Stage 4 Science – Separating Mixtures Chemical World
Teacher lesson plan – Crystallisation

Sydney WATER

Key inquiry questions What is crystallisation? Why is it an important part of understanding water treatment?	Time: 2 x 45 - 60 min

Syllabus outcomes	**Working scientifically skills**
SC4-1VA, appreciates the importance of science in their lives and the role of scientific inquiry in **increasing understanding of the world around them.** SC4-13ES-explains how advances in scientific understanding of processes that occur within and on the Earth, influence the choices people make about **resource use and management.** SC4-17CW-explains how scientific understanding of, and discoveries about the properties of elements, compounds and **mixtures relate to their uses in everyday life.**	SC4-5WS - collaboratively and individually produces a plan to investigate questions and problems. SC4-6WS - follows a sequence of instructions to safely undertake a range of investigation types, collaboratively and individually. SC4-7WS - processes and analyses data from a first-hand investigation and secondary sources to identify trends, patterns, and relationships, and draw conclusions.
Syllabus content CW3 Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques. • Research how people in **different occupations** use understanding and skills from across the disciplines of science in carrying out separation techniques. • Identify different ways of **separating mixtures.** • Explore reasons for separating mixtures - **water purification** (treatment). • Separate the components of some common mixtures through techniques including **crystallisation.**	**Sydney Water aim for activity** • Our core objectives are to protect the environment and protect public health. Every day we provide clean safe drinking water, treat, and recycle wastewater. • In this lesson, we'll investigate what's in water and why we need to understand crystallisation in the water industry. • This investigation will look at how we use scientific knowledge in a real-world application.

Teaching and learning	**Resources**
Lesson 1 - Introduction: Why do we need to know about crystallisation? **Activity:** Place a glass of tap water in front of students, observe the glass of water. **Q.** Have you ever wondered about water? What are some of the features or properties that you would want from your water? **A.** Clean, safe, clear, colourless, tastes and smells good, affordable. It's amazing stuff and we rarely think about what goes into getting it to us. See our Water quality and filtration and Water analysis webpage for more information about the whole story of your drinking water. **Did you know?** In Sydney, we have some of the best drinking water in the world. We have many sources of water. Right now, most of Sydney's drinking water comes from rainfall. About 80% of it is captured by Warragamba Dam. See our Water sources webpage for more information. **Activity:** Hands up if you use water? Care about water? Care about science? We all care about water. To look after it and make sure that it meets all the features we want from water, we need to understand science. You will be a water scientist today and look at how we can use scientific knowledge of separation techniques - crystallisation to manage water.	**Sydney Water resources** High school *Practical investigation - Crystallisation* Water quality & filtration Water analysis Water sources

Q. What are crystals? How do crystals form (crystallisation)?
A. Crystals are solids with highly ordered structures. In nature, we see crystals like salt by the sea and stalactites in caves. Crystallisation or formation of crystals, in nature usually requires high concentrations of mineral and salts (solutes) and water. Water is an excellent solvent it dissolves solutes. When water and solutes separate overtime (like evaporation), solutes become concentrated and only then crystals can form.

Activity: Look at crystals under microscope or refer to images from textbooks, mobile app or resource of choice. Some examples of crystals we need to consider in the water industry include – limescale, salt (NaCl) and struvite.

Q. Why does Sydney Water need to know about crystallisation and solute levels?
A. Understanding when solutions, like tap water, have too many solutes and will crystallise is important. We do need some solutes in water, and we adjust salt and mineral levels, to have water we like. But if there is too much it can cause problems later. For example:

We need solutes	**Too many solutes**
We need naturally occurring salts and minerals for our water to taste good.	If our water has too many solutes like salts and mineral it forms 'hard' water, often bitter in flavour.
Some minerals are important for our health.	Soaps and detergents may not lather with the 'hard; water so cleaning is more difficult.
Water without solutes or is too 'soft' can strip minerals out of concrete pipes, wearing them out.	Water with too many solutes 'hard' causes problems like limescale (crystals of calcium carbonate build-up) that can block pipes.
Small doses of salts and minerals in a dilute solution at desalination and advanced water recycling plants to meet water guidelines.	If we have high concentrations of salt and mineral at water treatment plants, crystallisation may happen and block our machines.

Did you know? Our scientists and production officers need to know all about the science of water, mixtures and separation techniques to best design water and wastewater treatment to meet drinking water and recycled water standards. We evaporate water to concentrate and test for the types of solids (like salts) it leaves behind to indicate water quality – this is done in small scale for laboratory testing.

Activity: To learn how to think like our scientists, you need to do experiments and see science in action. Do our *Practical investigation - Crystallisation* to see how this separation techniques works. You can find everything you need on our High school webpage.

Safety first! Conduct a risk assessment before the practical.

Risk	**Rating**	**Control**
Cuts	M	Administration – use glass carefully, do not place on uneven surfaces Elimination – use heat-proof containers
Poison	L	Administration – follow instructions on packages, don't consume the substances PPE – safety glasses
Burn	M	Administration – handle hot liquids with care, have first aid kit nearby, know what to do if you get a burn PPE – safety glasses and heat proof gloves

Extension: Following practical activity: • Use a digital microscope, stereomicroscope, hand lens or camera to observe the crystals of the salt before and after the experiment. In both cases, describe the crystals in terms of size and colour. • Draw a few crystals or take a digital photo. • Compare the salt crystals before and after the activity. Discuss your observations.	
Lesson 2: Why and how we remove solutes? **Activity:** Lets observe and record what has happened with your *Practical investigation – crystallisation*. Has there been much change? Let's see… • Did any crystals form? What shape are the crystals? • Are the crystals the same size? Did they take the same time to grow? Require the same amount of salts? **Q.** Who can remember what we discussed about this separation techniques before we started? **A**. Recall: • Solutes can be separated by creating concentrate solutions such as crystallisation and evaporation. • Too many or too little solutes in water can both cause problems. • We need to get solute levels just right to meet drinking and recycled water standards. **Did you know?** Our drinking water from Warragamba Dam requires very little change to its level of solutes. There are other sources of water with different levels of solutes. • Wastewater is the water that is after we use it in our homes. It has many solutes from the things you've added. We need to understand crystallisation as some solutes can build up in our pipes. We also need to remove these solutes, so we can use the water again as recycled water. • Stormwater can also be harvested for reuse. The quality and reliability of stormwater is impacted by the type of pollution it gathers as it runs from hard surfaces to our waterways. • Seawater is a source of drinking water. It's very high in solutes (salts). Understanding separation techniques and crystallisation is important as we work with the Sydney Desalination Plant. **Activity:** Discuss what method you would use to separate solutes (salts) and water. Questions to think about: • How easy was it to remove salt from a jar, but what about a tank of water? • It took us a week to get results, what if you only had two hours before more water was on its way to treat? • What are some better methods? **Q.** How do we remove salts and solutes to purify water without crystallisation, evaporation or distillation? **A.** Crystallisation, evaporation and distillation are only used on the small scale intentionally at Sydney Water like laboratory testing. We use advanced technology known as membrane filtration which includes reverse osmosis at our plants. See our St Marys Advanced Water Recycle Plant webpage for more information and the extension idea below for more information	**Sydney Water resources** High school St Marys Advanced Water Recycling Plant Wollongong Water Recycling Plant **Other resources** Sydney Desalination Plant
Extension **Q.** Why use membrane filtration and reverse osmosis? **A.** St Marys Advanced Water Recycling Plant treats 60 million litres of water a day with membrane technology! That would be too difficult using other separation techniques.	**Sydney Water resources** *St Marys Recycling Plant video* Wastewater treatment High school

Q. Why purify wastewater to that high quality? **A.** Salts and nutrients can only be mostly removed at specialised advanced wastewater recycling plants. This advanced recycled water can be used as an alternative source of water on our water treatment plants, specialised industrial processes or to keep creeks and rivers healthy. See our St Marys Advanced Water Recycling Plant and Wollongong Water Recycling Plant page for more information. **Activity:** Watch *St Marys Recycling Plant video* – you can stop after 2 minutes. Discuss: • How does removing solutes help keep rivers healthy? • What future uses of this advanced recycled water can you come up with? • How are other places around the world using advanced recycled water? You can also see some of these separation techniques by either: • using our Wastewater treatment webpage and resources to spot all the different separation techniques that Sydney Water uses. • downloading our other lesson plans and experiments to investigate separation techniques and the application of scientific knowledge used in managing water. Go to our High school webpage for more information. • reading about treatment processes on our Orchard Hills Water Filtration Plant, Penrith Water Recycling Plant and St Marys Advanced Water Recycling Plant webpages.	Penrith Water Recycling Plant Orchard Hills Water Filtration Plant **Other resources** PUB - Singapore's National Water Agency WA Water Corporation
Conclusion **Evaluation questions** • What can water dissolve? What crystals can it dissolve? Why is this important to know? • Can you come up with new separation techniques to protect public health or the environment? **Reflection Activity** - Students finish these statements 1. I used to think (at the start of these lessons) 2. But now I think (at the end of these lessons)	**Sydney Water resources** **Find out more** • sydneywater.com.au/education • facebook.com/SydneyWater • instagram.com/sydneywater • twitter.com/SydneyWaterNews