Wonder Project

Water Challenge

# Key concepts

engineering new zealand te ao rangahau

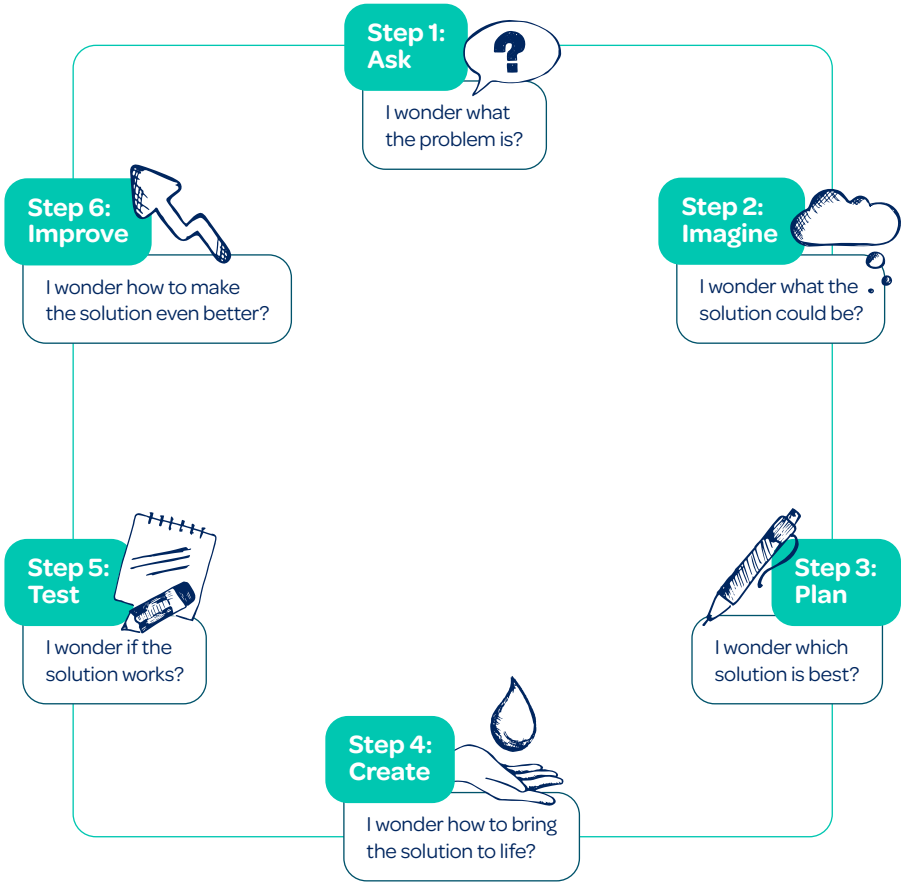
SUPPORTED BY Beca Fulton Hogan GHD Foundation

# Contents

# STEM design process

**The STEM Design Process is a series of simple steps that STEM superstars use to solve problems and make ideas work.**

STEM superstars go back and forth between the steps until they find the best solution. This is called iterative thinking.




| | |
|---|---|
| **Step 1: Ask** | STEM superstars ask pātai (questions) to help them understand the problem they're trying to solve. |
| **Step 2: Imagine** | STEM superstars imagine some possible solutions to the problem they defined in the 'ask' step. |
| **Step 3: Plan** | STEM superstars plan which solution to progress, and how to progress it. |
| **Step 4: Create** | STEM superstars bring their solution to life. |
| **Step 5: Test** | STEM superstars test their solution to see whether it works, and if there are any ways it can be improved. |
| **Step 6: Improve** | STEM superstars use all the knowledge gained throughout the STEM design process to improve their mahi. |

# Wai is a taonga / He Taonga te Wai

- Wai is the reo Māori word for water. Taonga is the reo Māori word for a treasure (there isn't a direct translation). Taonga can be treasured possessions, or even culturally valuable ideas or techniques.
- In te ao Māori (the Māori world), wai is considered to have its own mauri (lifeforce). The mauri of wai is a direct reflection of the health of the land, and the people. So, wai is a highly valued treasure to care for and respect.
- He Taonga te Wai is included at the beginning of the challenge to frame ākonga understanding of wai throughout the Water Challenge, and in their own lives.

## Kaitiakitanga

- Kaitiakitanga is the reo Māori word for guardianship or protection, especially in relation to preservation for future generations.
- A kaitiaki is usually someone who will perform kaitiakitanga. Tangata whenua (people of the land) determine who is a kaitiaki.
- Kaitiakitanga is practised to help protect the mauri (lifeforce) of a taonga such as an awa (river). For example, not overfishing or collecting too much wai from the awa.
- In te ao Māori, people are part of the environment – not superior to it.
- So, in prioritising the environment through kaitiakitanga, the environment is supported to protect us in return.


## The Mauri Compass

The Mauri Compass was developed by Te Rūnanga o Turanganui a Kiwa and the Gisborne District Council.

It's an environmental tool designed to assess and restore the mauri (lifeforce) of waterways using 12 attributes relating to Tāngata (people), Tane (land), and Tangaroa (sea). We've included a simplified version in the Water Challenge using 6 attributes that ākonga will be able to identify and assess through imagery.

We have used the kupu (words) tāngata (people), whenua (land), and wai (water) (instead of Tane and Tangaroa) to support ākonga to make the connection between the Mauri Compass and the interconnectedness of people, land and water.

If kaiako or ambassadors wish to cover ngā atua (the deities), eg Tane and Tangaroa, we welcome this.

More information on ngā atua

# Te Hurihanga Wai

**Kōrero tuku iho (stories that have been passed down through generations) are vast and rich. This is but one kōrero (story) of te Hurihanga Wai.**

## Te Hurihanga Wai

- Te Hurihanga Wai is an expression of love between Ranginui (the Sky Father) and Papatūānuku (the Earth Mother). Freshwater is a living being guided by ngā atua (deities) through this process. It is the essence of all life.
- Ranginui and Papatūānuku were locked in an embrace. Their children lived between their parents in the dark. One of their sons, Tāne Mahuta (deity of the forest and birds), decided that he had had enough. He pushed his parents apart, separating them and pushing Ranginui high into the sky – allowing light to come into the world.
- Ranginui and Papatūānuku wept for each other every day. We can see the tears of Ranginui as rain, helping Papatūānuku to grow plants and trees to cover and protect her.
- The tears of Papatūānuku are springs that come out of the land. The tears created oceans and waterways – these waterways are the bloodlines of Papatūānuku.

Comprehensive information on te Hurihanga Wai can be found **here**, including information on ngā atua, if you wish to cover te Hurihanga Wai in more detail.

## The Water Cycle

The eternal dance between Ranginui, Papatūānuku and their children can be seen in the water cycle.

In the water cycle, wai is constantly recycled through a series of processes across the atmosphere, and the Earth. This means it doesn't run out. These processes are:

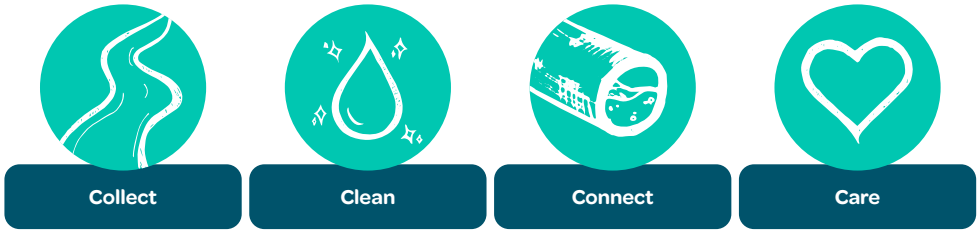
| Precipitation | Collection | Evaporation | Transpiration | Condensation |
|---|---|---|---|---|
| When wai falls down to Earth as rain, snow, sleet or hail. | When wai is "collected" in bodies of water like lakes, rivers and oceans. | When wai on the land and in bodies of water turns into a gas called water vapour because of energy from the sun. | When a plant releases water in the form of water vapour. Kind of like a plant sweating. | When water vapour turns back into a liquid as it reaches the sky. Condensation can form clouds or water on your windows. |

While the water cycle may seem cyclical, there are many different journeys that wai can take through it, especially once it reaches Papatūānuku.

# The journey of wai

**While some hapori can collect wai directly from natural sources like awa, wai is not accessible to everyone, and excessive collection of wai can damage natural wai sources like awa.**

So, to support wai to reach all hapori while respecting natural sources of wai, STEM superstars created Aotearoa New Zealand's wai network. The journey of wai through this network can be broken down into four stages:




## Collect

In the **collect** stage of the wai network, wai is collected from a natural or manufactured source.

**Natural sources of fresh water include:**

- **Precipitation, eg:**
  - Snow, rain, hail, etc.
- **Surface water, eg:**
  - Lakes, rivers, streams, etc.
- **Groundwater:**
  - Wai beneath the Earth's surface.
  - It can be found, and moves, within geologic formations of soil, sand and rocks called aquifers.
  - Around 40% of the drinking water in Aotearoa comes from aquifers, which also feed rivers and lakes.

**Manufactured sources of wai can include:**

- Dams
- Water tanks

## Clean

While wai isn't inherently paru (dirty), we can't always be 100% sure that the wai collected in our network hasn't become paru with pollutants or natural debris.

So, in the clean stage of the wai network, STEM superstars test and treat water to make sure it's healthy, protect its mauri, and remove pollutants if required.

This is generally done at a water treatment plant. In the Water Challenge, ākonga will monitor and treat for turbidity, and pH.

### Turbidity

- Turbidity measures water clarity, or the ability of a light beam to travel through water.
- When wai is turbid, it contains more suspended particles. This can make it appear cloudy or murky.
- The suspended particles in turbid water absorb light which reduces the ability of a light beam to travel through it.

You can measure turbidity of water using sight, and/or a light source like a torch.

| Turbidity | Explanation |
|---|---|
| Low turbidity | Water is clear of particles, light shines through easily. |
| Medium turbidity | Water is slightly cloudy with some particles visible in the water, some light shines through. |
| High turbidity | Water is cloudy with a high number of particles visible, barely any light shines through. |

# The journey of wai (continued)

## pH

- pH is a way of measuring how acidic or basic a substance is.
- It's measured on a scale from 0–14 with 0 being the most acidic, 7 being neutral, and 14 being the most basic.
- pH stands for the 'potential of hydrogen'. So, when we talk about acids and bases, we're really talking about the concentration of hydrogen ions (a tiny particle).

| Acids | Bases |
|---|---|
| Acidic substances have more hydrogen ions.<br>Their pH level can be from 0 to 6.<br>Examples of acidic substances include:<br>• Stomach acid<br>• Lemon juice<br>• Coffee<br>• Milk | Basic substances have less hydrogen ions.<br>Their pH level can be from 8 to 14.<br>Examples of basic substances include:<br>• Sea water<br>• Baking soda<br>• Soap<br>• Bleach |

Wai is safest for nourishing the hapori when it's neutral at pH level 7. This means that it has a balanced number of hydrogen ions and hydroxide ions and is neither acidic, nor basic.

## Connect

In the **connect** stage of the wai network, water is connected to our hapori through a series of pipes.

In Aotearoa, our wai network is gravity-fed, meaning that water moves through them thanks to the force of gravity. Pumps can also be used in wai networks to help the flow of water, especially if the area they're supplying is uphill, or at a flatter elevation.

## Care

In the **care** stage of the wai network, wai cares for us, and we care for wai before it's returned to Ranginui.

# Ngā momo wai | Water types

**In mātauranga Māori, there are many different momo wai (water types), each with different values and uses. Each type of wai has a mauri that shouldn't be mixed with another type.**

**Ranginui**
Sky Father – Ua (rain)

**Wai-ora**
Pure/healthy water

Wai in its purest form with mauri that is life-giving, and a source of wellbeing.

**Wai-māori**
Fresh water

Wai in its natural state that sustains life, runs free and has no sacred associations.

**Wai-tapu**
Sacred water

Wai that's had a tapu imposed on it. It can be used for ritual and ceremony.

**Wai-tai**
Seawater/salt water

Wai of the sea or tide. Can also refer to rough or angry water (waves).

**Wai-kino**
Polluted/dangerous water

Wai that can cause harm because its mauri has been altered through pollution, or because it's dangerous (rapids).

**Wai-mate**
Dead water

Wai that no longer has mauri and cannot sustain life. It's dangerous because it can cause illness or misfortune.

**Ngā puna wai (tapu) o Papatūānuku**
The weeping springs of the Earth Mother

## Wai-māori | Freshwater

- Freshwater is the wai that most commonly nourishes our hapori.
- Only 3% of the wai on Earth is freshwater, and around 80% of this wai is contained in icecaps – so there's not much available.
- Thanks to te Hurihanga Wai (the water cycle), freshwater is constantly recycled.
- However, if we don't take care of the wai-māori (freshwater) available now, it will become wai paru (dirty water) and there will be less freshwater available for future generations.

# Gravity and flow

## Flow

- Flow is the motion of a gas or liquid. It can be measured by speed/rate and volume.
- To get water to flow through a pipe ākonga will need to consider gravity.
- This is what STEM superstars call fluid dynamics – looking at how fluids behave while in motion.

## Gravity

- Gravity is a force that pulls objects towards each other.
- Every object with mass exerts a gravitational pull. On Earth, gravity pulls things towards the centre of the planet.
- Gravity is the reason objects fall when you drop them, and why humans stay on the ground.
- So, if water enters a pipe that's travelling downhill, the water will also flow downhill – thanks to gravity.

# Manning's Equation

$$Q = a \times 1.486/n \times R^{2/3} \times \sqrt{S}$$

| Letter | Water Challenge definition | Things you can consider |
|---|---|---|
| Q | Flow rate | • How much wai ends up at each hapori connection point.<br>• How quickly wai flows through the network. |
| a | Cross-sectional area (the amount of space inside the pipe) | • Diameter, radius, and pi (circumference) of the pipes. |
| n | How rough the pipe material is (roughness of the space the wai flows through/over) | • How many connectors are used.<br>• How jagged the pipe edges are. |
| R | Hydraulic radius (how much of the pipe comes into contact with water, eg is the pipe half full or completely full of wai?) | • Perimeter, pi, diameter, and width of pipes. |
| S | Slope | • Change in elevation and horizontal distance. |

- Manning's equation is used to calculate the flow of wai in open channels, such as awa (rivers), and partially filled closed channels, such as pipes.
- It was named after Irish Engineer, Robert Manning, who built on the early works of French Engineer, Philippe Gaspard Gauckler.
- Using Manning's equation, STEM superstars can better understand how the flow of wai in pipes will influence its journey through Aotearoa New Zealand's water network.
- For the Water Challenge, we're not asking ākonga to calculate flow with Manning's equation. We've included it to support understanding of the factors that impact wai flow.
- If ākonga would like to calculate a hypothetical wai flow rate, they can use a graphics calculator. To do so, they should put each part of the equation into brackets eg $Q = (a) \times (1.486/n) \times (R^{2/3}) \times (\sqrt{S})$.
- The value of 'n' generally ranges from 0.010 – 0.100. 0.010 is typical of glass, plastic, or well-finished concrete – similar to the materials used in the Water Challenge.