatic environment:

Related concepts

- Separation techniques – physical versus chemical processes.

Activity 5m Comparing Water

Curriculum links **Science**

Environment Education – about

Any level
5
Science

Resources required

- Waiora (Sections 5 and 6) for reference
- Digital camera
- Honey pots
- Clarity tube
- Template
- Litmus paper
- Optional – filters, swinnex, tweezers, syringe, Vulcan tubes

Method

Compare water quality of a clean lake e.g. Lake Tarawera, and dirty lake edge (Lake Okaro or Lake Rotoehu). Check Environment Bay of Plenty's website (www.envbop.govt.nz) before going to see whether the lake is safe to enter – don't go if signs are up or the water looks unusually green.

Although it would be preferable to make this part of a field trip, water could be collected before to the activity and brought to class. You will need approximately 4 L from each lake.

1 With a clarity tube (available by booking at Environment Bay of Plenty office, see instructions in Waiora), test the two types of water.

2 Test the water's pH (litmus), Waiora page 85 and 125.

3 a Fill a clear jar with water from each lake.

b Leave sealed in a warm sunny spot and see what happens. (Students involved in predictions and observations.) A record of algal growth may be taken using digital photos.

c Record observations, including colour, smell etc

4 Brainstorm possible reasons to explain any differences found between the two lake water samples e.g. catchment use, erosion etc

5 Reflection

- Summarise your findings in a comparison chart, e.g.

	Lake 1	Lake 2
pu		
Algal growth		
Catchment		
Action		

Possible next steps

- Filter same quantity of water from each lake using Swinnex filter holder, 60 ml syringe, tweezers and Advantec GC50 25 mm filters. Photograph the filters and compare between lakes. Take 50 ml water samples, in clean 50 ml Vulcan tubes put on ice and send to Hills or Environment Bay of Plenty laboratory to analyse for Total Phosphorus and Total Nitrogen.
- Contact Te Arawa Maori Board Trust, Rotorua District Council or Environment Bay of Plenty and research what actions are planned for each lake and what is happening already – go to www.envbop.govt.nz for information.

Activity 5n Safe to Swim?

Curriculum links **English**

Science

Environment Education – about

Any level
5
Science/
English

Resources required

- "Saving the Rotorua Lakes" fact sheet

Method

1 Study the "Saving the Rotorua Lakes" fact sheet.

2 Copy and complete the following table:

Cause	Problem created	Possible solution	Work underway
Sewage discharge			
Pastoral farming			
Septic tanks			

3 Answer the following questions:

a Do we want high or low TLI? Why?

b Why do you think that all the aspects of each option should be assessed?

c Identify the largest lake and the smallest lake in the Rotorua catchment.

d Identify the lake with the most degraded water quality.

e Which nutrient source do you think is the most damaging? Justify your answer. How can you stop this nutrient source?

4 Reflection

- How can you communicate this information to the community?

Possible next steps

- Create a poster of the Rotorua Lakes – the poster is to depict the water quality. People should be able to see which the cleanest etc is.
- Design a boating 'travel plan' showing boaties how to plan their travels from lake to lake – ensuring that they move in the best direction for the safety of each lake's water quality – helping the 'Stop Hitchikers' campaign.

Activity 5o Littering

Curriculum links **English**

Environment Education – about

Any level
5
English

Resources required

- Rotorua Daily Post newspaper articles:
  a "Rubbish at lake disgusts community" 18/01/05
  b "Get the basics right on rubbish, council told" 20/1/05 or other relevant articles

Method

1 In groups, read the article(s) and discuss the relevant questions.

2 If either of these were your local community, what do you think you and your friends could do about it?

3 Use Templates 6 – 11 to plan a course of action.

Newspaper Article 1

"Rubbish at lake disgusts community" Rotorua Daily Post 18/01/05

a What is the setting for this article?

b What is the issue/problem this article talks about?

c What had been done in this area so that rubbish/litter wouldn't be left lying around?

d What is the Maori name for the area?

e What arrangements should have been made if large crowds are using the area?

f Whose role is it to empty the bins?

g What is one solution to the rubbish problem suggested in this article?

h Which Act is in place to stop the dropping of rubbish?

i What are the consequences for dropping rubbish?

j This article uses a simile to describe the rubbish dumping. What is it?

k What is your personal opinion of what happened to the area?

Rubbish at lake disgusts community

Camp workers left to clean `tidal wave' of litter, including dirty nappies

by KELLY BLANCHARD

ROTORUA litter bugs have been given a stern ticking off for the disgusting state they left Tikitapu (Blue Lake) in at the weekend.

The hot days saw hundreds of people flock to the popular lake near Rotorua. Despite there being plenty of Rotorua District Council rubbish bins across the beach, lakegoers left behind a disgusting mess which Blue Lake Top 10 Holiday Park staff voluntarily cleaned up.

Di from Okareka, who did not want her surname published, said that when she drove to work yesterday morning the area looked as if a tornado had struck it.

``I've never seen it look that bad. The lake has been given to us to enjoy and use. People need to have a bit of respect for what they have been given.''

Di said it was particularly disgusting because there were several rubbish bins in the area yet people instead chose to drop their litter where they sat.

``It's a beautiful place and everyone enjoys it but take your bloody rubbish home with you.''

Blue Lake Top 10 Holiday Park manager Susan Timmer said she, her husband Jack and their staff often took it upon themselves to clean up the rubbish.

``I walk my dog every day along the beach and pick up rubbish. This weekend was particularly bad.

``I'd hate to think of what the tourists think being exposed to that. People even leave dirty nappies down there.''

She said she believed it was local people and not visitors who were responsible.

``It is locals who are fouling up their own recreational areas. Sometimes they are even just sitting in their own rubbish.''

Mrs Timmer said she had walked up to groups of people on the beach and picked up the rubbish accumulating around them.

``No-one has hit me over the head yet.''

Although the rubbish bins were cleared daily, Mrs Timmer wondered what it would take to employ people to clean up the beach area during busy weekends.

She said hundreds of people gathered at Tikitapu on hot days, creating a crowd similar to that at a sporting event.

``After those events, people come along and are paid to clean up the mess. You can't have that amount of people in an area without some kind of regime to clean up afterwards.''

Mrs Timmer said the lake was not being policed for rubbish and their staff felt it was their responsibility to clean up because a lot of the camp's guests used the lake.

``The way it is, it is not a very clean and pure image for our tourists.''

Rotorua District Council park asset officer Walter Miller said Castlecorp was contracted to empty the rubbish bins. He said Castlecorp staff often picked up the rubbish around the bins but did not have time to scour the entire beach.

``It is really up to people to put their own rubbish in the bins. It doesn't matter how many bins we have there, some people just don't clean up after themselves.''

Mr Miller said the council should not have to spend money to employ staff to clean up other people's rubbish.

``It is more education of people than anything else. We shouldn't have to go and pick up all the rubbish that they drop.

``But we don't want to see rubbish around, particularly in a tourist town. It just looks terrible.''

It is an offence against the Litter Act for anyone to wilfully drop rubbish. Council inspectors have the ability to issue infringement notices to people littering. These result in fines of about $100.

Rotorua Daily Post, 18 January 2005

Newspaper Article 2

"Get the basics right on rubbish, council told"
Rotorua Daily Post 20/01/05

a What are the similarities between this article and the article "Rubbish at the lakes disgust community"?

b What are the differences?

c What additional solutions to the litter problem does the second article suggest?

d What do you believe causes the litter problem?

e Suggest three solutions to the litter problem at the lakes? Consider positives and negatives to your solutions.

Get the basics right on rubbish, council told

by KELLY BLANCHARD

A LAKE Okareka resident fed up with Rotorua's litter problem is calling on the Rotorua District Council to get the basics right.

Sue Gunn has recently moved to Rotorua with her family from Auckland, and although she loves her new lifestyle, she is disgusted by the amount of rubbish around the city.

Mrs Gunn said she often walked around the Lake Okareka area and was constantly picking up several bags of rubbish.

``We are a tourist town and as New Zealanders we promote that we live in a pure and pristine environment - but it simply isn't.''

She wrote to Rotorua mayor Kevin Winters about her concerns on December 28 but had not yet received a reply.

In the letter she said Rotorua's rubbish problem did not fit well with the city's ``feel the spirit'' branding.

``There's no feel good factor in rubbish.''

Since litter at the Tikitapu (Blue Lake) was highlighted in The Daily Post this week, Mrs Gunn has resent her letter to Mr Winters and contacted The Daily Post.

Mrs Gunn said she was at a council function before Christmas where it was said ``the council is more than just picking up rubbish''.

She said she wanted to see the council picking up rubbish before it tackled harder tasks.

``They need to concentrate on the basics of what they are meant to be providing.''

She said although the buck was supposed to stop with the person who actually dropped the rubbish, the reality was not everyone would stop doing it.

``Someone has to pick it up. What about the PD [periodic detention - now community service] workers? Surely they have not run out of them?''

She also suggested that multi-national companies such as fast food outlets and cigarette firms needed to use less packaging, or make it biodegradable.

``I'm just so disappointed that we spend so much money, effort and energy in promoting New Zealand as being 100 percent pure and yet we are not delivering on our promise.''

Mr Winters said many of the public's concerns about litter would be addressed in the council's current waste management strategy.

He said he had passed Mrs Gunn's letter on to the relevant council staff member.

Mr Winters said although there might be things the council could do, the solution to the problem boiled down to people being educated about not littering.

``It is not the done practice of winding the window down and turfing your rubbish out. ``When I go walking with my dog, I take a plastic bag with me - I can pick up a couple of bags full.

``It just astounds me that people cannot be bothered waiting until they get to the next rubbish bin. ``The Blue Lake is a classic example. There are heaps of big blue council bins there. ``I don't know whether we can do any more as a council than what we are doing now.''

Rotorua Daily Post, 20 January 2005

Activity 5p
Why Do People Build Walls?

Curriculum links **Social Studies**

Science

Environment Education – about and for

Level 3–5

5

Science/
Social Studies

Resources required

- Ohau Channel Diversion Structure fact sheet – (file box)
- Lakes Rotorua and Rotoiti Catchment Management Action Plan, Environment Bay of Plenty

Prior learning

- 3d Mourea: Then and Now

Method

1 In groups study the photos and written material provided. Answer the following questions:

a How does Lake Rotorua affect the quality of water in Lake Rotoiti?

b Does this problem occur all year round?

c What solutions have been presented to solve the problem?

d When suggesting a solution, what factors must be considered? List three.

e A proposal has been put forward to build a wall in Lake Rotoiti.
What is the purpose of this wall?

f If you are going to build a wall, what do you need to think about concerning the fauna of the lakes?

g What types of things are worrying people about the wall proposal?

h The environment around the Ohau Channel has been drastically changed over the years:

- What was it like before? – contact some of the elders from there to find this out.
- What is it like now?
- What effect do you think these changes have on today's problem with Lake Rotoiti?

i Suggest/design your own solution to the issue.

j Evaluate your proposal, considering: cost, effect on the environment etc.

2 Use Templates 7–11 to plan an action for this issue.

Activity 5q Lake Dynamics

Curriculum links Science

Any level
5
Science

Resources

- Long rope (15 m)
- Shorter ropes – two different colours (approx 4 m long)
- Strips of material long enough to tie around students' heads (or some other way of identifying each group) – 5 x pale blue (top water), 5 x dark blue (bottom water), 5 x green (green algae), 15 x blue-green or red (cyanobacteria – red for toxic, or blue-green for their colour), 5 x white (oxygen)
- Large weather cards with the following on – 1 x warm, calm summer/autumn weather, 1 x wind, 1 x sun, 1 x cooler winter/spring weather - see attached sheet
- Labels – Littoral zone, Limnetic zone, Profundal zone, Benthic zone with brief description on back – see attached sheet
- Labels – Epilimnion (warm low density water at the top), Thermocline (this layer stops the mixingof the waters with the temperature decreasing from the top of the layer to the bottom), and Hypolimnion (the cold dense water at the bottom) – see attached sheet

Teacher's notes

- A lot of detail is included in the Lakes dynamics fact sheet – this can easily be adapted to suit the class level it is being used with, or to fit in with an aspect of lake dynamics that you particularly want to teach.
- You can also go through the actions with only very limited detail so that students get the idea then repeat it with more detailed information to introduce the scientific concepts and terminology.

Method

1 Lay the rope out to represent a deep lake – explain the parts of the lake as per the attached page 'Lake Processes'. How in-depth you wish to go will depend on your audience.

2 Each student selects or is given a role, (you can adapt the numbers of each group to suit the numbers in your class).

3 Get each group to sit together, discuss what they are and what they think they might be doing. Some lead-in questions to each group might help them get started e.g. Top water – do you stay on the top? Oxygen – how did you get to be in the water? Green algae – what do you do? etc

4 Then ask one person from each group to introduce their group to the rest – "We are the top waters, we are warm water". Again, what level of scientific language you get students to use will depend on their ability level.

5 Read this abbreviated version of the fact sheet and as each group hears their role being mentioned they act it out. The shorter pieces of rope are to signify the summer stratification of the lake, once these are in place the two waters can't go past it either way. Clarification questions and reflections are included in this sheet.

Lake Dynamics - Simple Explanation

We often think of lakes as large pools of still water, with some water flowing in from streams and some flowing out to streams.

There is a lot more than this happening in our lakes!

Just as warm air rises (think about steam) and moves constantly, so too does the water in our lakes – well to some extent anyway.

Some of our Rotorua Lakes are deeper than others. Lakes Rotorua, Rotoehu and Rerewhakaaitu are shallow lakes with Tarawera, Rotoiti and Rotoma being deep lakes. It is the deep lakes that are having the most trouble with algal blooms. (As you say this you can lay out the rope)

The deep lakes are most affected by the seasonal weather changes. Just as warm air rises so does warm water which 'floats' on the denser/heavier cold water.

In winter and spring:

- Weather is generally cool and calm.
- The water temperature throughout the lakes is approximately the same.
- The water in the lakes mixes fully from top to bottom (bottom cold/top warm).

However, our lake is a deep lake it so can only mix fully from top to bottom in winter.

During summer and autumn:

- The weather generally is warm, with calm periods.
- The surface water gets heated by the sun becomes warmer and buoyant (less dense); while the bottom waters remain cool and dense as the sun's warmth doesn't reach that far down.
- The temperature at the bottom of deep lakes doesn't change much throughout the year. Our Rotorua Lakes stay above 4ºC but in summer the top layer becomes warmer than this.
- Warm water floats on top of the dense cold water and so the waters no longer mix.
- Our lake stratifies (as do other deep lakes) into layers. Have you ever had a cake with the layer of cream in the middle? (Lay down the extra rope) That's what happens here we get a layer of water in the middle of the lake.
- So we have a layer of warm water on top then the water in this middle layer is fairly warm at the top of it but it gets gradually colder as you go down. Below that is the layer of cold water at the bottom – why do you think this layer is so cold (where the sun doesn't reach)?
- In shallower lakes mixing occurs most of the year round, with only brief periods of stratification during very warm, calm periods. Why do you think shallower lakes continue to mix?

Lake Dynamics - More Complex Explanation

We often think of lakes as bodies of still water.

There is a lot more than this happening in our lakes!

Just as air changes density and moves constantly so too does the water in our lakes – well to some extent anyway.

Our Rotorua Lakes vary in depth with some deeper than others. Lakes Rotorua, Rotoehu and Rerewhakaaitu are shallow lakes with Tarawera, Rotoiti and Rotoma being deep lakes. It is our deep lakes that are having the most trouble with algal blooms. As you say this you can lay out the rope.)

The deep lakes are most affected by the seasonal weather changes. Just as warm air rises so does warm water which 'floats' on the denser cold water.

Lakes have different zones

- **Littoral –** which is the shallow water area, near the lake edge. This zone gets lots of sunlight and nutrients, which are washed, off the land. Lots of fish and plants live in this area because it is warm and there is lots of food. There are also lots of decomposers as well as frogs, snails and insects.
- **Limnetic –** this is the open water area of the lake that still gets a lot of sunlight. This zone only goes down as far as the sunlight reaches. Fish, phytoplankton (tiny little plants) and zooplankton (tiny little animals) live in this zone.
- **Profundal –** this is the deep open-water area. It is too dark for plants but some fish live here.
- **Benthic –** this is the very bottom of the lake where it is cold and dark. Fungi and bacteria live in this zone along with some larvae (baby insects).

The deep lakes are most affected by the seasonal weather changes. Just as warm air rises so does warm water which 'floats' on the denser cold water.

In winter and spring:

- Weather is generally cool and calm.
- The water temperature throughout the lakes is approximately the same.
- The water in the lakes mixes fully from top to bottom (bottom cold/top warm).
- During this time the oxygen levels are fairly constant with any losses from respiration replenished by the photosynthesis process or from the atmosphere.
- This means a steady flow of oxygen in and around our lake waters.
- Also during this time the green and brown algae, other water plants and phytoplankton are able to capture the light energy and continue to photosynthesise. They are growing and fish etc are able to feed off them.

However if our lake is a deep lake, it can only mix fully from top to bottom in winter.

During summer and autumn:

- The weather is generally warm, with calm periods.
- The surface water gets heated by the sun and becomes warmer and buoyant (less dense); while the bottom waters remain cool and dense as the sun's warmth doesn't reach that far down.
- The temperature at the bottom of deep lakes doesn't change much throughout the year. Our Rotorua Lakes stay above 4ºC but in summer the top layer becomes warmer than this.
- Warm water floats on top of the dense cold water and so the waters no longer mix.
- Our lake stratifies (as do other deep lakes) into layers. Again you can get students to lay these cards out for you as you read out the descriptions and lay down the extra rope.

Each of these levels also has a scientific name:

- **Epilimnion –** warm low density water at the top,
- **Thermocline –** this layer stops the mixing of the waters with the temperature decreasing from the top of the layer to the bottom,
- **Hypolimnion –** the cold dense water at the bottom.

- In shallower lakes mixing occurs most of the year round, with only brief periods of stratification during very warm, calm periods.
- During stratification periods, with no top/bottom mixing, nutrients and algae and cyanobacteria disperse across the lake faster than through the lake depth.
- Because the blue green algae can reproduce quickly and is toxic it is not eaten as much as the green or brown algae.
- Blue green algae – which is considered by some to be an algae (because it photosynthesises) but by others a cyanobacteria (because of the way it reproduces) – also increase across the surface, blocking sunlight from others. Blue green algae can migrate vertically. They are usually on the surface in the morning using the sun's energy to photosynthesise. When they have built up their cells they descend and then return to the surface later in the day. No photosynthesis occurs while they are at the bottom so they use up their carbohydrate supplies and ascend. Sometimes they can't make it to the surface again and die. As their cells breakdown, toxins and more nutrients are released. During a bloom a 'crash' can occur when large numbers die off at the same time causing a large toxin release into the lake at the same time. When this happens, health warnings are given.

As dissolved oxygen levels at the bottom decrease, phytoplankton die off. This means there is no release of oxygen into bottom waters. As phytoplankton (and the blue green algae that don't make it back to the surface) die off, the cyanobacteria feed off it. When this becomes scarce then the loss of oxygen from bottom waters means bacteria begin to 'scavenge' more from the bottom layers. As a result, there is a large amount of nutrients released e.g. phosphorous, into the water. When the water mixing begins again with cool weather, these nutrients get mixed throughout the lake. Then during the next stratification period, the cyanobacteria increase more. The cycle gets worse each year.

6 Reflection

- What did this activity show us about our lakes?
- Why do you think there are more algae blooms in the lakes now than in the past?
- Do you know of anything being done to help the situation?
- What do you think might be done to help?
- What actions could your school take to help?
- What can you do to help?

Possible next steps

As an extension of this activity students could:

- Investigate further the lakes pollution issues.
- Investigate the human influence on these issues.
- Justify personal or community involvement in a lakes restoration project.

Littoral zone	Limetic zone
Profundal zone	Benthic zone

Littoral zone

Shallow water near the lake edge.

Gets lots of sunlight. Nutrients are washed off the land and down the streams feeding the lake. More plants and fish live in this zone as it's warm, bright and there is lots of food. Many decomposers like bacteria and fungi live here as well as frogs, snails, insects and fish.

Limnetic zone

This is the open water area of the lake that still gets a lot of sunshine. This zone goes as far down as the sunlight reaches. Fish and tiny plants called phytoplankton and tiny animals called zooplankton live here.

Profundal zone

This is the deep open water.

It is too dark for plants but some fish live here.

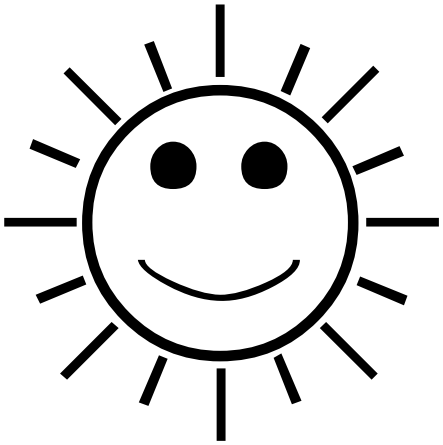
Benthic zone

This is the very bottom of the lake.

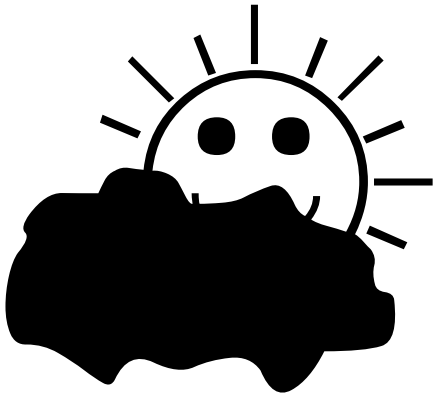
It is cold and dark down here.

Fungi and bacteria live here.

Some larvae (baby insects) also live here.



Warm, calm summer/autumn weather



Cooler winter/spring weather

Eplimnion

Thermocline

Hypolimnion

Epilimnion layer

Warm

More buoyant

Low density

Thermocline layer

Warmer at top

Colder at the bottom

Stops water mixing

Higher level of density

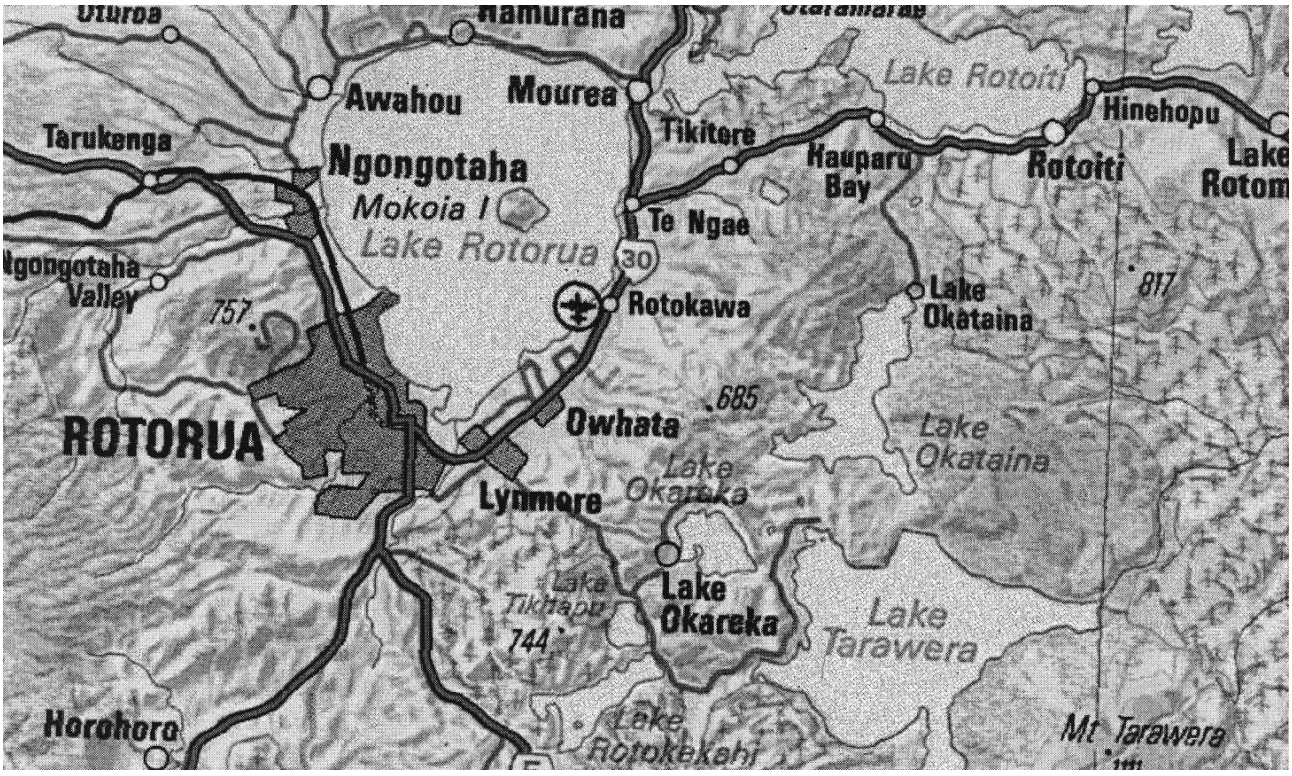
Hypolimnion layer

Cold layer

Dense layer

Sinks below other water

Background Information



Lake Rotorua has been an integral facet of Rotorua for its inhabitants. The uses have changed over time – from being a food/kai provider, to clothing/material harvesting. It's been through a stage of neglect and almost abuse to now, an era of respect and acknowledgement of its importance in the eco-balance of the community.

Here is a summary of the factors that are affecting the lake's health. These factors are to an extent 'natural' factors which have become unbalanced. This is because of the use or misuse of them or overloading in areas.

The lake's health is shown to be declining because of increasing levels of nitrate and phosphate in the water. These have a number of points of entry –

- Pasture fertilisation/pasture runoff
- Farming stock effluent
- Decomposing sewage – septic tanks and waste water seepage.

Following early lake water health decline, the Rotorua District Council stopped discharge of treated waste water into the lake in 1991 and instead sprayed it onto areas of forest. Sewage diversion in 1991 was followed by significant improvements in lake water clarity, nutrient and chlorophyll concentrations from 1993-1995, but since then lake water quality has again deteriorated.

Most of the decline is associated with increasing nitrate in streams that drain agricultural land. The lake also has an amount of nitrates that are locked up in the lake bed sediments. This is called the internal load. Internal nutrient loads (nutrient releases from the lakebed when the lake stratifies in calm, summer weather) may also be contributing to continued poor lake water quality and are likely to delay recovery if or when external nutrient loads (from sewage and/or the catchment) are reduced and stabilised.

- It's believed that nitrate generated 30-70 years ago by land clearance is only now finding its way into the streams through deep groundwater. It's likely that similar land-use/groundwater links operate in the Rotorua catchment, and the most effective method to improve lake water quality control is to control the external loads of both nitrogen and phosphorus.

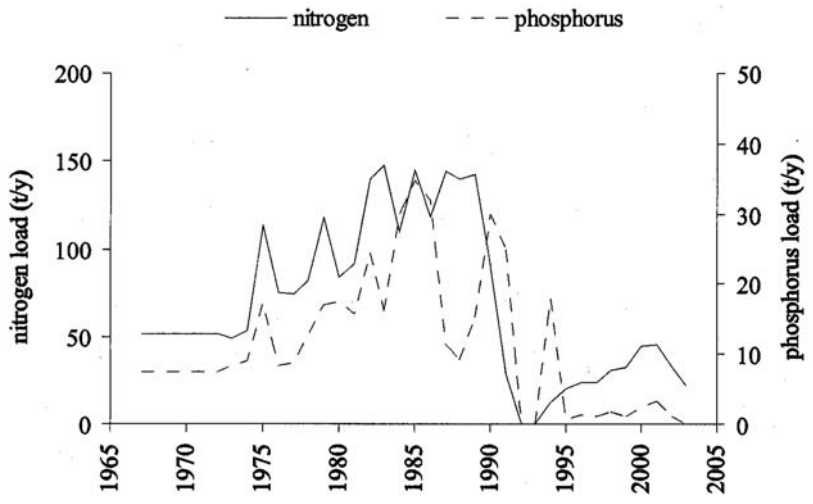
During the 1970s it was recognised that water quality was deteriorating in Lake Rotorua because of increased nutrient loads - notably from treated sewage, streams draining pasture, and aerial top-dressing. The water quality issues from this include:

- high chlorophyll concentrations (high algal (phytoplankton) biomass),
- low water clarity,
- rapid de-oxygenation during summer stratification, more rapid de-oxygenation leading to more frequent periods of anoxia (with adverse effects on aquatic organisms including fish),
- more frequent nutrient releases from the lakebed (termed 'internal loads'),
- sporadic blooms of nuisance blue-green algae. It was recognised that there was not a clear association between nutrient inputs and problems associated with rooted macrophytes ('aquatic weeds') although water clarity might have some effect.

During the 1980s lake water quality targets for Lake Rotorua were adopted by the regional council, the decision was made to stop directly discharging treated sewage to the lake, and nutrient load targets were set for sewage-derived nutrients.

Figure 5 shows the variation in TP (Total Phosphate) and TN (Total Nitrate) input from domestic sewage during the period 1967-2002. Inputs from 1967-1973 are based on estimates of the number of people connected to the municipal septic tanks that operated in Rotorua at that time. Inputs from 1973–1991 are based on monitoring results from the Rotorua sewage treatment plant to which an estimate of the TN input from septic tanks has been added. The assumption is made that no TP enters the lake from septic tanks. Inputs from 1991-2002 are estimated from monitoring results in the Waipa Stream below the Rotorua land treatment site (RLTS) in Whakarewarewa Forest.

Figure 5:



Lake Rotorua nutrient inputs and water quality 1965-1985. Source: Rutherford et al. (1989).

Lake Rotorua nutrient inputs and water quality 1965–1985. Source: Rutherford et al. (1989)

	1965	1976-77	1981-82	1984-85	Target
Population	25,000	50,000	52,600	54,000	-
Phosphorus input					
Raw sewage t/y	5	18	30	47	-
Treated sewage t/y	5	7.8	20.6	33.8	3
Stream t/y [a]	34	34	34	34	34
Internal t/y	ND	0	20	35	0 [b]
Total t/y	39	42	75	103	37
Nitrogen input					
Raw sewage t/y	34	100	170	260	-
Treated sewage t/y	20	73	134	150	30
Stream t/y [a]	455	485	420	415	405
Septic tanks t/y	50	80	15	10	0
Internal t/y	ND	0	140	>260	0[a]
Total t/y	475	558	694	>825	435
Average lake quality					
Total phosphorus mg/m3		23.8	47.9	72.6	20

During the 1970–80s there was a steady increase in sewage nutrient load associated with reticulation in Rotorua City. This was partially offset by introducing phosphorus stripping at the sewage treatment plant, beginning in 1973. The low phosphorus loads during 1976–78 and 1987–88 correspond with periods when phosphorus stripping was effective, while the peaks occurred in years when stripping was either suspended or had low efficiency. Land disposal in 1991 resulted in a significant reduction of sewage derived nutrient inputs from 1991–1993. However, nutrient losses from the spray irrigation site increased from 1994–2001.

The trophic level index

To help with the early detection of trends in lake water quality, Burns et al. (1999) developed the trophic level index (TLI). The TLI is a single numerical index calculated from four measured lake water quality parameters: total nitrogen (TN), total phosphorus (TP), and chlorophyll (CHLA) concentration, and secchi disc water clarity (SD). The TLI is used by Environment Bay of Plenty to monitor lake water quality and to help set goals for lake management (Burns, 1999; Gibbons-Davies 2003). The goal for Lake Rotorua is a three year average TLI = 4.2.

Table 2: Lake Rotorua water quality targets and associated TLI.

Date	CHLA mg/m^3	SD m	TP mg/m^3	TN mg/m^3	TLc	TLs	TLp	TLn	average TLI
1960s	10	2.5 3	20	300	4.76	4.23	4.02	3.85	4.27 4.21