WATERWISE

WATER RESOURCE MANAGEMENT AND CONSERVATION

TEACHER'S GUIDE

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Water resource management and conservation

Teacher's Guide

by

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Part B Classroom Activities

Objectives

The following teaching notes are designed to be copied and re-arranged to suit your classroom situation or excursion. Topics discussed in this section include:-

1. The need to be waterwise
2. Water movements in our local catchment
3. How water enters and leaves your our catchment
4. The composition and definition of raw water and the problems it creates for our water treatment plants
5. The structure, location and construction of our local dams
6. How dams work to deliver water to treatment plants, the problems of stratification of layers and algae blooms in particular
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   (b) How microorganisms behave in dams and the differences in behaviour patterns of these "bugs" in summer and winter
   (c) How a dam intake tower can be effected by stratification
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13. How some household water appliances work including a
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   (b) toilet
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14. The difference between full and half flush toilets
15. What a composting toilet is and how it works
13. The difference between waste water and storm water
16. How a water meter works and how to read it
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29. The roles disinfection and ponding play
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Did you know

Here are some surprising facts about water:

★ About 80% of the world is covered by water or ice.

★ Only 1 % of the world's water is suitable for human needs (97% is salt water in the ocean and 2% is ice).

★ Australia is the world's driest continent. Of all the inhabited continents, Australia has the lowest average rainfall and the lowest water runoff.

★ The human brain is 15% water.

★ A man's body is 60-65% water (measured as a percentage of body weight) and a woman's is 50-60% water. Men tend to have more muscle and muscle tissue contains a large amount of water.

★ The human body loses 3-3.5 litres of water in an average day. This may be increased by exercise and climatic conditions.

★ Less than 1% of the treated drinking water produced by Local Authorities is actually consumed by people. Most is used for lawns, showers, laundry, etc.

★ An average person can survive for nearly two months without food, but less than a week without drinking water

★ Many leading environmental educators believe that water and its use will be the greatest environmental issue of this decade

Why we need to conserve water?

"Statewide statistics on the water consumption levels of Queenslanders are quite high. Figures vary across the State but on average each Queenslander uses 635 litres of the State's urban water supplies every day. That's enough to fill four full length bathtubs.

It's definitely too much water for one person, especially when you realise that much of it is wasted. It's wasted when we forget to turn the lawn sprinkler off, leave the hose running while washing the car, stay too long in the shower or on dozens of other occasions when we simply take water for granted.

Local Authorities invest a substantial amount of their annual budgets into new capital works and maintenance of existing water supply systems.

When consumers have finished using the water most of it drains into sewerage systems for further treatment. This system also needs to be funded and maintained. These costs account for millions of dollars every year.

Other costs, not so easily measured, have an even greater significance than dollars. If demand is greater than supply, new dams and treatment plants are required, bringing with them the possibility of adverse environmental effects. Dams inundate large areas of land, often with drastic effects on human inhabitants as well as native flora and fauna. Other adverse environmental effects result from higher water usage, such as increased power consumption due to pumping, treating and heating water, and increased effluent levels.

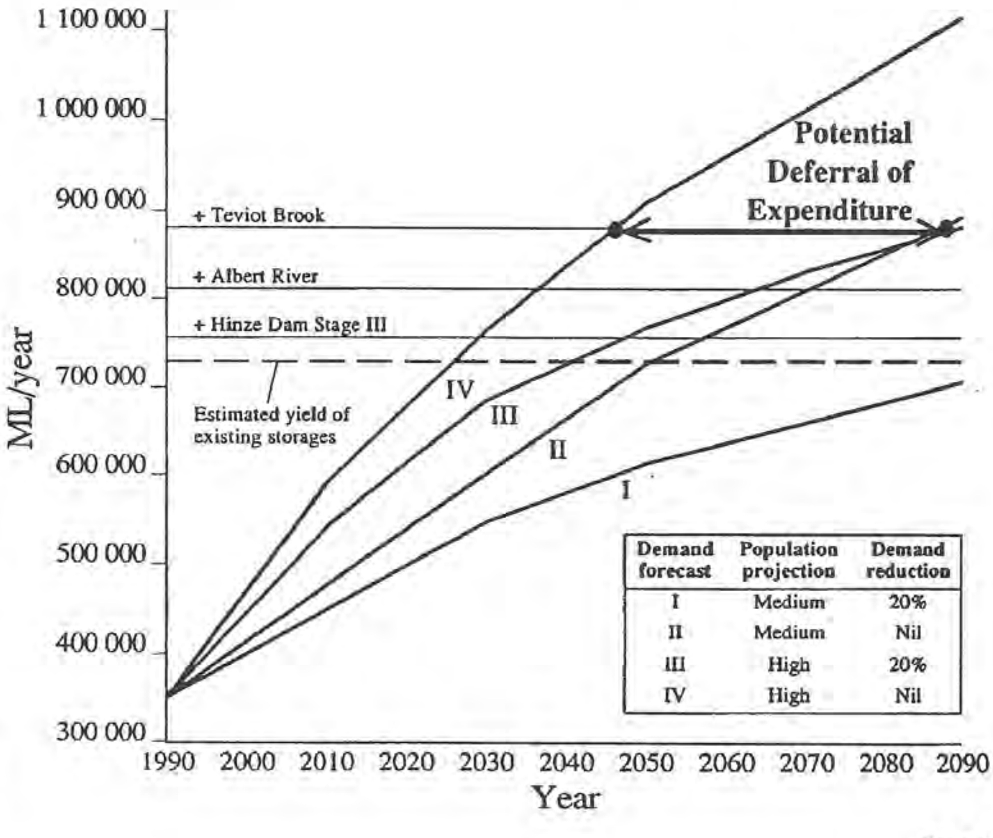
Queensland's population is expanding rapidly, and with it the demand for water. So there is a serious need to encourage people to consume less and use water more wisely. Research has shown that most consumers have no idea how much water they use, but once told, they all admit that they could do something about reducing it.

They actually feel guilty about how much water they use and want to be told how they can do something about it. They genuinely want to become WaterWise.

Further studies have shown that a general 20% reduction in water use is possible without reducing our quality of life. This will save Queensland $40 million per year in running and maintenance costs on our existing water supply infrastructure, and another $40 million per year through the deferral of new infrastructure development. It will also contribute significantly towards a better environment, as well as lower household water charges and water heating bills.

Urban water conservation programs need to involve as many Queenslanders as possible to reduce water consumption Statewide. The need for this has been identified by the Queensland Government in a 1990 study conducted by the Water Resources Commission called 'Water Supply Sources in South East Queensland'. As well as recommending the development of new water supply dams, trunk mains and pump stations to satisfy future water needs over the next 100 years, the study also recommended demand management be implemented Statewide.

The study said, *'The Water Resources Commission should engage in the active promotion of demand management and take a lead role in promoting of demand management both in the study area and throughout the State'*. Cabinet fully endorsed these recommendations.



In 1991 the Public Sector Management Commission (PSMC), in its review of the operations of the Commission as part of the Department of Primary Industries, also recommended that the Commission should embark on a public education program to assist Local Authorities apply demand management principles.

With the need to conserve water clearly identified, the Water Resources Commission has developed WaterWise Queensland as a public education program with a long term objective of assisting Local Authorities to reduce urban water consumption by 20%.

In some communities, significant progress has already been made by Local Authorities with their own public education programs, sprinkler restrictions, mandatory installation of low flow dual flush toilets, and 'user pays' pricing policies.

WaterWise has an on-the ground approach, reviewing and consolidating successful ideas from the existing demand management strategies of other States' water authorities. These ideas were modified to suit effective implementation in Queensland.

There are four clear goals for Local Authorities applying the WaterWise Queensland campaign in their own areas. These are:

★ to more effectively utilise existing resources
★ to defer capital expenditure for new resources
★ to promote voluntary water conserving practices
★ to minimise any impact on the environment.

Local Authorities will be able to supplement their existing demand management strategies or even initiate new approaches with what is being offered by the Commission through the WaterWise campaign."

From the WaterWise Public Communication Kit, Water Resources Commission, August 1992.

Water catchment areas

A **catchment** is an area of land bounded by natural features such as hills or mountains, from which all run off water flows to a low point. It is like water in a bathtub flowing to the plug hole, or water that falls on a roof flowing to a downpipe. In the case of a natural catchment, the low point could be a dam, a location on a river, or the mouth of a river where it enters the sea.

Catchments vary in size and make-up. The Gold Coast catchment is bordered by mountain ranges and includes major drainage networks of creeks and rivers. Our catchment is made up of many smaller "sub catchments" which are bordered by low hills and ridges and drained by creeks bordering the ranges of the hinterland. Figure 2 shows a large catchment that is broken into a number of smaller sub-catchments. The way that each of these small catchments is managed affects the overall well-being of the larger catchment.

Water movement in a catchment

Water is the linking factor in our catchment. In the water cycle shown in Figure 1, the sun's energy transfers water from the sea and land to the atmosphere in the form of water vapour. This process of evaporation also takes place on land. Plants add water vapour through transpiration.

Humans, animals and machines add small amounts of water vapour as well, by means of respiration and combustion. The water vapour condenses and precipitates to fall as rain, sleet or hail.

Some precipitation evaporates while falling and returns to the atmosphere while most precipitation soaks into the soil in a process called infiltration. Some of the infiltrated water returns to the surface and is evaporated while the rest of it sinks to the water table. Any excess water runs off the land and is carried away by streams and rivers in surface runoff as shown in Figure 1.

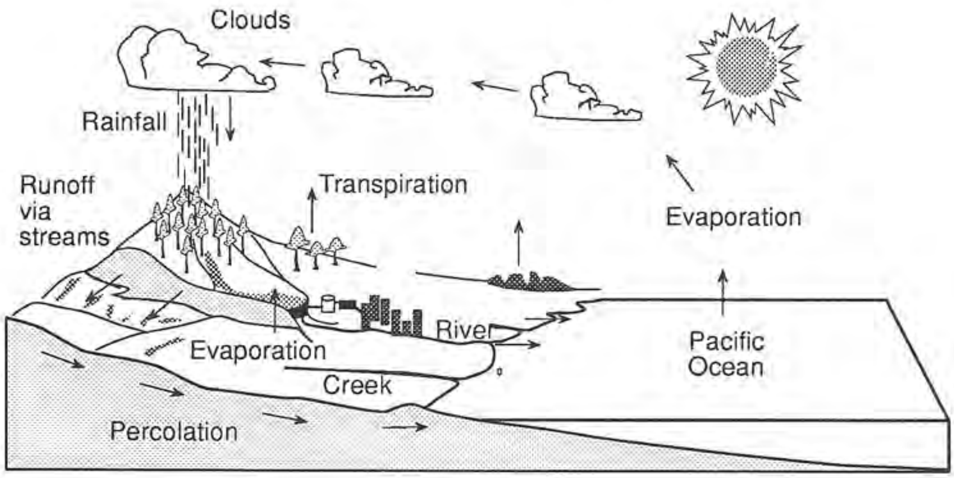


Fig 1 Schematic diagram of the water cycle

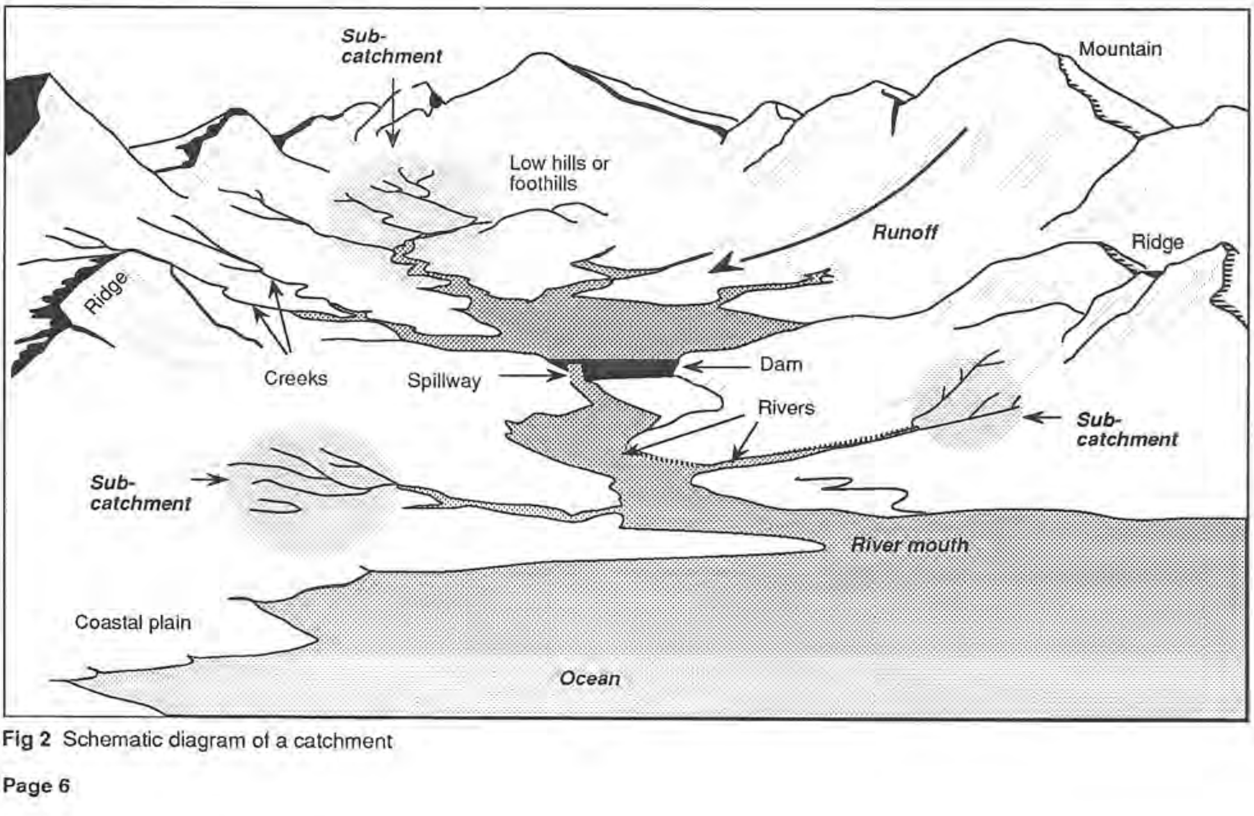


Fig 2 Schematic diagram of a catchment

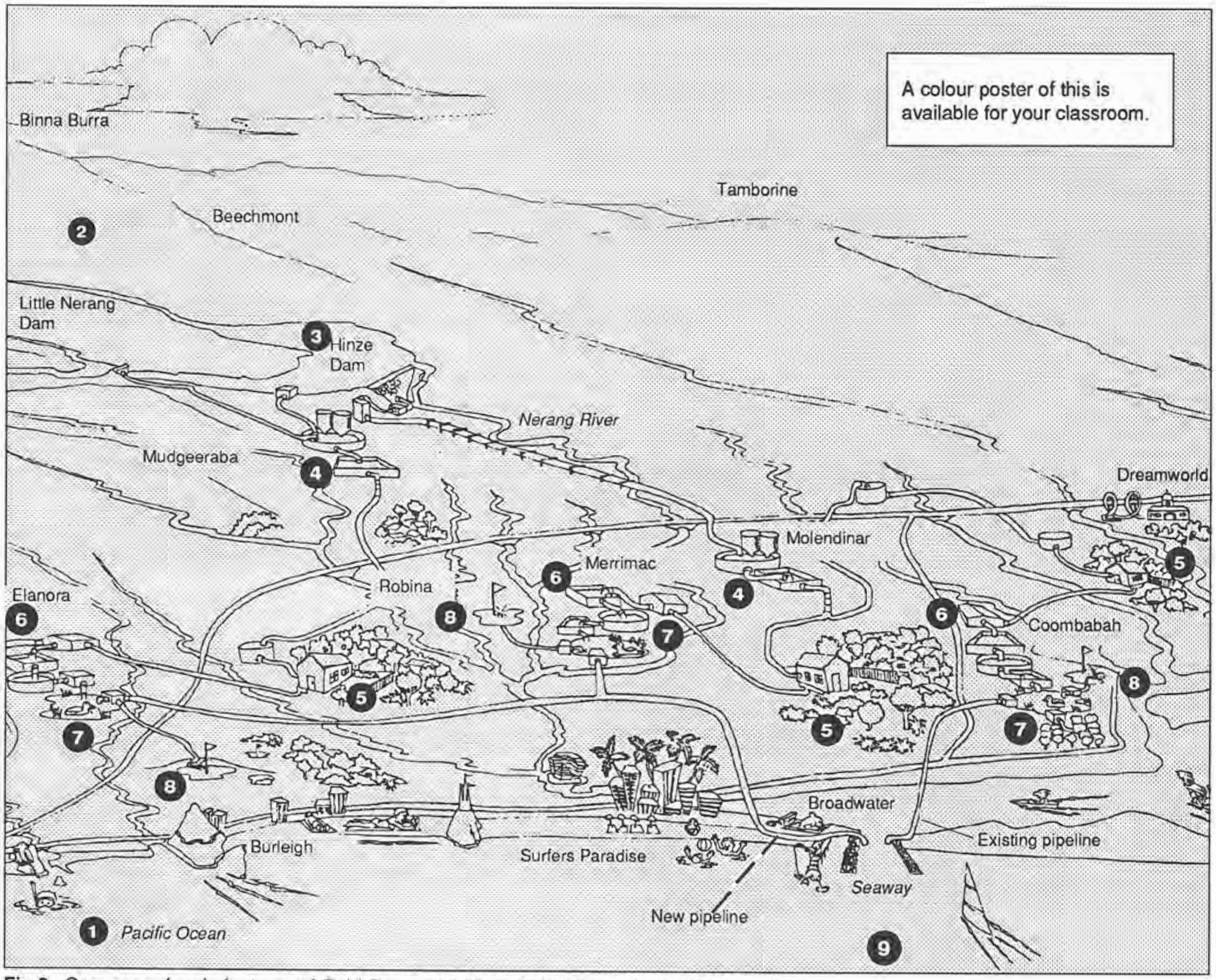


Fig 3 Summary of main features of Gold Coast and Albert Shire Water Cycle (Not to scale)

In natural environments water on our earth cycles from the sea to the land and back to the sea flowing down rivers and streams. In urban environments, this is trapped in dams to provide people with water for their daily use and it has been estimated that each one of us uses on average about 600 litres of water a day. After we use this water much of it goes down the drain as waste water which is treated at sewage treatment plants.

In recent times, the use of this waste water has been the source of much controversy with pollution an all too familiar occurrence on some beaches in Victoria and New South Wales. But could this ever happen to our local beaches? To answer this question we must look at the use of water in our own water cycle as shown by the steps one to nine in Figure 3.

1. **Water evaporates** from the ocean to the clouds which condense over mountains.
2. **Runoff** from the mountain slopes in the hinterland accumulates in creeks and streams.
3. **Dams** are built above townships and cities to store water so that gravity can carry the water to the town.
4. **Water treatment plants** at Molendinar and Mudgeeraba clean the water to make it fit for human consumption.
5. **Pipes** carry the treated water from reservoirs to **houses** where it is used.
6. **Waste water** is transported from the house to waste water treatment plants at Elanora, Merrimac and Coombabah. (Storm water is not shown in the diagram)
7. **Reclaimed water** called **effluent** is stored in a pond where ducks and birds live.
8. **Re-claimed water** can be used on Golf Courses, Nurseries, Sporting Fields or Parks during dry periods.
9. **Water that is not used** from the duck ponds (effluent lagoon) is pumped into the sea on the outgoing tide.

Our catchment area

Let's start by looking at our water cycles in our coastal area. Water evaporating from the sea soon condenses over the ranges of the hinterland falling on a catchment area comprising the Numinbah Valley and Springbrook Plateau. These valleys are bounded by the Beachmont, McPherson, Nimmel and Talli Ranges providing a total of 207 square kilometres of catchment area as shown in Fig 4. Water flows back to the sea through the Nerang River, Currumbin and Tallebudgera Creeks which have been modified greatly by canal developments since 1960.

To appreciate the complexities involved in this cycle we need to examine each of the sub-catchments involved.

Sub-catchments - above the Hinze Dam

A catchment is made up of a number of **sub-catchments.**

These regions are characterised by lush tree growth and subtropical rainforests that grow on the slopes of valleys. This lush tree growth breaks down the heavy rain. If you have ever

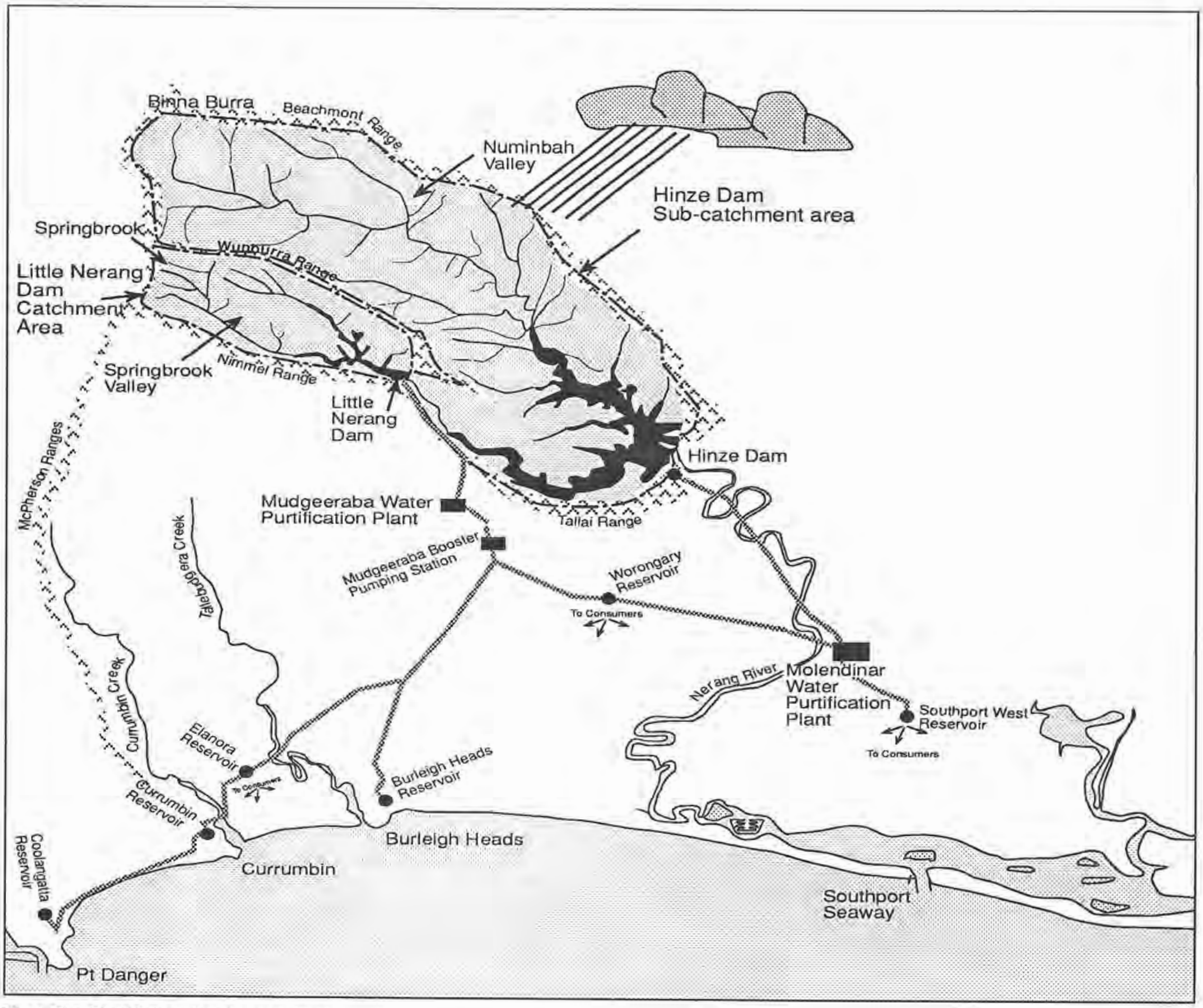


Fig 4 The Gold Coast Catchment Area

walked through the rain forests at Binna Burra or Lamington Plateaus, you will notice that the rainforest canopy filters the large rain droplets to form a mist which percolates though the soil into creeks as shown in Figure 5 . The creeks form rivers which carry the sediments and minerals leached out by the rain, to the sea.

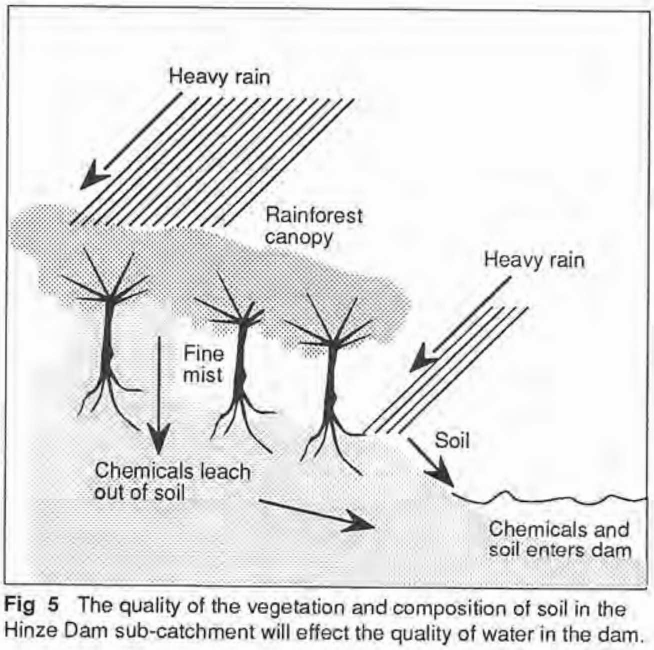


Fig 5 The quality of the vegetation and composition of soil in the Hinze Dam sub-catchment will effect the quality of water in the dam.

In natural conditions, little sediment flows back to the sea, but with the development of the coastal zone, large areas were cleared for housing and industry exposing the soils to erosion. Cedar timbers were harvested in the early part of this century loosening the soil in the mountains and so adding to the sediment that flowed down the rivers.

Raw water

Water that is untreated and used for a water supply is called **Raw Water.** Raw water is composed of everything that rain water accumulates along the way as it falls on the catchment area. Rain water even as it falls collects dust particles from bush fires, atmospheric pollutants (e.g. sulphur dioxide) and insects and other organic matter as rain passes through the rainforest canopy

As the rain percolates thorough the rainforest floor, it picks up the remains of dead animals, pathogenic organisms and their excrement which contains nitrate and phosphate.

Naturally occurring bacteria are also added to the water along with any organic matter that lies in the catchment area. Water will soak thorough the old toilets of the timber cutters and septic systems of residents in the valley. Rotting leaves, twigs and logs will also enter the dam.

Our dams

Dams are used to store raw water and to create a head of pressure. This pressure allows water to flow through pipes to purification plants where it can be cleaned, filtered and dosed so that it is safe to drink.

Dams also collect water during heavy rain to prevent local flash flooding and are at a sufficient height to allow purification plants and reservoirs to be gravity fed. The spillway at the Hinze Dam is designed to back up water to prevent flash flooding while controlling the volume of water that flows back to the sea.

The Gold Coast has two dams as shown in Figure 4. The Hinze Dam is made of earth fill and the Little Nerang Dam of concrete. Both are constructed between two valleys which come close to each other at one point.

The city of the Gold Coast was established in 1949. Prior to this the area was administered by a number of smaller councils. A water supply for Southport was completed in 1932. It consisted of a low barrage, intake and pumping station on the Nerang River known as Weedons Crossing and was known as the Nerang River Pumping Scheme.

The Little Nerang Creek Gravity Scheme

The Little Nerang Dam was completed in 1962, and until the completion of the Hinze Dam, the Little Nerang Creek Gravity Scheme supplied the water requirements of the Gold Coast City and adjacent areas in the Albert Shire.

The scheme draws its supply from a mass concrete dam with radial drum crest gates constructed across little Nerang Creek. The water then flows by gravity pipeline to the Mudgeeraba Water Purification Plant.

This plant, which was constructed in 1969, is situated 5.8 kilometres from Mudgeeraba, and had a capacity to treat 55 million litres of water each day. In 1976, duplication of the plant (at a cost of $1.5 million) raised its capacity to 110 million litres a day. From the treatment plant, water flows via gravity mains to the city's storage reservoirs.

The Hinze Dam

The Hinze Dam is located where the Nerang River and Little Nerang Creek join and forms the principal water reservoir for the Gold Coast City and Albert Shire. In addition to supplying water for the entire Gold Coast Region, the dam and its lake have the additional benefits of flood mitigation, environmental protection and recreation. Water from the Little Nerang Dam also flows into the Hinze dam as shown in Figure 5.

The Hinze dam is a earth fill dam constructed of earthen materials found in the Talli and Beachmont ranges where clay and rocks were extracted on site. The rocks were crushed to the specific sizes to make materials for concrete and blown apart to make dam wall materials.

The **spillway** was constructed to allow water to backup during flood times and to slow the amount of water that flowed to canal estates, thus allowing flood water to exit through the Southport Seaway.

Water from the dam is drawn through an intake tower which passes the water through the dam wall. If the dam is at a lower point than the water purification plant it will be necessary to pump it to a higher point so that the plant can be gravity fed. Water for Burleigh, Coolangatta and Tweed Heads was pumped from Tallebudgera Creek from an intake and pumping station completed in 1935. Additional storage was later provided by a small dam nearby, completed in 1950.

Why doesn't the dam leak?

Water does not pass through clay so if we can pack enough clay together with rocks, fine sand and rock dust, we can make a dam to hold back water of enormous pressure.

The Hinze dam has a clay core with layers of sand, finely crushed rock, larger rocks and huge boulders as shown in Figure 6.

Dam Chemistry

In a dam rich in oxygen, elements such as manganese and iron form oxides and settle into the sediment at the bottom of the dam. Living in the sediment are bacteria which grow and live off this oxygen.

Temperature and density

Water density varies with temperature. Colder water is more dense and so it sinks. In winter the temperatures are relatively constant and the water is called **isothermal** - that is the temperature is the same at the top as on the bottom. Therefore water of the same density mixes with water throughout the dam as shown in Figure 7.

During summer, surface waters warm up, become less dense and rise forming layers of similar water density. These are called thermoclines and are shown in Figure 8.

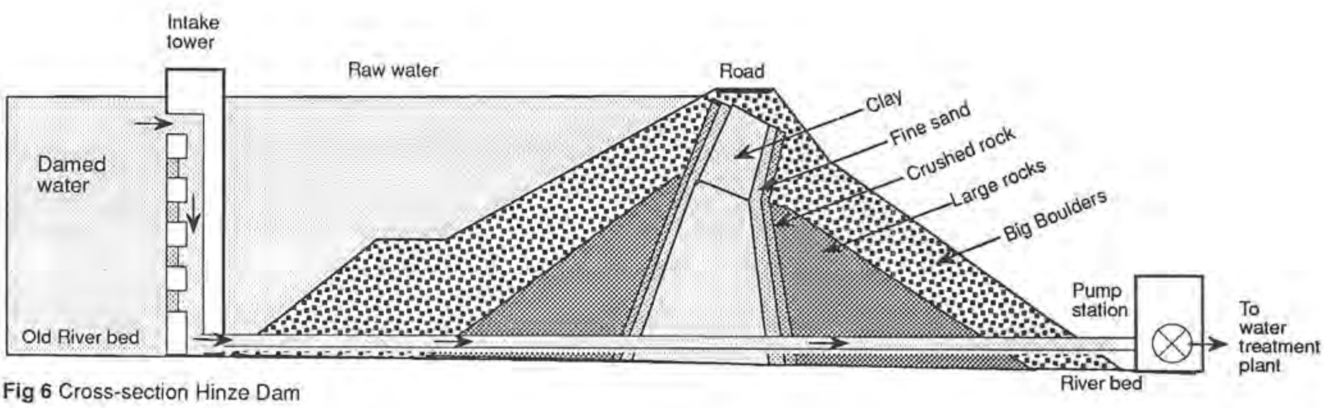


Fig 6 Cross-section Hinze Dam

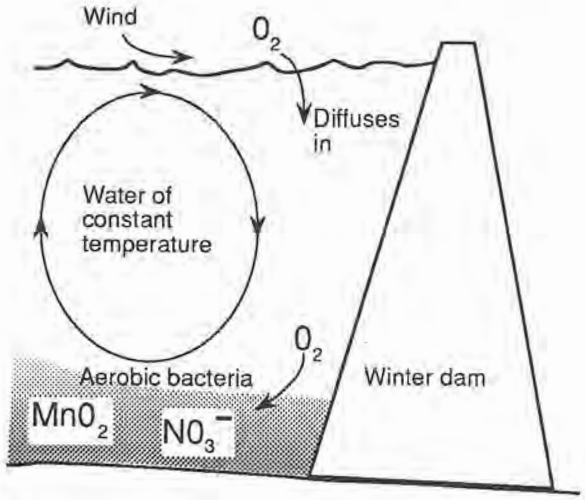


Fig 7 In winter dam oxygen can diffuse to the bottom of a dam

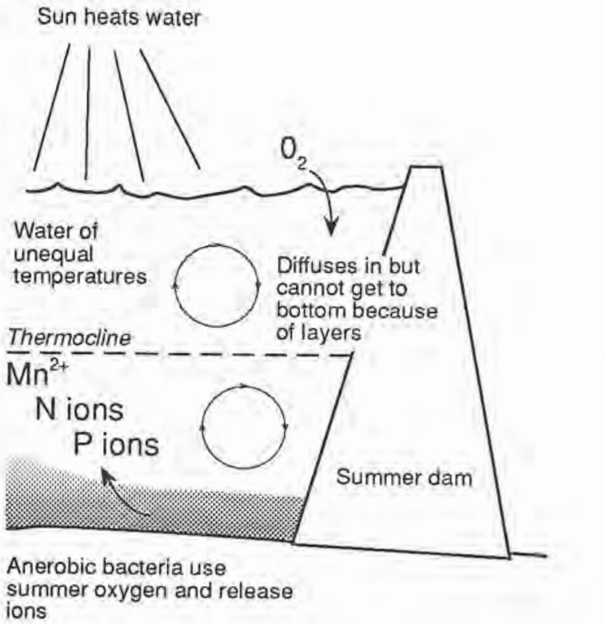


Fig 8 In summer, strata form creating a thermocline. This stops the mixing of nutrients and changes the behaviour of the bacteria that live in the sediment.

Manganese, nitrogen and phosphorus

The amount of **dissolved oxygen** inthe water is determined by the water temperature, which during winter is relatively constant. As wind blows over the dam convection currents are set up causing surface water rich in oxygen at the surface to mix with deeper water low in oxygen.

This mixing can occur right down to the bottom of the dam because temperatures are relatively constant and there are no barriers to uniform mixing.

The bacteria that live here behave in an aerobic way. i.e. they respire by using oxygen and produce carbon dioxide which dissolves in the water.

At other times of the year, the temperature rises and different layers form in the dam.

Water density changes because of its relationship to temperature and by summer a thermocline has formed making two or three layers (strata) of water that do not mix.

This means that the oxygen rich waters of the surface can no longer supply bacteria that live on the bottom of the dam. These bacteria now seek the oxygen found in compounds such as nitrogen dioxide and manganese dioxide. **Phosphate** and **nitrate ions** are soluble in the form PO_4^{3-} and NO_3^- and when oxygen is removed they form other ions or complexes.

Figure 8 shows in a schematic form, the release of nitrogen and phosphate ions into the dam. It the concentrations of these ions that will determine algal blooms as will be seen later in the discussion of Algae on Page 11.

i.e. The solubility does not change for N or P ions.

Some examples of other ions are NO_2^- nitrite, NH_4^+ ammonia, PO_3 -PO_3 -PO_4 - polyphosphate.

On the other hand MnO_2 is insoluble. When oxygen is removed it forms Mn^{2+} which is soluble. Manganese is responsible for the dirty water experienced at times and has to be converted into an insoluble product so that it can be removed at the water treatment plant.

Understanding the bugs

Bacteria are not the only organisms that feed in the sediment. A whole host of single celled and multicelled animals live in this rich ecosystem.

For purposes of discussion we will call all the organisms "bugs" because if you can understand how they react in the dam situation, you will understand how engineers and scientists use their power to treat sewage.

Winter bugs

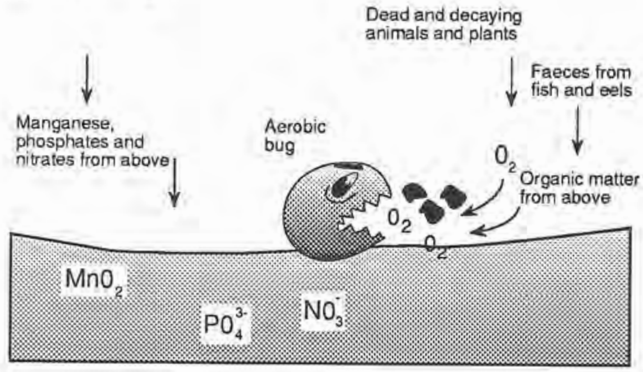


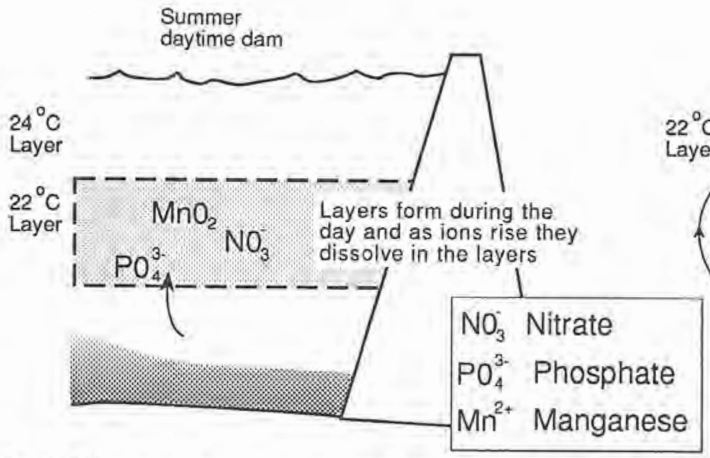
Fig 9 In winter, bugs use free oxygen and food from above

Like all life, the bugs need food. To digest and absorb this food, they need oxygen. The food comes from above and is composed of the faeces of animals like fish and eels that live in the dam.

Dead algae and plants also contribute to organic matter and animals that live in the catchment like spiders and worms will be washed into the sediment when they die. The sediment is literally a cesspit of dead and decaying matter that once lived in the catchment and dam fed on by millions of bugs.

In winter, the oxygen from the surface can reach the bottom. The bugs use this oxygen to digest organic matter that is constantly sinking in the dam. Oxygen is plentiful and the microorganisms grow and reproduce. Adult bugs then die to become part of the sediment.

During this time **manganese**, iron and phosphorus react with this rich supply of oxygen to form substances called oxides. Substances such as - Manganese dioxide - MnO_2, Phosphate - PO_4^{3-} and Nitrate NO_3^- form as shown in Figure 9.



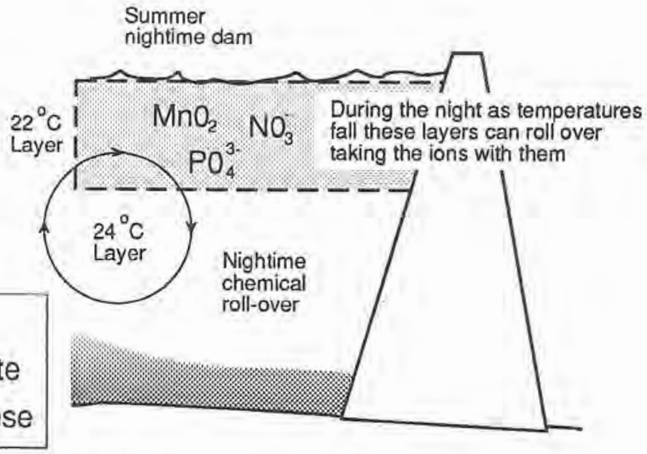


Fig 10 Different situations prevent oxygen from getting down to the bottom of the dam

Summer bugs

As summer approaches and the temperature layers stop the oxygen from getting down to the bottom, the bugs rapidly use up the winter oxygen. The bugs also have a second way of feeding and find a rich supply of oxygen in manganese oxide, phosphate and nitrate substances.

As a result of a complex series of chemical reactions and microbiological activities, manganese, iron and nutrients are released back into the water from the sediment. *(Although this is not strictly true we could imagine that if a bug takes the O out of MnO_2, then only the Mn is left behind. Similarly if they*

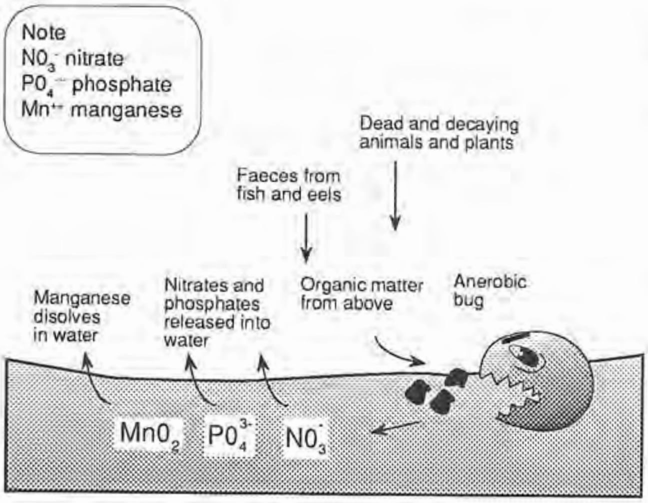


Fig 11 Summer bugs attack the oxygen bound up in nitrate, phosphate and manganese compounds

take the O from PO_4^{3-} and N from NO_3^- then P and N are left behind.)

The Mn, P and N are mixed with the water above increasing the concentrations of Mn, P and N. So we have increased levels of nitrogen, phosphorus and manganese in the surface layers where we are taking in the water.

The N and P act as fertilizers and increase plant growth in the surface waters. Blue green algae (as do all algae) love nitrogen and phosphorus and can reach plague proportions and so we have blue-green algae problems which have plagued inland river systems. This also occurs in shallow dams.

Algae and the N/P ratio

Increased phosphorous and nitrogen levels diffuse to the surface waters and act as a fertilizer for microscopic algae shown in Figure 12. The N/P ratio determines the rates of growth of these species.

If the ratio is < 8, some blue green algae such as *Anabaena* grow. Production of toxins by some species of blue-green algae creates many problems. Not all blooms are toxic and toxicity of blooms can change over time or with the age of the bloom. Toxins are released when algal cells die or are disrupted. Toxins are classified into three classes:

- Hepatotoxins which affect the liver - produced by *Microcystis*, *Nodularia* and *Anabaena*.
- Neurotoxins which affect neuromuscular function - produced by *Anabaena*.
- Endotoxins which may cause allergic reactions, skin and eye irritations and gastroenteritis - produced by most blue-green algae.

Toxins are removed from water by adsorption onto activated carbon.

Blue green algae blooms occurred in summer streams and rivers in some Eastern Australian states and waterways had to be closed recently to swimming and recreation to protect users from internal infection.

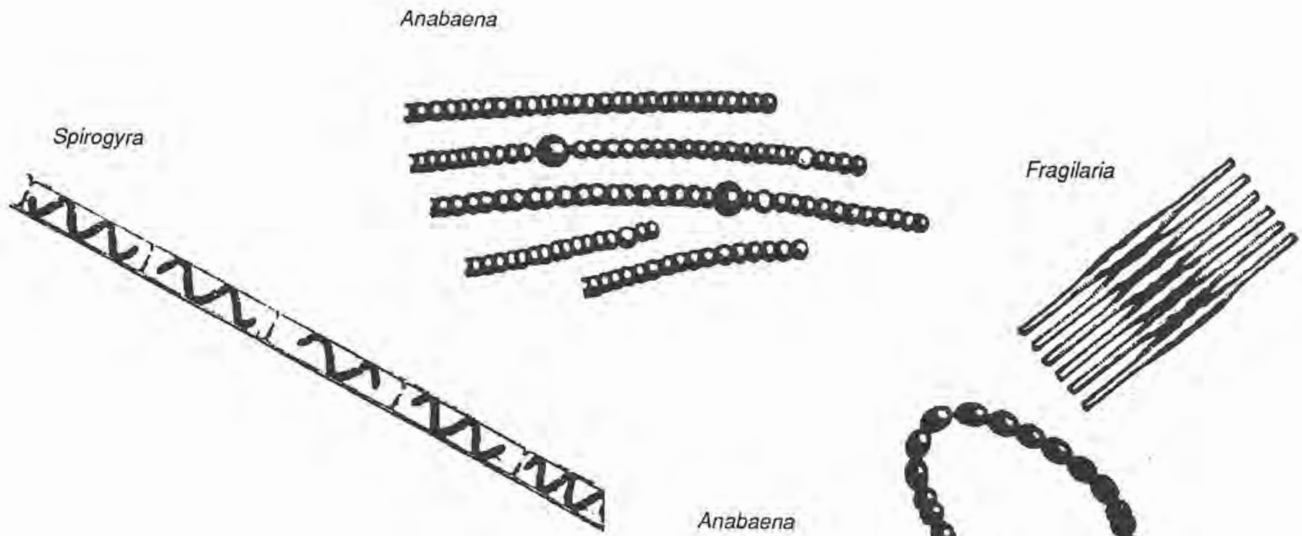
Other aspects of algae

Ann Wooley, from the Water Resources Commission has provided the following notes,

"**Algae** are a diverse group of simple plants, varying in size, shape and colour, that are natural and necessary in healthy water bodies.

Algae are photosynthetic, that is they are able to fix and utilise light energy from the sun for their metabolism. Microscopic algae (phytoplankton) are classified into two groups, true algae and blue-green algae (cyanobacteria), the latter being more closely related to bacteria than plants. The true algae of most significance in freshwater are the green algae, diatoms, dinoflagellates, chrysophytes and euglenoids.

When an algal population becomes dense it is said to **bloom**. The dominant algal group at any time is determined by the nutrient status of the water and other factors such as water temperature, light intensity and pH.



Algae can cause a number of problems in water supply operations including:

- Clogging of filters most commonly by **diatoms** which have hard silica shells;
- Interference with coagulation because of increased organic content of the water and both an increase and diurnal variation in water pH when significant blooms occur. Higher coagulant doses will be required as will more frequent testing of raw water to optimise coagulant dose and close monitoring of plant performance.
- Taste and odour can be imparted by all types of algae. This is the impact most noticeable to consumers. Blue-green algae, in particular the genera Anabaena and Microcystis produce two chemicals, geosmin and methylisoborneol (MIB), which produce taste and odours characterised as earthy and musty at extremely low concentrations (10 ng/L = 10 parts per trillion). Diatoms produce taste and odours described as grassy or fishy.

  Odours characterised as grassy, fishy or swampy can generally be removed by chemical oxidation with chlorine or potassium permanganate. Earthy, musty odours are more difficult to oxidise requiring treatment with a ozone, a stronger oxidant. Taste and odour compounds can also be removed by adsorption onto activated carbon.
- Reticulation system problems. The increased organic content of the water resulting from algal activity will impose a greater disinfectant demand to achieve effective disinfection. The potential for increased production of disinfectant by-products, such as trihalomethanes (THMs) when chlorine is used, is enhanced.

In untreated water supply systems, algal cells will enter the distribution system and may result in increased dirty water complaints, taste and odour problems and poor disinfection."

Dam site monitoring

It is important for water quality engineers to know what type of water they are going to treat. Aeration and controlled dam intake procedures control levels of algae that give water a poor taste.

Very dirty water obviously needs to have more treatment than clear water and so the dam water is sampled regularly so that engineers can get a complete picture of the type of water they are going to have to treat until conditions change.

Fig 12 Algae affecting our drinking water.

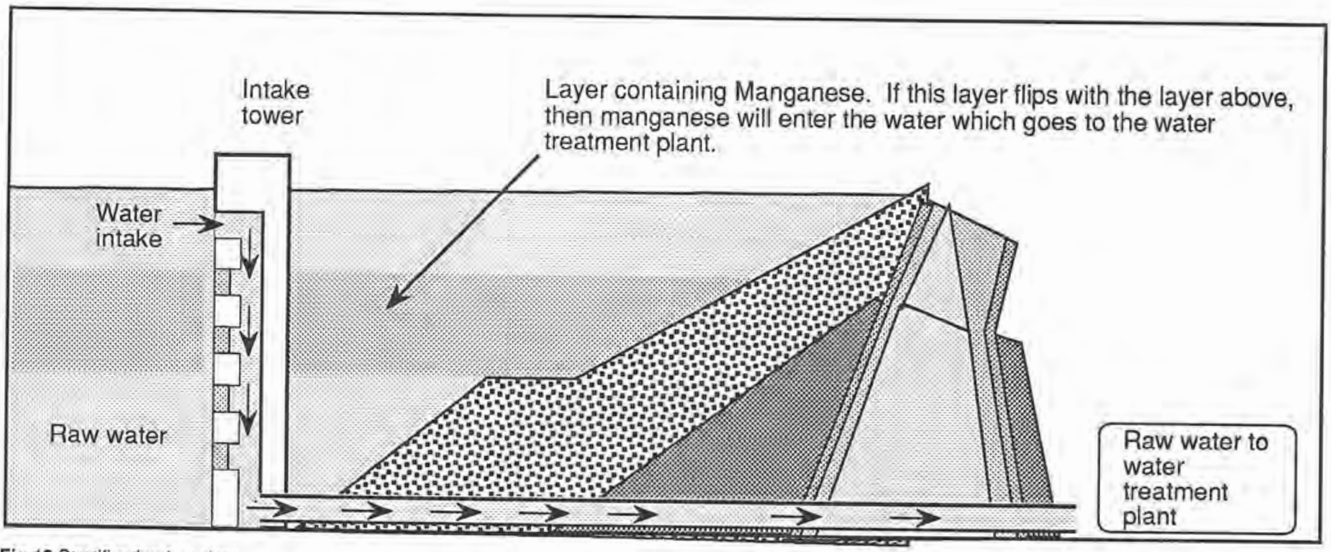


Fig 13 Stratification in a dam

"Dirty Water"

Manganese ions are responsible for making the water dirty. As the oxygen is removed from manganese dioxide, it becomes soluble. The same happens for iron and other metal oxides. Put another way, the summer bacteria turn anoxic and eat up the oxygen from the PO_4^{3-}, NO_3^- and MnO_2 compounds causing P, N and Mn ions to dissolve in water.

The stratification that occurs during summer also occurs at night. As the surface water cools, the layers of water can flip introducing Mn substances into the intake layer requiring increased treatment to remove them.

The bacteria in the sediment effects the quality of water that is drawn off from the intake tower. Sediment and decomposed organic matter can accumulate at the base of a dam leading to a build up in hydrogen sulphide. This can be released in dams by a purge value which creates quite spectacular water flows when the dam is full and under great pressure. Chlorine is used to keep bacterial numbers within our water supplies to safe levels.

Why water needs to be purified

Ann Wooley from the Water Resources Commission has provided the following notes

"Drinking water is disinfected to prevent the spread of water borne pathogens that cause diseases such as cholera, typhoid and gastro-enteritis and to control biofouling (growth of bacterial slimes) in reticulation systems.

When evaluating a disinfectant the following aspects should be considered.

- Its ability to kill pathogens under the prevailing conditions of pH, temperature, turbidity.
- The provision of residual disinfectant for the distribution system.
- The toxicity of end-products, by-products and residuals.
- The effect of the disinfectant and by-products on palatability and acceptability of water to consumers e.g. taste and odour
- The availability of simple and inexpensive analytical techniques for dose, residual, end-products and by-products.
- Cost - capital and operational.
- Safety aspects and ease of transport and storage.

The disinfectants that are most commonly used in domestic supplies are:

- Chlorine (C12)
- Chloramillation
- Chlorine dioxide (C102)
- Ultra violet light (UV)
- Ozone

Their properties are summarised and compared in Table 1 on Page 14 over. None of the options discussed fulfil all of the requirements for a desirable disinfectant. The advantages and disadvantages have to be assessed for individual system requirements and water quality goals.

Chlorine is receiving adverse publicity as a disinfectant for potable water supplies due to the formation of by-products which have health implications. However the alternative disinfectants such as ozone, chlorine dioxide, chloramines and UV light all have important disadvantages such as lack of residual, formation of by-products which also have health implications, higher cost and, in some cases poorer biocidal activity.

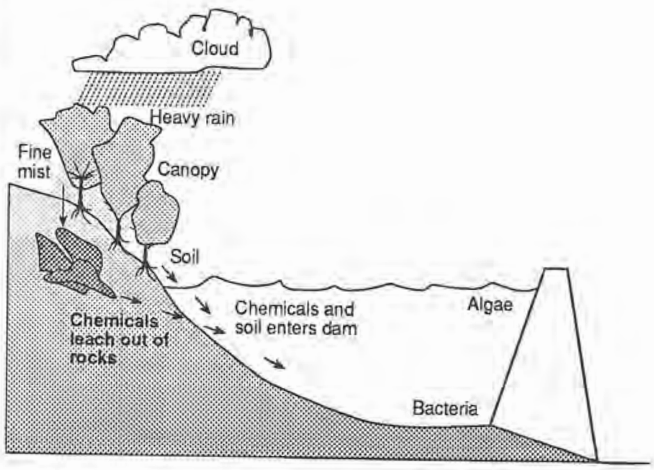


Fig 14 The dam creates a new environment where bacteria and other microorganism build up in the sediment behind the dam wall.

Table 1: Relative comparison of alternative disinfectants.

	Chlorine	Chlorine dioxide	Chloramine	Ozone	UV
Ability to kill pathogens					
• bacteria	good	good	good	good	good
• viruses	moderate	good	poor	good	good
Contact time	moderate	moderate	moderate/ long	short	short
pH dependent	yes	slight	yes	slight	no
Provision of persistent residual	moderate	moderate	long	no	no
Relative complexity of technology	simple/ moderate	moderate	simple/ moderate	complex	simple/ moderate
Safety considerations					
• transport	yes	yes	yes	no	no
• on site	substantial	substantial	yes	moderate	minimal
By-products of possible health concern	THMs, other chlorinated organics	chlorite	THMs but at lower levels; nitrite & nitrate	oxidised materials - significance unresolved	no
Analytical methods					
• dose/residual	yes	yes	yes	yes	n/a
• by-products	yes (not routine)	yes	yes	research	n/a
Process Control	well developed	developing	well developed	developing	developing
Cost*	+	++	+	+++	++

* Costs: comparison is difficult because of the lack of Australian data for methods other than chlorination and chloramination. Rating given is relative based on USA data. Plant size is a further complicating factor. Chlorine is the cheapest disinfectant but for small plants (< 5ML/day) UV and chlorine dioxide may be comparable.

While every effort should be made to minimise the presence of toxic disinfection by-products, there should be no compromise on the microbiological safety of water. The risks from water borne diseases still outweigh the risks associated with drinking water containing disinfection by-products such as trihalomethanes (THMs).

Chlorine, chlorine dioxide and ozone are strong oxidants and have other treatment uses in domestic water supplies such as oxidation of iron and manganese and the oxidation of organic substances that cause tastes and odours. It is important to distinguish between the use of these strong oxidants as either pre-oxidants/pre-disinfectants of raw water or as post-disinfectants of treated water.

Free chlorine disinfection remains the most cost effective method for post treatment disinfection of water in most water supplies.

For systems with long detention times chloramination may be a more effective means of maintaining residual disinfectant levels.

Chlorine dioxide has application as an oxidising and a disinfecting agent in both pre and post water treatment situations. However, water quality limits on the concentration of oxidising residuals means that it is more often used as a chemical oxidant rather than for post treatment disinfection.

For small supplies of good quality water (low colour and turbidity) where residual disinfection is not required, UV irradiation has application.

While ozone treatment is expensive it probably represents the best available technology for pre-oxidation and pre-disinfection of potable water.

Ozone treatment normally includes activated carbon filtration to remove oxidised organics prior to post disinfection with chlorine or chloramines for the provision of a residual disinfectant in the distribution system. Ozone has not been used for water supply disinfection in Australia to date."

Water purification plants

Characteristics of good water

Good drinking water is free of bacteria and viruses, looks crystal clear, smells and tastes just great. Good washing water means that the detergents we use, lather well so that our washing machines can remove the dirt that accumulates in the fibres of our clothes.

Water quality problems arising from dam storage

It is very important to treat raw water so that the health of the townspeople can be maintained as well as keeping pipes and plumbing fittings in good repair.

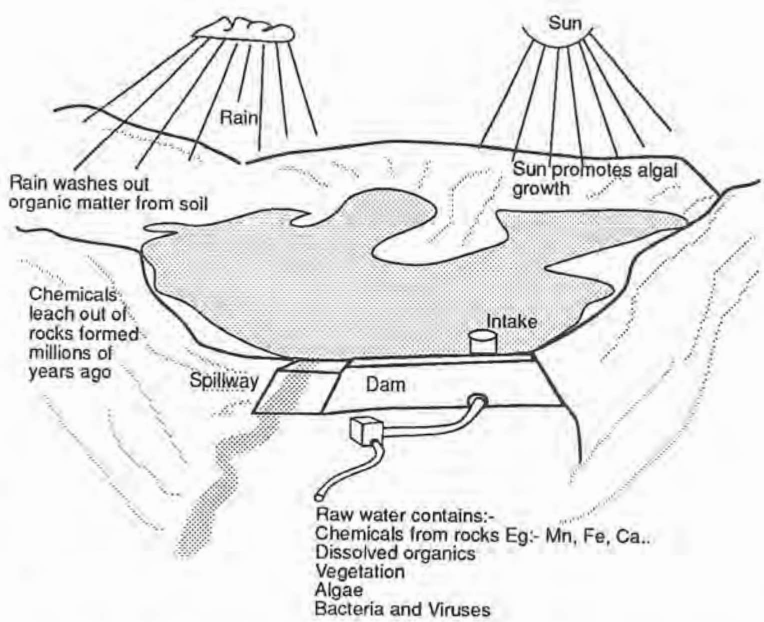


Fig 15 Natural forces like rain and sun create raw water with many problems when dams are built

One big problem facing engineers is the sediment that develops behind the dam wall during summer. **Sediment** is composed of chemicals leached out from the rocks in the catchment area as well as bacteria living in organic matter washed off from the leaf litter found under the rainforest trees.

So that urban dwellers can have safe drinking water, the water from the Hinze and Little Nerang Dams is fed by gravity to water purification plants located at Molendinar and Mudgeeraba. From here water is fed to reservoirs located at different heights above sea level, and then to homes. Figure 16 shows how a typical water treatment plant on the Gold Coast works. Water is taken from the Hinze Dam to a "break of head" tank and is fed by gravity to the plant.

Inlet structure

Oxygen, alum, and lime are added here to remove organic matter and leached chemicals to give clear tasting, pleasant smelling drinking water.

The addition of oxygen is achieved by letting water run through concrete channels or fall over a waterfall creating a cascade effect. Oxygen simply enters from the atmosphere. This helps improve the taste of the water, removes carbon dioxide and hydrogen sulphide and assists in the removal of manganese. Activated carbon can be used to remove compounds which would otherwise give the water an unpleasant taste. Raw water collected from the catchment area contains:

★ fine sediments that cloud the water
★ elements leached from rocks - manganese and iron that discolour the water
★ bacteria and viruses that can cause disease
★ algae that give water a poor taste

Take a jar, fill it with dirt and water, give it a good shake and let it stand. Over time the bigger particles fall to the bottom and clear water forms on the surface.

However it takes some days for the finer particles to settle out. Suppose however, you could make these smaller particles stick to the bigger particles. This would mean that as the bigger particles fell to the bottom of the jar, they would take the smaller ones with them. The process can also be hastened by the addition of materials that attract solid particles.

Scientists long ago, discovered that chemicals called **coagulants**, could achieve this and that a naturally occurring chemical - alum, could be used in water treatment plants to achieve this process. For coagulation to work efficiently, the acid-alkali balance or pH has to be 6.5 on a 1-14 scale.

Lime, dissolved in water in a room on site, is added in controlled amounts to make the pH 6.5.

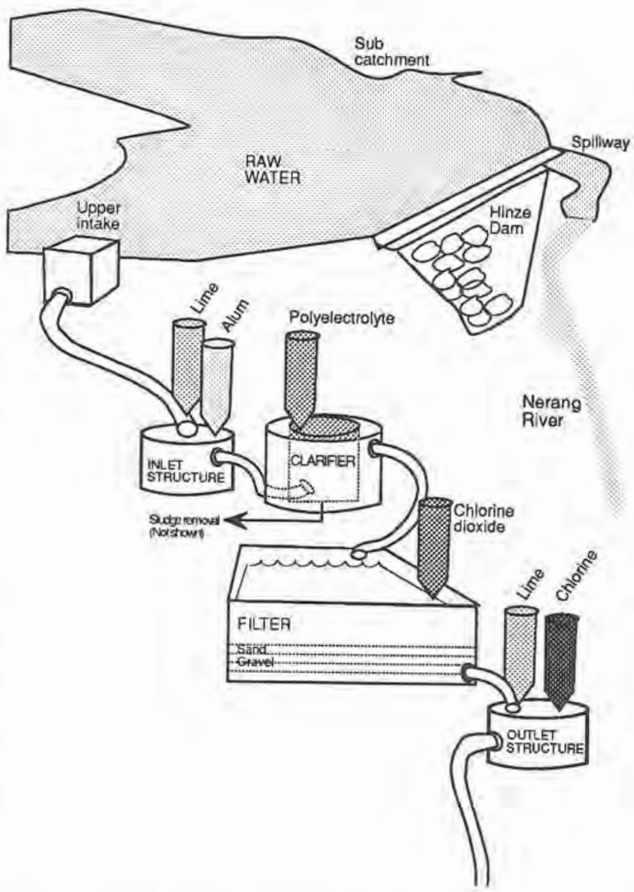


Fig 16 Schematic diagram of Gold Coast water treatment plant

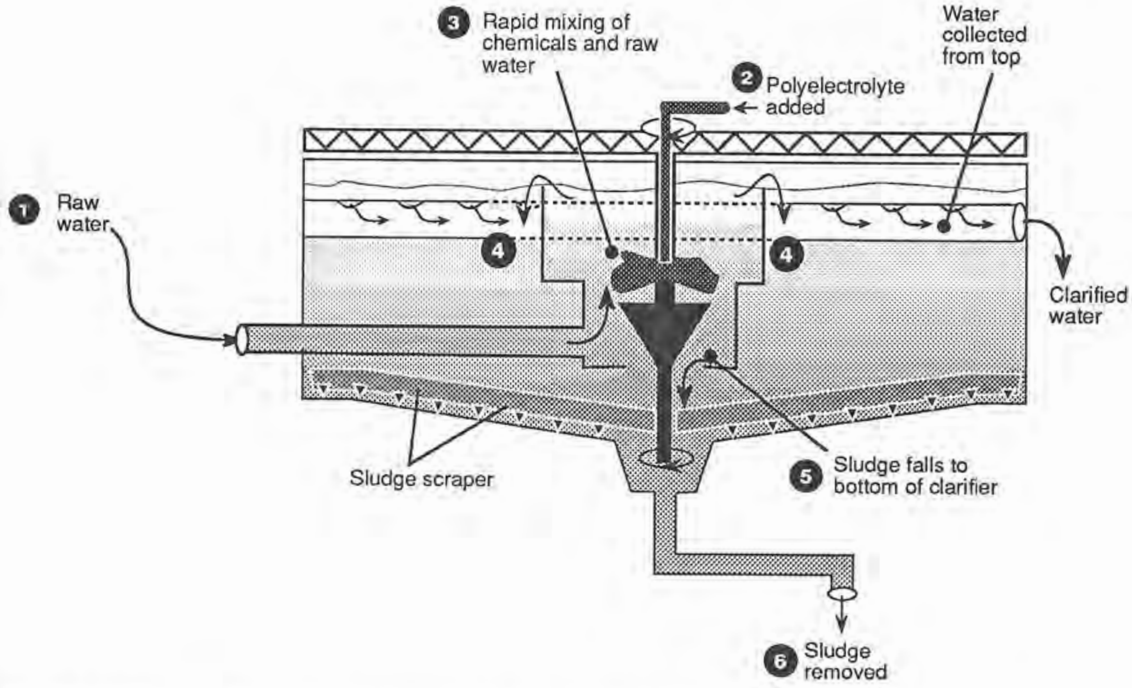


Fig 17 A clarifier is used to remove solid materials by the addition of polyelectrolyte. Clear water forms as the sludge settles out from the raw water

Lime is used to provide the correct pH for the alum to attract suspended solids to each other and settle out. Most of the iron and manganese attaches to the particles and settles out too.

Clarification

The process by which sediments are allowed to settle in a tank is called clarification. To understand what goes on follow the steps 1-7 in Figure 17.

1. Water, containing lime and alum enters the centre of the clarifier from the inlet structure.
2. **Polyelectrolye** (a synthetic organic polymer, with many electrically charged points) is added and rapidly mixes with the raw water coming up from below.
3. Organic material in the water is attracted to the polyelectrolyte, becomes more dense than the surrounding water and sinks. The process by which ployelectrolyte and particulate matter combine to form sinking particles is called **flocculation** and is not a chemical reaction.
4. Clear water now forms on the surface and flows through channels from the clarifier. This clarified water still contains dissolved chemicals - of which manganese is one.
5. The settled material is known as sludge and is removed by scrapers which rotate around the bottom of the tank.
6. The sludge is removed and pumped to the sludge thickening tank where water is removed (not shown in this diagram).

Filtration

Clarified water from step 4 in Figure 17 is passed to a filtration tank to remove further fine suspended matter and manganese.

Chlorine dioxide is added to convert soluble manganese salts into insoluble manganese dioxide, which is removed by filtration The filters also remove algae with the end result being clear drinking water.

Each day the filters must be backwashed at regular intervals to remove the manganese dioxide from the filters.

Sludge is also removed and wash water reclaimed in a washwater recovery tank (not shown) Sludge from step 6 in Figure 17 as well as washwater sludge, is concentrated in a thickening tank where further chemicals are added to de-water the sludge. The chemicals cause the sludge to separate from the water particles and so reducing the water content.

The sludge is then fed to a rotating drum for further removal of water before being dumped as landfill.

Summary - Water Treatment Process

1. The initial process is coagulation. Alum is a coagulant. The role of the polyelectrolyte in this instance is a coagulant aid. It forms bridges between smaller coagulated particles to form larger particles,
2. The next stage is floculation. This occurs at No 3 in Figure 21 above where slow stirring/mixing helps the smaller coagulated particles grow in size (floc together) to form larger flocs which settle more readily in the clarifier.
3. The final stage is filtration. Here chemicals like manganese can be removed along with other solid particles. Lime is added to correct the pH and chlorine added to kill any harmful bacteria remaining in the system before the water is pumped to reservoirs for gravity feed to the home.

Just in time

If water could be delivered to houses before bacteria had the chance to grow and multiply, the need for chlorination could be reduced.

Water Supply and Sewage

Water is fed to houses by a series of water mains which link the reservoir to the house. As the years go by the mains accumulate deposits on the inner surfaces and have to be cleaned. This process scrubs off the scale making for a clean water supply.

If manganese deposits are found in raw water they must be removed otherwise consumers end up with dirty water.

The figure below summarises the main aspects of water reticulation and supply.

1. Water is stored in dams
2. Water purification plants prepare water for piping to houses
3. Reservoirs store water and create pressure for gravity feeding to houses
4. Water travels along the street in council water mains
5. Water enters the house from the street and passes through a water meter
6. Water mains are checked regularly for leaks and poor quality water
7. Waste water used in the house is collected in sewer pipes
8. Pumps in the sewerage system pump waste water to treatment plants
9. Waste water treatment plants reclaim water for use on the land
10. Golf courses, nurseries and irrigation fields provide excellent places for reclaimed water to be reused

Fig 15 Summary of water supply and sewerage systems

Why We need to Be WaterWise

The following notes are from WaterWise Qld 1992

"Imagine being a Moreton Bay convict building Queensland's first dam in 1838. It was made of earth, and hollow logs were used to pipe water to the colony. One can only imagine what the water would have been like, and it was either be WaterWise or perish.

Today, things are much better. Urban Queenslanders have high quality drinking water available at the turn of a tap, however, a lot more than convict labour and hollow logs are required to achieve this.

Queensland's infrastructure of modern dams, pumps, water treatment plants and reticulation pipes is valued at $12 billion. This represents a $15,000 investment for every Queensland household. Add to this annual running and maintenance costs of $300 million, and we start to appreciate the true cost of the water that flows from our taps.

Other costs, not so easily measured, have an even greater significance than dollars.

If demand for water is greater than supply, new dams and treatment plants are required, bringing with them the possibility of adverse environmental effects. Dams inundate large areas of land, often with drastic effects on human inhabitants as well as native flora and fauna. Higher water usage also means increased power consumption due to pumping, treating and heating water; and increased levels of waste water flowing from our stormwater and sewage systems - all things the environment can do without.

Queensland's population is expanding rapidly, and with it the demand for water. Our present domestic, commercial and community usage is around 635 litres per person per day.

This is putting the existing water supply infrastructure under pressure. In some areas, new dams and water treatment plants are already required, and most areas of Queensland have to accept some level of water use restriction.

Australians are among the top three consumers of water in the world, yet we have the driest continent. Because it's so dry, and often hot, we tend to use more water than we really need. We all want lush green lawns, swimming pools and the latest labour saving devices such as automatic washing machines and dishwashers. Typically, less than 1% of water treated is actually consumed by people.

Research has shown that a general 20% reduction in water use is possible without reducing our quality of life. This would save $40 million per year in running and maintenance costs on Queensland's existing water supply infrastruc-

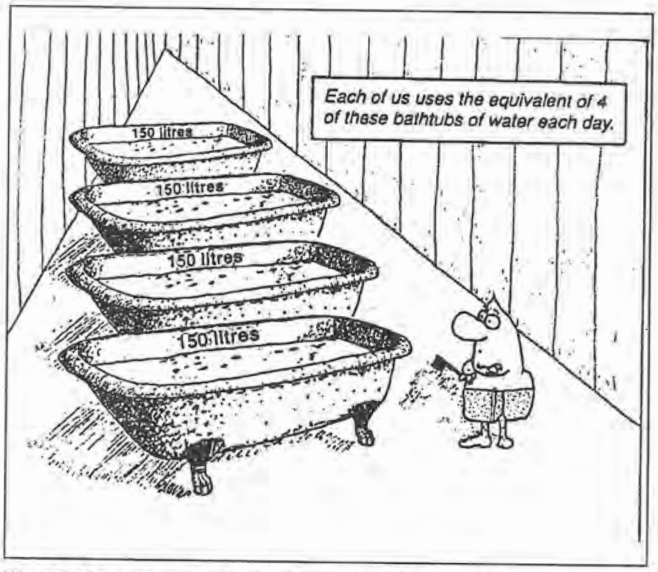


Fig 16 Daily water use can be compared to bathtubs

Current use of water

Inside (Domestic)	**Volume**
Toilet (full flush)	12 litres
Bath	50-150 litres
Shower	40 - 250 litres
Dishwasher	20-90 litres
Washing machine	40-265 litres
Tap running while brushing teeth	5 litres
Hand basin	5 litres
Drinking, cooking, household cleaning. .	8 litres
Queensland's daily inside average (litres per person)	205
Outside (Domestic)	
Garden sprinkler .... litres	up to 1000
Car washing with hose	100-300 litres
Hosing driveway	50-l00 litres
Dripping tap all day	l50 litres
Queensland's daily outside average (litres per person)	205
Industrial, Commercial (litres per person)	125
Fire Fighting, Leakage & Community Use (litres per person)	100
Overall daily total (litres per person)	**635**

Fig 17 Daily water in litres

ture, and $40 million per year through the deferral of new infrastructure development. It would also contribute significantly towards a better environment, as well as lower household water charges and water heating bills.

All we have to do is be conscious of the way we use water, and set a good example for others to follow. This often involves using more water-efficient appliances. However, the most effective water-saving device is the water user. Turn taps off if water is flowing away to waste, and think about effective use of water rather than habitual use of water.

Water is valuable in many ways - some of them surprising. Whatever its role, water plays an important part in all our lives."

The value of water

Water's availability has dictated the location and survival of civilisations down through the ages. It is impossible to maintain public health and provide food without water.

Water is also essential to the community's quality of life. Relaxing in a quiet garden or park would not be possible without a reliable water supply. And people all over the world flock to dams, lakes and rivers for recreation. This gives water an intangible social value that cannot be measured in money terms.

The tangible economic value of water is demonstrated by industry's need for its use. Economic stability for all sectors of industry depends on access to reliable, good-quality water. A nation's economy is seriously affected by water shortages through drought or mismanagement.

Our water resources must therefore be managed appropriately to maximise the social and economic potential of the land, both for the public interest and the economic future of the State.

How much money has been invested?

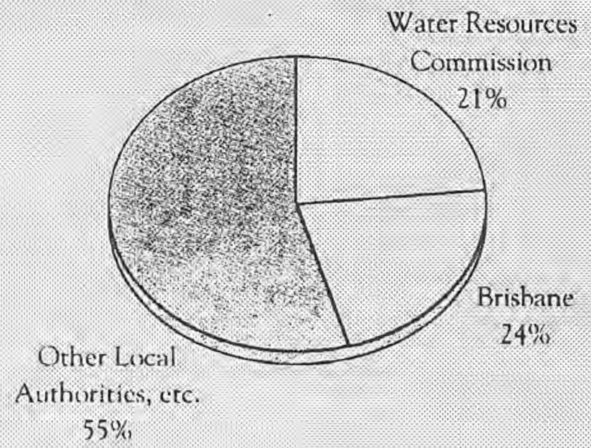
The water supply infrastructure is a valuable investment for the State; it has cost Queenslanders almost $12 billion. This amount is made up as shown in the diagram opposite.

Average water use

Water consumption levels in Queensland vary throughout the State.

- The variation can range from as little as 1500 Litres/household/day in south-east Queensland to as much as 5000 Litres/ household/day in northern and western Queensland.
- The current average water consumption in Queensland is calculated at 1965 Litres/ household/day which includes domestic, industrial and other water use.
- This is equivalent to 635 Litres/person/day. In 1987 the average water consumption was only 590 Litres/person/day.

Water supply investment



The hidden costs

Water supply	Assets
WRC infrastructure	$2.5 billion
Brisbane water supply infrastructure	$2.8 billion
Qld water supply infrastructure (excluding Brisbane)	$6.5 billion
Total water supply infrastructure	$11.8 billion
Water supply	**Operating costs**
Qld interest and redemption costs	$90 million
Qld operation and maintenance costs	$170 million
Water production	**Average costs**
Based on operation and maintenance plus replacement cost depreciation	**$0.46 per litre**

Fig 18 Cost of water per litre taking into consideration all the money we have spent over the years

Various studies done around Australia on the ratio of industrial to domestic use found that industrial and fire fighting use, production wastage, and leakages were about 30-40% of total use. Domestic water use is broken down into outside and inside use. Studies in Townsville and Brisbane have shown that similar amounts of water are used inside and outside the house. However, this varies across the State with outside use ranging from as low as 40% up to 75% of total use.

Who looks after our water supply?

Because water is valuable to the community water supplies must be protect from exploitation. An Act of Parliament (The Water Resources Act) empowers the Water Resources Commission to investigate develop, manage and regulate the States water resources.

The Water Resources Commission has developed an expert staff and technical support to ensure that Queensland communities and industries have sufficient top-quality water. The Commission must also manage todays water usage so that there is enough for future generations. The Crown has delegated to Local Authorities the responsibility for managing water resources at a local level.

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Saving water

By using water wisely you save

- ★ one of the resources humans must have to live
- ★ money
- ★ energy
- ★ flooding of land for water storage.

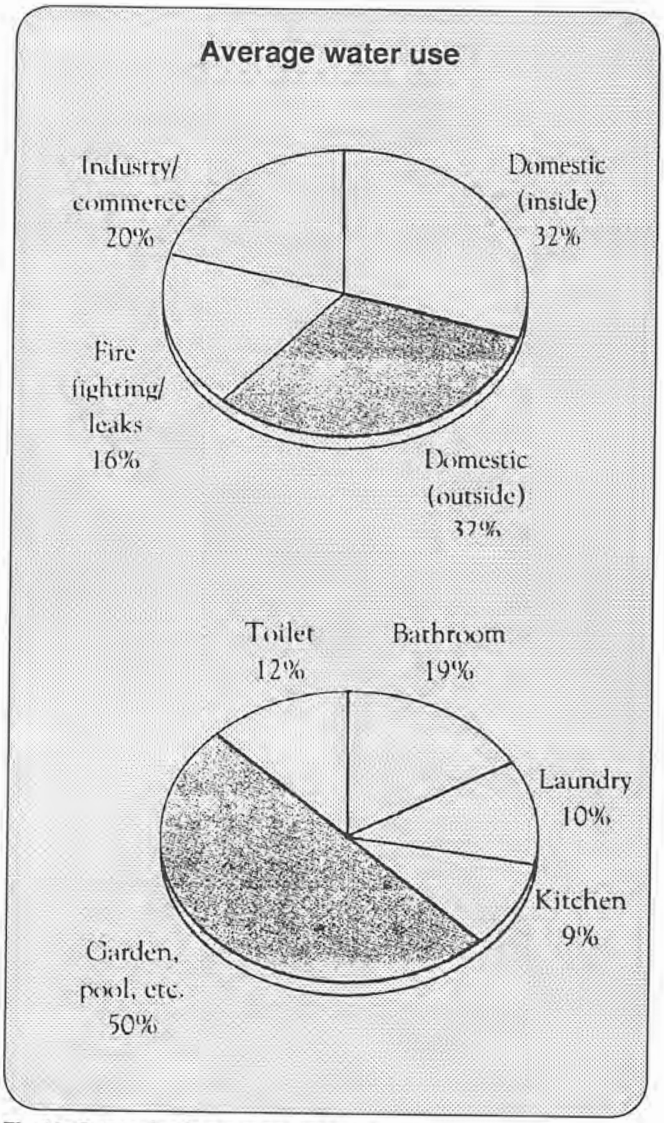


Fig 19 Queenslands average water use

What Governments do to conserve water

National Governments help by

- ★ Organising a National Water Resources Council to set guidelines and advise Ministers of all states on water conservation issues and research
- ★ Promoting the WaterWise 2000 concept
- ★ Publishing proceedings of workshops and conferences

Standards Australia helps by

- ★ Producing specifications for plumbing and drainage products and materials
- ★ Establishing the water conservation rating and labelling scheme
- ★ Establishing the national plumbing and drainage code which specifies installation of drinking water supply within premises, hot water systems and domestic irrigation systems

State Governments help by

- ★ Passing acts of parliament which set standards and by-laws for sewerage and water supply
- ★ Organising committee meetings to authorise use of plumbing and draining fittings
- ★ Funding a Water Resources Commission to organise a water conservation campaign

Local Governments help by

- ★ Enforcing the standard by-laws
- ★ Providing reliable, adequate and a high quality supply of water
- ★ Administer local requirements and by-laws
- ★ Establishing education programs to encourage people to save water
- ★ Charging for water use by a metered (user pays) system

Research and Water Conservation

Qualitative Research on Urban Water Conservation by Val Staddon (using 6 Focus groups, 18-24, 25-44, 44-60 Males/ Females resident in South East Qld early in 1992) found that:-

Motivation to conserve water is triggered by

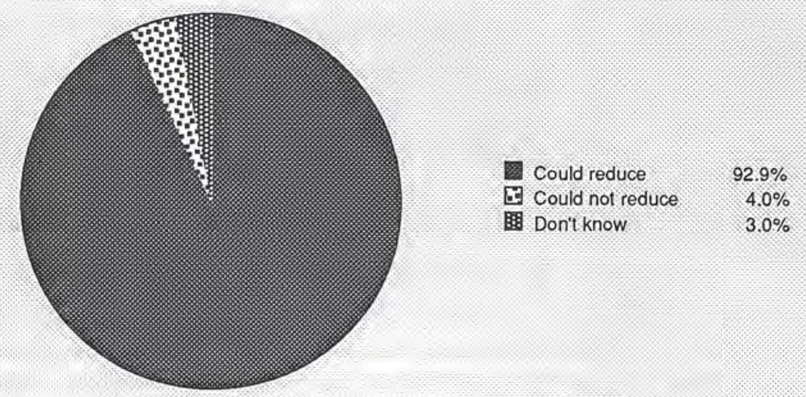
- ★ awareness
- ★ conserving the environment
- ★ water meters
- ★ restrictions
- ★ excess water charges
- ★ incentives

Education needed in the following area

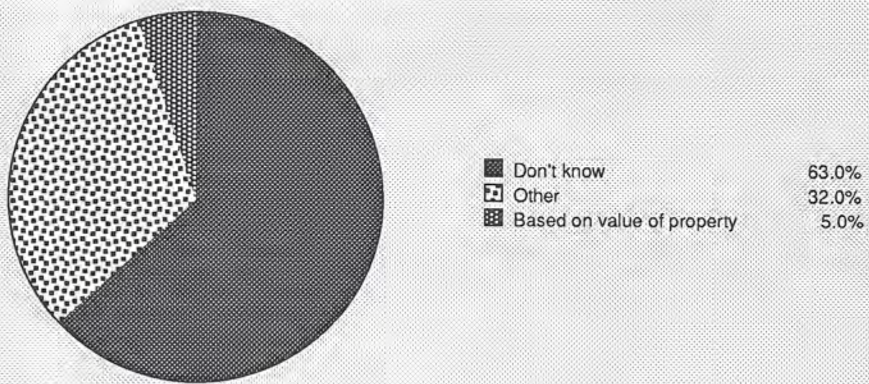
- ★ the quantity of water used and volume perception infra-structure (what happens beyond the tap)
- ★ measures for conserving water- **outside** the house
- ★ SE Qld water board
- ★ Water Resources Commission

Some key questions asked to over 500 Queenslanders by telephone interview

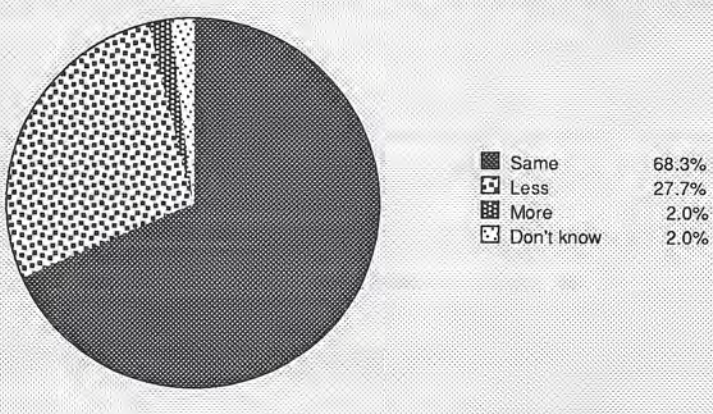
Q1 Would most people reduce the amount of water they use if they could?



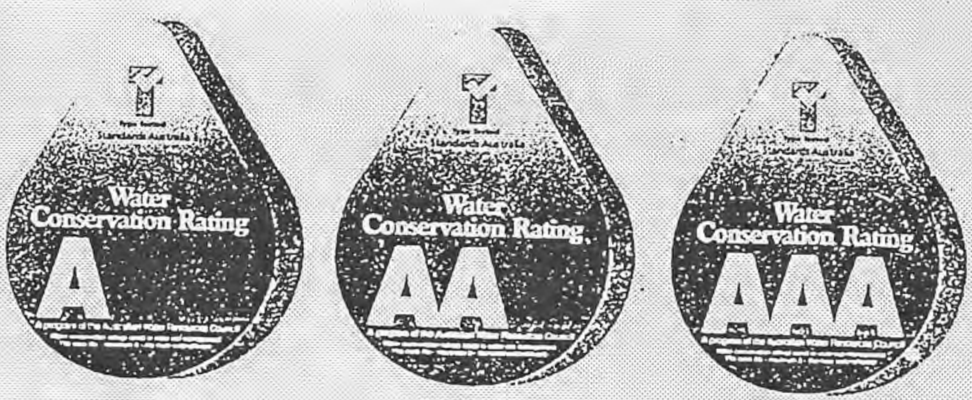
Q2 How does your local council work out what your household should pay for water?



Q3. If water charges and costs did go up, do you think you would use more, less or the same amount?



Standards Australia and Water Conservation



Labelling

The Water Conservation rating label from Standards Australia is awarded to water-efficient domestic appliances which conforms to a specific standard for water efficiency.

The scheme is voluntary. Any manufacturer or importer of water saving appliances may apply to the Quality Assurance Services Division of Standards Australia for a Certificate and Licence to use the Water Conservation Rating Label.

Appliances are rated against the three categories of water usage specified in the water efficiency standard. There are three ratings:

A acceptable

AA high water efficiency

AAA excellent water efficiency

The benefits of labelling are:-

For the Supplier

★ It tells the customer your product is water efficient

★ It proves it has been independently tested and certified

★ It offers a powerful point of sale feature

For the Customer

★ It makes buying decisions easier

★ It gives them the comfort of knowing they have made an environmentally friendly decision

★ It offers then the potential to save money on their water bill

Water distribution and Conservation

As discussed earlier, water enters the house from the street at the water main. Figure 20 shows a service pipe connected to a stop cock from a water main.

When the stop cock is turned on, water flows through a water meter to the house. The water meter and stop cock are situated on local authority land. Any water used past the meter is paid for by the householder.

This is why it is important for householders to make sure that there are no leaks on the household end of the system.

Water is then used in the house for cleaning, cooking, washing, drinking as well as gardening.

Detecting leaks

You can use this meter to detect leaks in your household.

To do this, take a meter reading making sure no taps are used over the next three hours. After this time, take another reading and if there has been a leak, the reading will be different.

Detecting leaks

★ Taps or hot water system. There will be visible evidence around the tap.

★ Underground. In sandy soils, it may be impossible to see anything as leaking water will soak into the water table. If there is a leak underground, you need to seek expert advice from your local plumber or council water supply officers.

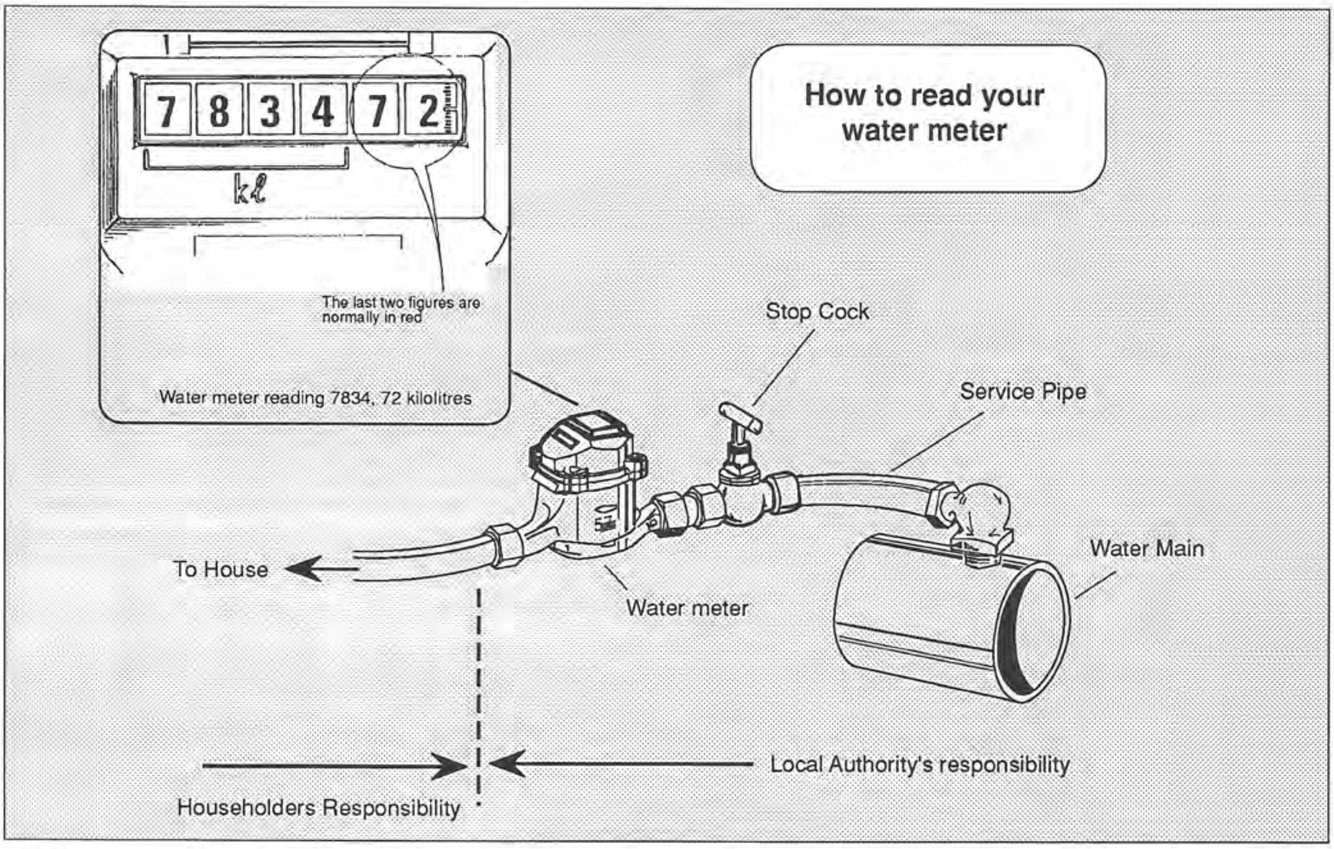


Fig 20 Responsibility for the water meter rests with the council. The responsibility for the amount of water used rests with the householder

Domestic water use

Taps and water flow

Ask anyone where water comes from and they will probably tell you - from a tap. It is important to make sure taps are in good working order. If they leak then water can be lost at an alarming rate .

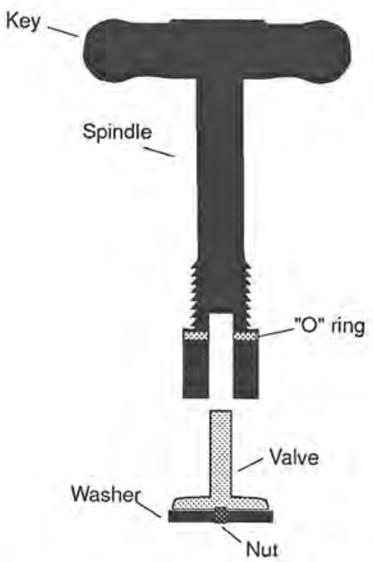
Taps are prevented from leaking by ***washers*** located at the base of the ***thread*** located below the ***tap handle***. So that the tap fitting can look attractive, a ***cover*** encloses this mechanism.

When closed, the tap washer at the end of a thread fits into a ***tap seat*** as shown in Figure 21 below. This seals off water, which is under pressure from the water main outside the house. If the washer is worn or broken, the tap will leak as a result of the pressure being forced under the broken part of the washer.

The tap is opened by the handle which releases the washer from the seat. The further the washer is from the seat, the more water will flow out of the tap.

When fully open, the tap delivers water under pressure. The amount of pressure is determined by the position the house is in relation to the local water reservoir.

Taps are made of brass or materials that resist corrosion. The water that passes through them has to be a pH of between 7 and 8 so that fittings last as long as possible saving the consumer money.



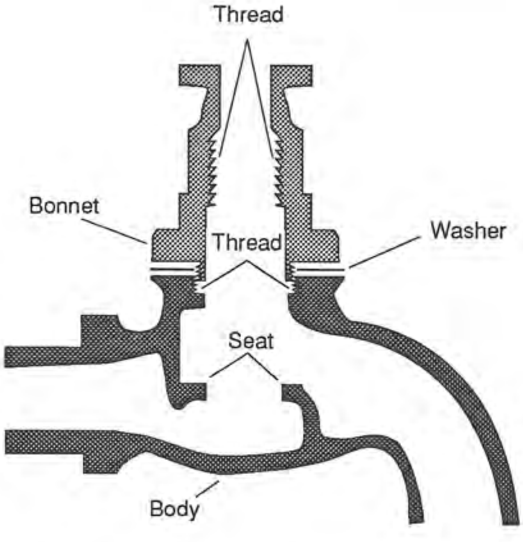


Fig 21 The components of a tap

Where water is used in the house

The house is connected to a council water main located in the street. This main is fed by water under pressure from a water reservoir located on a nearby hill.

1. Houses in the street draw water from this council water main. One of the reasons why **chlorine** is added to water at the treatment plant is to ensure bacteria are not allowed to multiply in the water mains.
2. Each house taps water from this main and the volume the household uses in a year is measured by a water meter. A stop cock allows the water to be "switched on and off".
3. Cold water divides and is diverted to a hot water system and cold water pipes. If a solar hot water system is used, then the pipes will connect to the system on the roof, where the sun will heat a bank of pipes.
4. Hot water will pass to the shower where it is mixed with cold water. If the pressure in the house changes, water flow can alter very quickly causing the pipes to make a loud sound. This is called water hammer.
5. Cold water passes to the toilet, the shower or kitchen.
6. Cold water which passes to the toilet, collects in a reservoir called a cistern. A button at the top of the cistern delivers water to the bowl below.
7. Hot water can also pass to the washing machine and kitchen sink.
8. At the kitchen sink, cold and hot water can mix or separate taps can be found.
9. The washing machine can be connected to the hot and cold water taps. The flow rates are controlled by the machine. Front loading machines usually use less water than top loading machines.
10. Cold water pipes deliver water to taps in the yard where sprinklers and hoses can be connected.

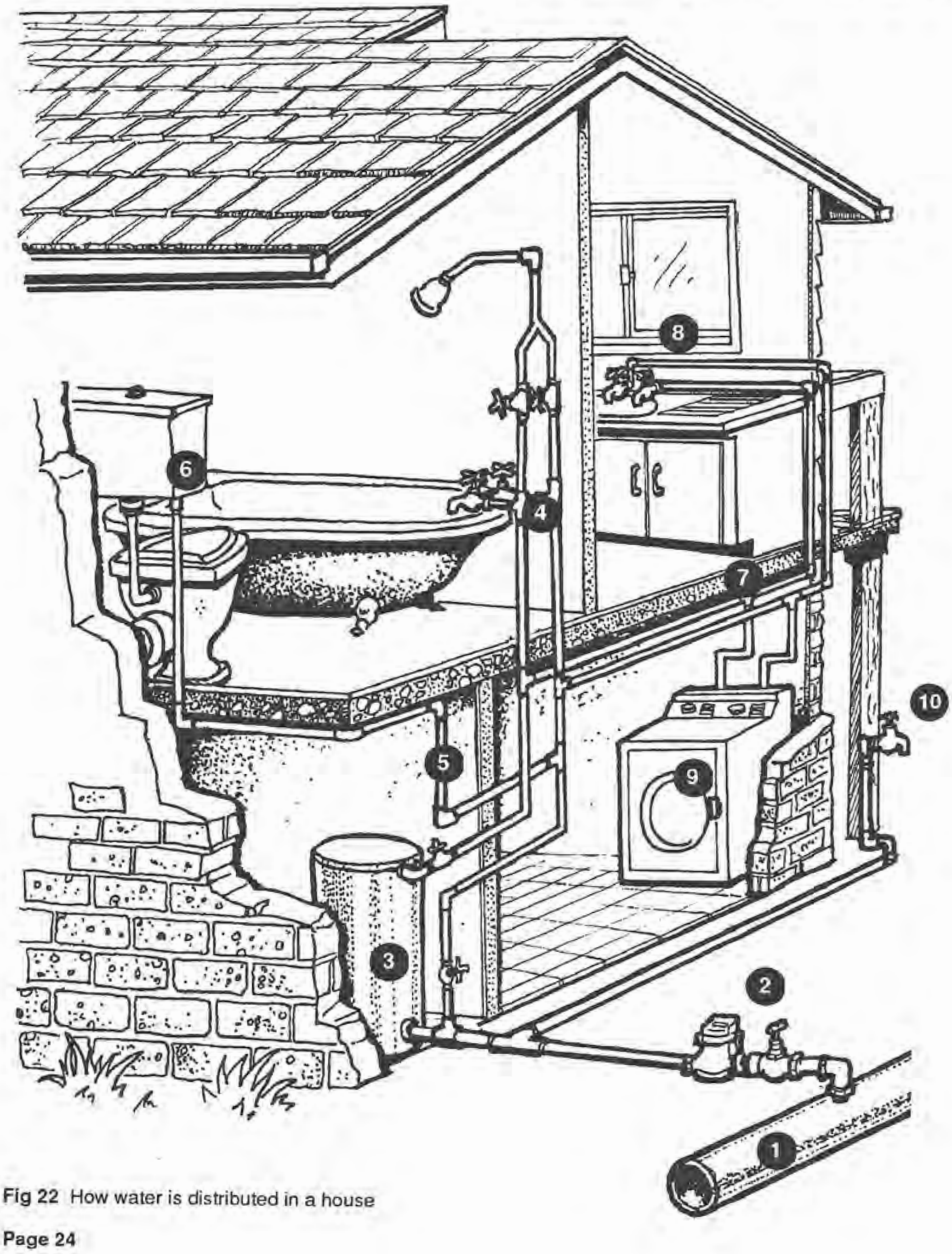


Fig 22 How water is distributed in a house

Saving water in the house

The Platypus System

The following notes have been supplied courtesy of Water Concepts 143 Melbourne St South Brisbane.

"Platypus is quite unique. It is perhaps the most significant advance in hydraulic technology in recent times.

The heart of the Platypus System is a compact valve maded of DR brass with no moving parts, which is inserted into the hydraulic system to control each water outlet.

The valve is maintenance free and will last as long, perhaps longer, than the taps into which it is inserted.

The System is a true water and energy management system and goes far beyond the capability of restricting devices which are basically limited to reducing water use.

It is a fully engineered system which was developed in Australia and is manufactured in Australia.

Platypus is also unique in that it is the only system that can guarantee performance.

The benefits of the system are:-

★ Reducing the amount of water used, in most cases by between 30 and 40%, but in some cases by more than 50% thus substantially reducing costs.

★ Reducing the amount of hot water used by a similar margin, thereby reducing the costs of the energy required to heat the water.

★ Reducing the amount of sewage put out by the system, by reducing the water going into it, once again reducing costs.

★ Balancing the water system so that fluctuations in the amount of water flowing from each tap or shower can be eliminated. (This can be guaranteed to within plus or minus 1 litre per minute).

★ Eliminating water temperature changes — particularly important in showers—even if other taps are turned on or off at any time. (This can be guaranteed to within plus or minus 1degree centigrade).

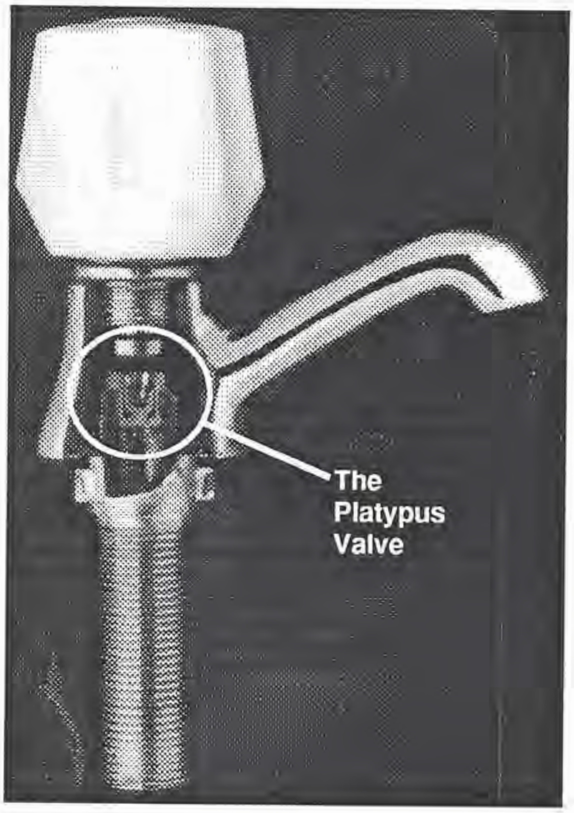
★ Eliminating or substantially reducing water hammer noise in water pipes.

★ Eliminating or substantially reducing velocity noise in taps or showers.

★ Eliminating splash when taps are suddenly turned on in basins.

★ Eliminating noise and excessive water use in W.C. flush valves.

This not only means large water savings, it means a quiet, balanced, efficient system with virtually no temperature or flow fluctuations. (Our guarantee to limit flow fluctuations to plus or minus 1 litre a minute and temperature fluctuations to plus or minus 1 °C is unparalleled)."



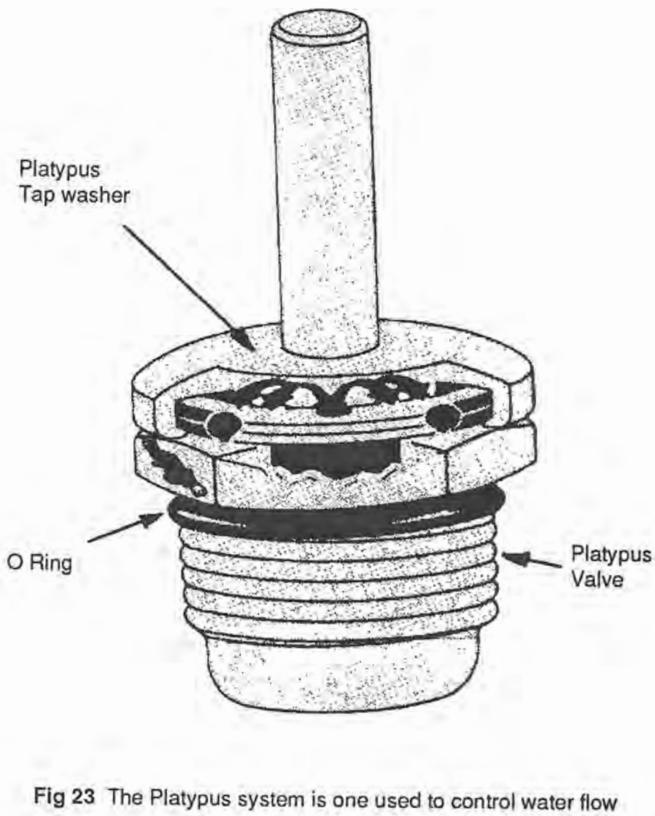


Fig 23 The Platypus system is one used to control water flow

The RMC system of valves

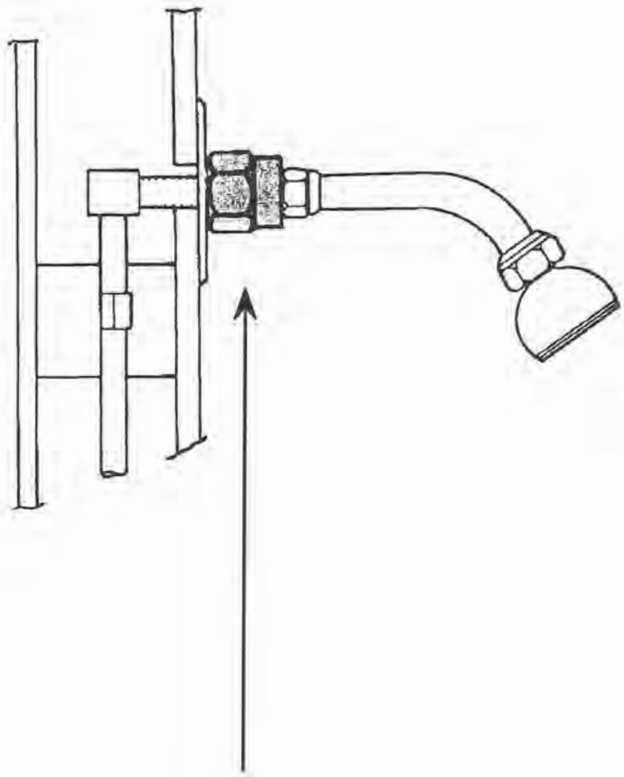
The following notes have been supplied courtesy of RMC 160 Breakfast Creek Rd, Newstead, 4006

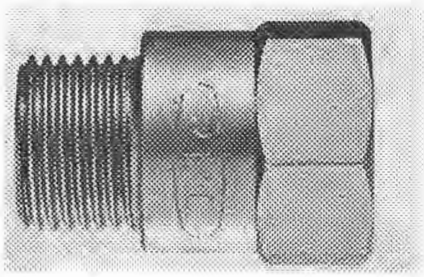
"Primarily designed to overcome high water pressure problems associated with the installation of mains pressure water heaters, R.M.C. **Pressure Limiting** valves are suitable for water line pressure control in a wide range of applications. The valve operates to control inlet pressures to a preset nominal maximum.

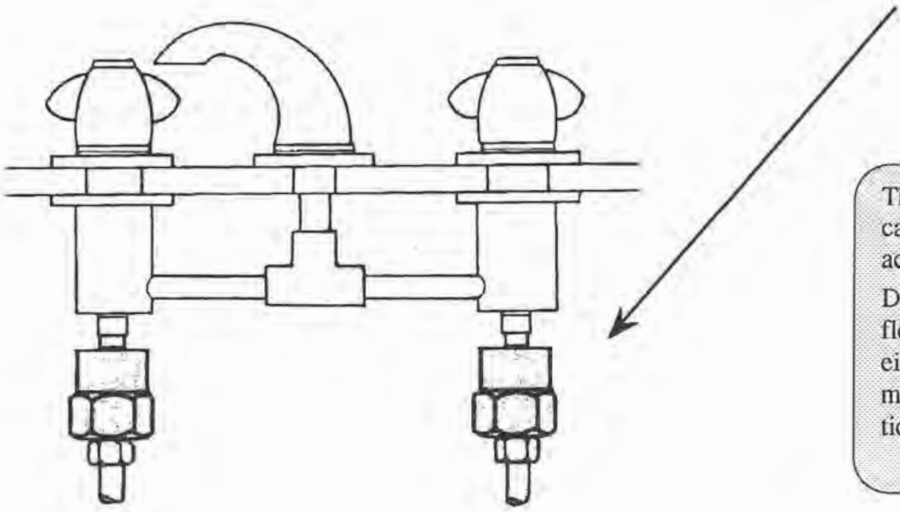
Pressure selection: The right pressure is important. Too much pressure is not only wasteful but also contributes to problems such as water hammer and overloads on reticulation systems etc.. As a general guide, dish washers, washing machines and instantaneous water heaters will operate effectively at 350 kPa pressures particularly if the Limiting Valve is fitted close to the inlet to the appliance.

For Storage Type Water Heaters where reticulated hot water is usually fed through 1/2" pipe work, pipe friction has some effect on flow characteristics. It is Important that the Limiting Valve pressure be selected to suit the pressure setting of the operating relief valve or cold expansion valve fitted to the water heater.

To determine the recommended pressure setting shown in the pressure selection guide, the effect of high inlet pressures on the set pressure of the limiting valve has been considered together with the tolerances allowed for pressure settings of relief or expansion valves. The fact that the closing pressure of a relief or expansion valve is lower than the opening pressure has also been taken into account."







The RMC Pressure Limiting Valve can be used to regulate flow rates according to demand.

Different valves deliver different flow rates. Valves are made for either 3, 4, 6, 8, 10, 12 or 16 litres a minute depending on the application of the valve.

Fig 24 Valves can be used to control water flow. The RMC valve shown here has a number of applications in reducing water flow, reducing water hammer and correcting pressure inside the house so as to prevent burns from hot water

The Delrana Equalizer Valve

The following notes have been supplied courtesy of Delrana 2 Ryecroft St, Carrara, 4211

"What is the equalizer?

It is a simple "drop in" replacement for the existing jumper valve as well as a new seat for the tap. The Equalizer is made of a high grade engineering quality acetal resin called Poloxymethylene. It provides an ideal seal of acetal and has a life expectancy in excess of twenty years.

Most importantly, it provides you more efficient and comfortable use of your existing water supply. Because of this, and it's unique water saving feature, the Equalizer makes all other tap valves obsolete.

How does it work?

When the tap is turned on, the needle comes progressively out of the orifice of the seat insert, the water being released gradually over two full turns of the tap. If more pressure and volume is required, the remaining three quarters of one turn will provide this.

This ability to gradually release the water flow means that a quarter turn of the tap - one 7th of the water normally used is actually being used, and this is adequate for handwashing, cleaning teeth etc., the flow being 4.3 litres per minute.

As the tap is opened up to 2 turns, the flow increases marginally to produce eleven litres per minute.

At this point the needle leaves the orifice and the fully opened tap allows a flow rate of 23.5 litres per minute, providing a 1:2.1 saving ratio.

In fact, with hot and cold taps fully open it takes only a minute to fill a standard laundry tub. Very simply, you have freedom of choice when more water flow is required to fill a sink or have a shower, the tap can be fully opened. How the equalizer will benefit you:-

Shower in comfort

Have you had to jump out of the shower because it ran hot or cold when a tap was turned on somewhere else in the home? Or the washing machine or dishwasher started filling, or the toilet was flushed? To solve this problem, fit the Equalizer to the hot and cold taps in hand basins, kitchen sink, laundry tubs, washing machine and dishwasher taps and toilet cistern tap.

The effect will be to eliminate or effectively reduce the sudden changes in shower water temperature while showering.

A tap valve which could outlast the tap!

Are you forever changing tap valves because the taps drip? Fit the Equalizer. It positively stops leaking, and has an expected life of in excess of 20 years.

Use less water and energy and save money

Do your family members waste water when washing hands, cleaning teeth, rinsing dishes, peeling potatoes, shaving etc? Fit the Equalizer to hot and cold taps in the hand basins, kitchen sink and wherever water is allowed to run, without being plugged.

This will save water and the energy to heat the water, and so will save you money. The Equalizer will pay for itself and the savings will be ongoing, year in, year out.

Mains pressure too strong

Fit the Equalizer in every tap in the house and reduce very strong mains pressure water flow. It is very effective in shower taps for this problem.

Gravity fed hot water showers and systems

If you have a gravity feed hot water system with mains pressure cold water, you will have a problem adjusting the shower temperature. To solve this problem, fit the Equalizer to the cold water tap only. The fine tuning this provides will delight you. If you have problems with the gravity feed shower when other taps are turned on, you will need to fit the Equalizer to every tap in the home. (excepting outside garden taps)

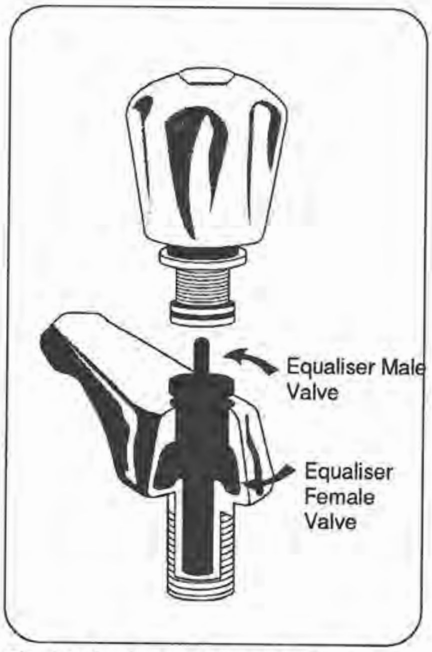


Fig 25 Another variation on restricting water flow is the Delrana valve

Delrana Showers

The Nova shower rose, connected to the Delrana universal arm, is simply the best mains pressure shower money can buy.

1. The Lopez shower rose, together with the Delrana fixed wall arm, provides a superior shower for gravity feed hot water systems.
2. Dial for either massage action or for soft natural spray with the massage mate shower rose.
3. Write to see the total range of Delrana/Alsons shower systems, Fittings and Finishes."

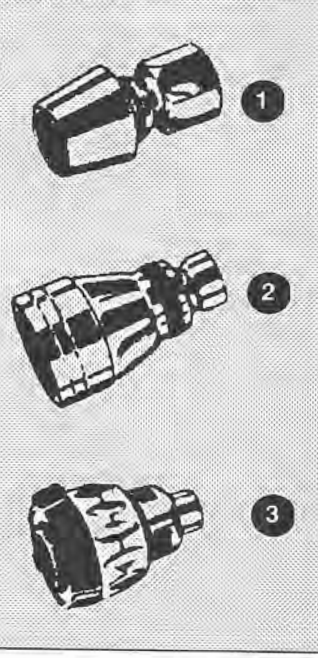


Fig 26 Water reduction shower heads.

Other benefits

The user is free to choose the water flow he wants for the job he is doing. With the Equalizer, water flow up to 23.5 litres per minute will result by opening the tap fully. Restrictor devices do not allow the freedom of choice as they are set to a specific water flow. Water hammer can be reduced or eliminated due to the gradual shut off of the water supply, by the Equalizer. Freedom from possible clogging problems.

The orifice in the Equalizer is quite large, which allows large particles to pass through. In addition the needle valve, is an active moving part and will keep itself and the orifice free of mineral build up and blockage. Restriction devices which have set flow rates are subject to blockage problems, particularly in hard water areas."

How to save water with water wasting shower roses

Lets face it, many humans like a strong shower. For some, there is nothing like the feeling of a strong hot shower on a cold winters morning, or a cool one on a hot afternoon.

If time is what you like - try a bath. Alternatively take a shorter shower. Four minutes is ample and the you will have saved water, without losing the enjoyment of the shower.

Water Conservation and Showers

Cold water enters the basic urban house from the water main and is distributed to a kitchen, bathroom, toilet and laundry.

Cold water is also fed into a hot water system which is heated by electricity, solar or gas. Pipes from this system are fed to the bathroom, laundry, kitchen and in many cases - a hand basin in the toilet.

The hot and cold water taps join in most cases, so that water can be mixed to the desired temperature.

Water wasting showers

Water wasting showers usually have a big shower head with large holes in the shower rose. There is usually no regulation of hot and cold water except at the taps.

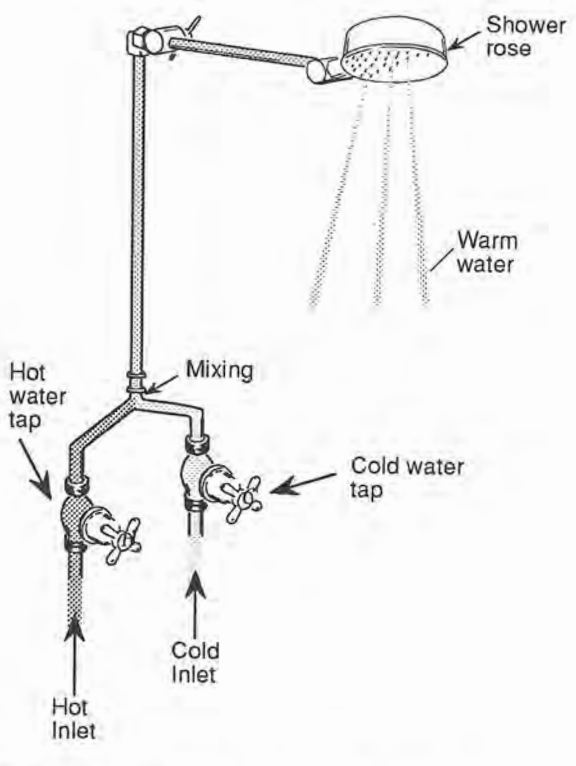


Fig 27 Water is mixed in pipes behind the wall

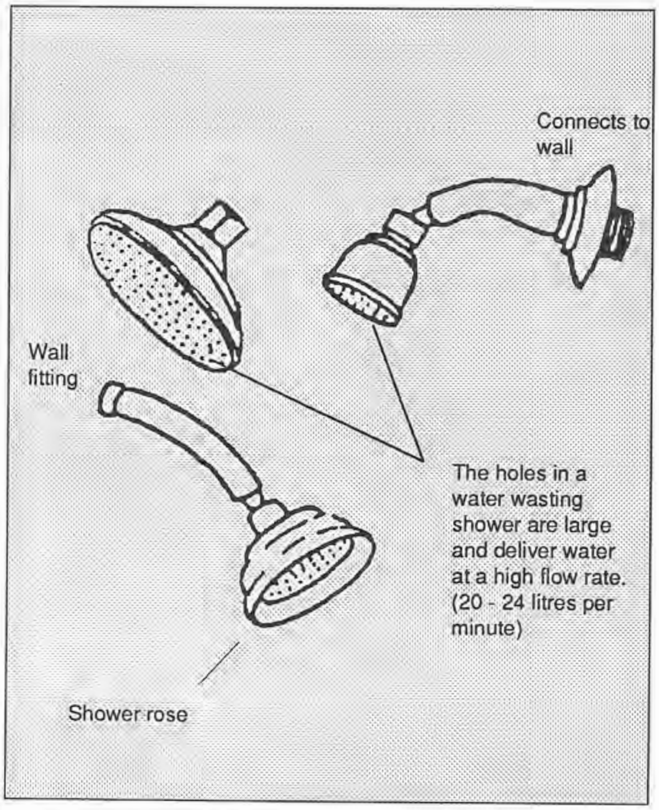


Fig 28 Water wasting shower heads have high flow rates. E.g 24 - 30 litres a minute would be a water wasting shower head

Water Saving Showers

These notes and illustrations reproduced courtesy ConServe Corporation, 5 Noble St Wilson 4051

"1. 'STANDARD showers are capable of using 20-30 litres of water a minute. The amount will increase as pressure increases.

If such showers are regulated to an economical 9 litres per minute the spray is usually not forceful enough to awake and refresh the skin or scalp. Brass spray plates are prone to corrosion and holes can block and spoil the pattern, especially when water has many impurities.

2. Even the quality self cleaning head used in the CON-SERV range is not a water saver alone.

   Without regulation it is capable of 24 litres/minute. Used in the CON-SERV system it is controlled to a constant output. Copies of this shower are available which use lesser quality internal springs and jet formers. Such copies only lead to customer disappointment.

3. Many patterns of flow controllers are in use. Controllers that rely on a small hole or a number of holes may well perform as their makers claim and give an economical flow at a fixed pressure.

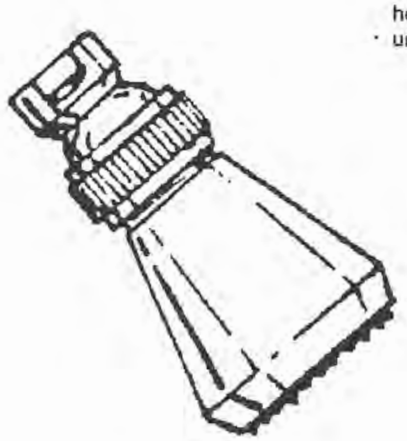
   At greater pressures the flow rate will increase. Such restrictors will also generate noise at higher water pressures. Metal restrictors will gradually have the holes enlarged by corrosion and abrasive materials in the water.

   For long life and best performance only flow controllers that automatically adjust to pressure to give a constant flow rate without extra noise should be considered. These are the only controls used in the CON-SERV range.

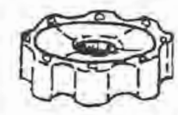
4. Showers that have no flow control and rely on small holes in the face plate can make lots of noise at high pressures and produce a stinging spray. These showers can be greatly improved with a CON-SERV flow controlled arm.

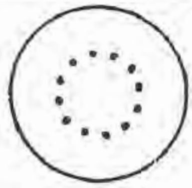
5. Hook and swivel handshower mounts are prone to become loose and floppy in time and add weighty hardware to the handpiece. Peg and socket mounts offer limited spray direction control and are easily damaged.

   The exclusive CON-SERV security bracket with nylon bearings offers long life with a complete range of spray direction options."

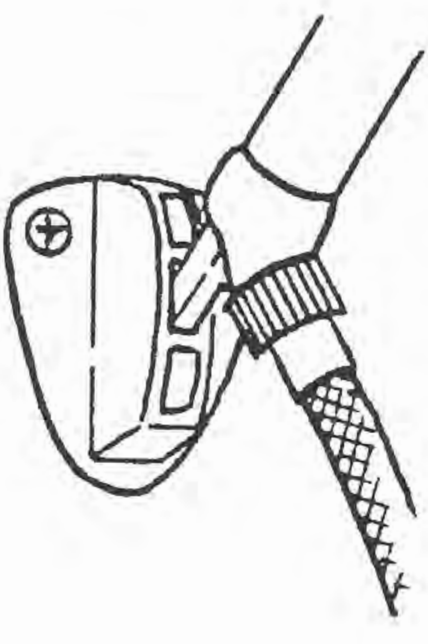


A water saving shower head has a flow control unit





Water saving valves reduce the flow rate so saving water



Water saving valves can be installed in the shower connections to limit the flow of water

Fig 29 Water reduction shower heads

Saving water with the toilet

The toilet works by a flushing action in a bowl from a reservoir called a cistern. The cistern refills with water after the toilet has been flushed.

Water enters at the bottom of the cistern under pressure from a water pipe in the house. It passes through a refill assembly that contains a valve that is controlled by a float on the end of a rod. The refill tube delivers water only when the float is down.

When the button is pressed, a plunger at the bottom of the cistern opens and releases all the water to the bowl. This action pushes the water from the bottom of the bowl upwards past the toilet leg allowing it to fall by gravity to the sewer pipes below.

The shape of the leg allows a quantity of clean water to form a trap at the bottom of the bowl, thus preventing odours from the sewer system entering the house.

In a half flush system only half the water is used. Older toilets flushed with 24 litres. Modern toilets use a system of 12 litres full and 6 litres half. With even greater engineering skill, toilets can be made to flush with 6 litres full and 3 litres half.

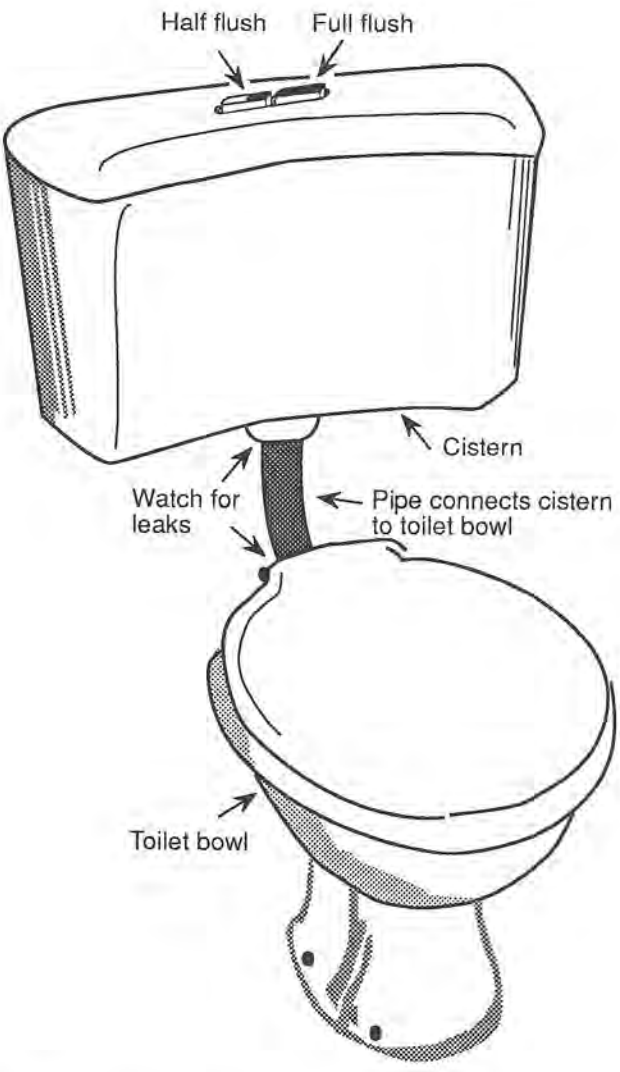


Fig 30 **A toilet is composed of a cistern and a bowl**

Composting toilets

The toilet was often called a WC or water closet. Not all toilets have to use water and much research is being directed to the development of a waterless toilet. Such toilets would breakdown human waste on site, with bacterial action.

In many National Parks such toilets are already in place however there is much research and development involved before we see the use of composting toilets in the urban situation.

Leaks

★ Toilet. To check, put some food colouring into the cistern. If colouring appears in the bowl, you have a leak in between.

How your toilet works

A toilet is designed so that a certain volume of water from a reservoir (called a **cistern**), can be released to the toilet bowl with the push of a button. Figure 00 shows that as the button is pushed, the plug at the bottom of the cistern is raised, allowing the water from the cistern to flow out through a tube to the bowl.

As the water flows out, the float drops opening a valve that is connected to the water pipe that is connected to the toilet. What starts to flow up the refill tube. When the button is released, the plug at the bottom of the toilet closes stopping any further water from leaving the cistern.

As the float rises, the valve is gradually shut off and you can hear the water shut off.

The water from the cistern was used to flush solids and liquids past a leg in the bowl that was a J shape. The shape was designed so that water would stay in the bottom of the J, and act as a trap top prevent sewage odours coming back from the waste water pipes in the house.

Over the years the volume in the toilet has changed. In early days, about 20 litres was considered necessary to flush solids and toilet bowls were designed for this volume. With water conservation now an issue, manufacturers are competing to produce a toilet that can flush with the least amount of water.

A word of caution

If installing a half flush toilet cistern, you need to check to see if the bowl has to be replaced as well

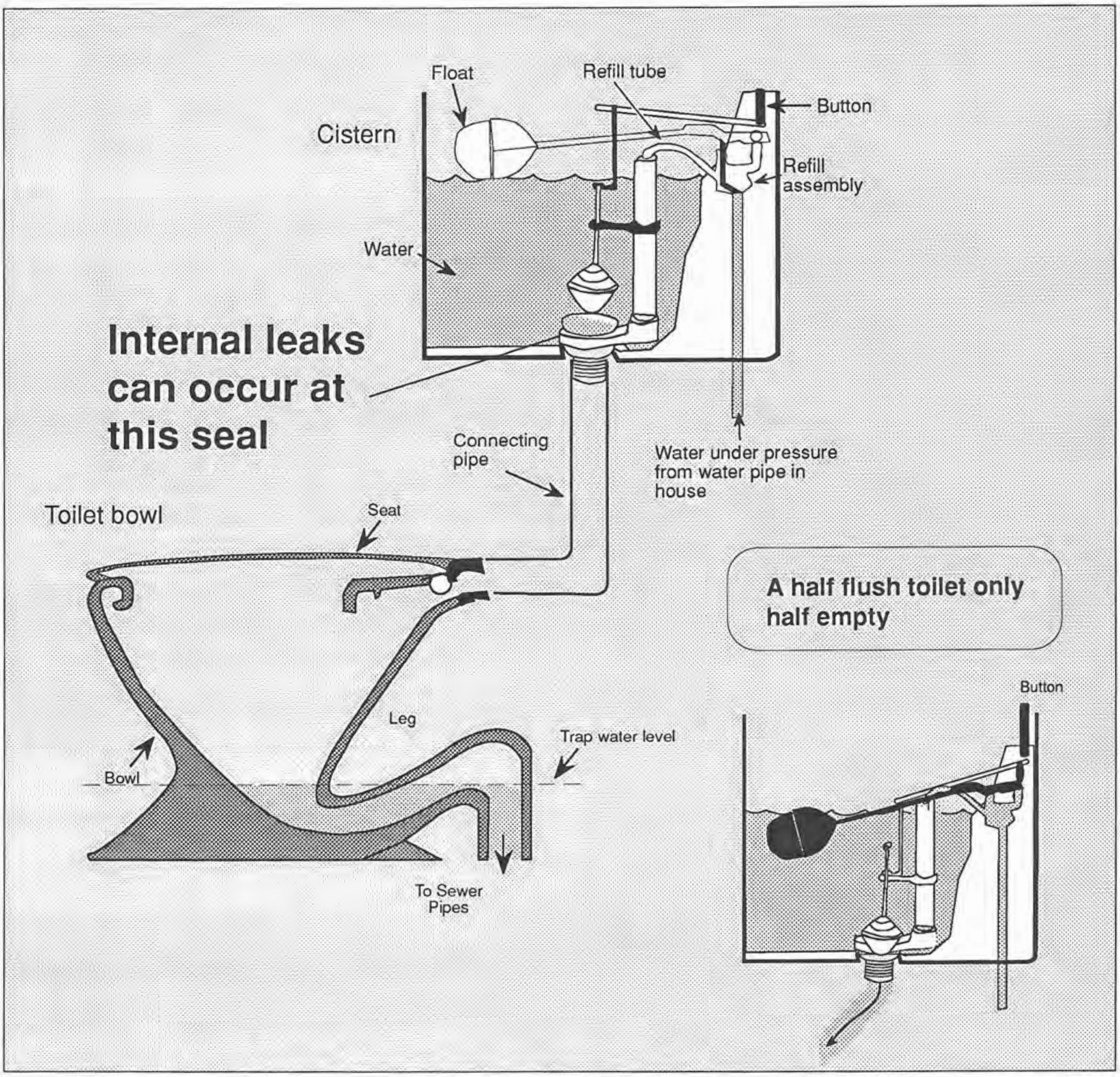


Fig 31 Toilets work by having a flush of water from the cistern to the bowl. The volume of water to empty the bowl can be greatly reduced by the shape of the bowl. Modern toilets can flush with a 6 - 3 litre ratio, however the bowl and cistern must be bought together.

Summary

In the bathroom

- ★ Don't leave the tap running while you brush your teeth or shave.
- ★ A leaking toilet cistern or tap can waste thousands of litres of water a year.
- ★ A water efficient shower head or flow control valve can cut water and energy use in the shower by half.
- ★ Take short showers or baths.
- ★ Check for leaks.
- ★ Don't use the toilet to flush away tissues, wrappers or small scraps.

In the laundry

- ★ Use the low level water setting on your washing machine for small loads. If there is no load adjustment, wait until you have enough washing for a full load. Washing partial loads can waste electricity, water and money.
- ★ Check for leaks

In the kitchen

- ★ Use the dishwasher only when it's full. Washing partial loads wastes water and electricity. Rinse the dishes in a bowl.
- ★ Use a bowl to prepare the vegetables.
- ★ Keep a jug of drinking water in the refrigerator, then you won't have to run the tap to cool it.

Saving water in the garden

★ A forgotten sprinkler can waste over 1000 litres an hour. Use a timer. Manual timers are ideal because they won't even turn themselves on unnecessarily.

★ Avoid watering when it's hot or windy and you'll reduce waste through evaporation.

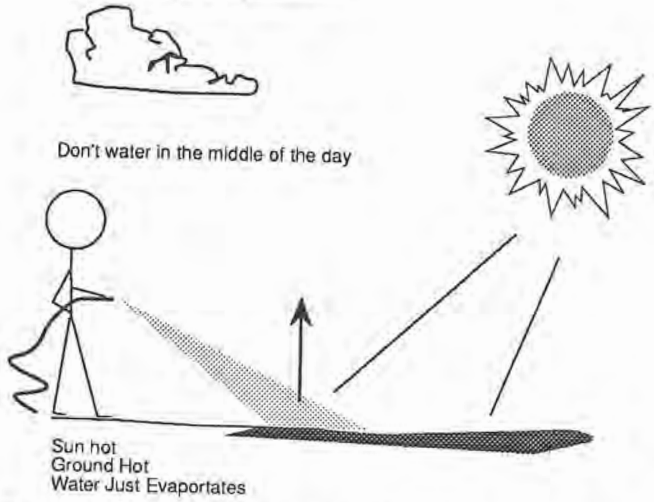


Fig 32 Watering in the heat of the day is a waste of time

★ Mulching can prevent up to 80% of the evaporation loss from the soil.

★ Soak don't spray. While giving the garden a quick drink every night may be good therapy for you, it does nothing for the plants. It makes them shallow rooted and dependent on the meagre amount of water you provide. Most of this water is wasted through evaporation.

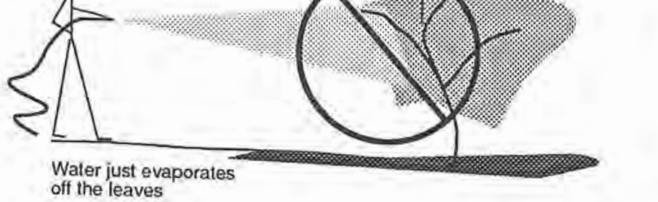


Fig 33 Watering the leaves in the middle of the day is also a waste of time

★ Water your plants every fourth day in summer, but for longer periods. This makes the plants hardier and encourages the roots to go deeper into the soil to seek out moisture. "Train your plant and lawns to be tough" Too many plants are pampered to the point where they are so dependent on you for water they do not go out of their way to find water. Use an indicator species like bamboo as an indicator - when the leaves start to droop, then water.

★ Use a good mulch. Mulches can prevent up to 73% evaporation loss and they are one of the cheapest and easiest ways to make the most of water in the garden. The best mulch is a well rotted compost which will also improve the soil structure. Place the mulch away from the trunk to prevent "collar rot" occurring around the base of the plant.

★ Group plantings make sense. By grouping the plants in the garden into high and low water users, you can design a watering pattern that is better for your plants that don't need it.

★ Remove weeds. Weeds compete for water and nutrient in the garden. Once removed, a good mulch will help stop other weeds taking root.

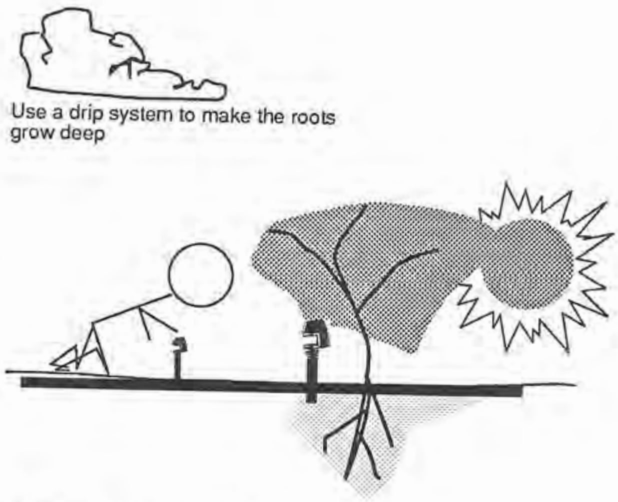


Fig 34 Water the roots not the leaves with drips

★ Install a drip system. This is probably the most beneficial and efficient method of watering your plants. It places the water right where its needed, and its cheap and easy to install. Water the roots, not the leaves. Contrary to popular belief, watering the leaves of trees and shrubs is not beneficial. It just increases water loss through evaporation. In fact, in some circumstances water on leaves on hot sunny days can damage them.

★ Use micro-sprays on garden beds. If you have a lot of annuals or ferns and feel that a drip system is not appropriate, use a micro spray. The water is placed on the garden at a rate the soil can absorb, reducing the water lost as runoff.

★ Catch it if you can. A small trench dug around the tree will give the water a chance to soak into the ground. Install a rainwater tank for garden use.

★ Let the lawn go brown. A lawn uses more water per square metre than any other area in your garden. While your lawn may go brown if not watered during summer, as soon as summer rain comes, the transformation to green is dramatic.

★ If you want a budget green lawn.

- Toughen the lawn with only two waterings per week.
- Give it a feed (but do not over fertilize)
- Aerate the soil

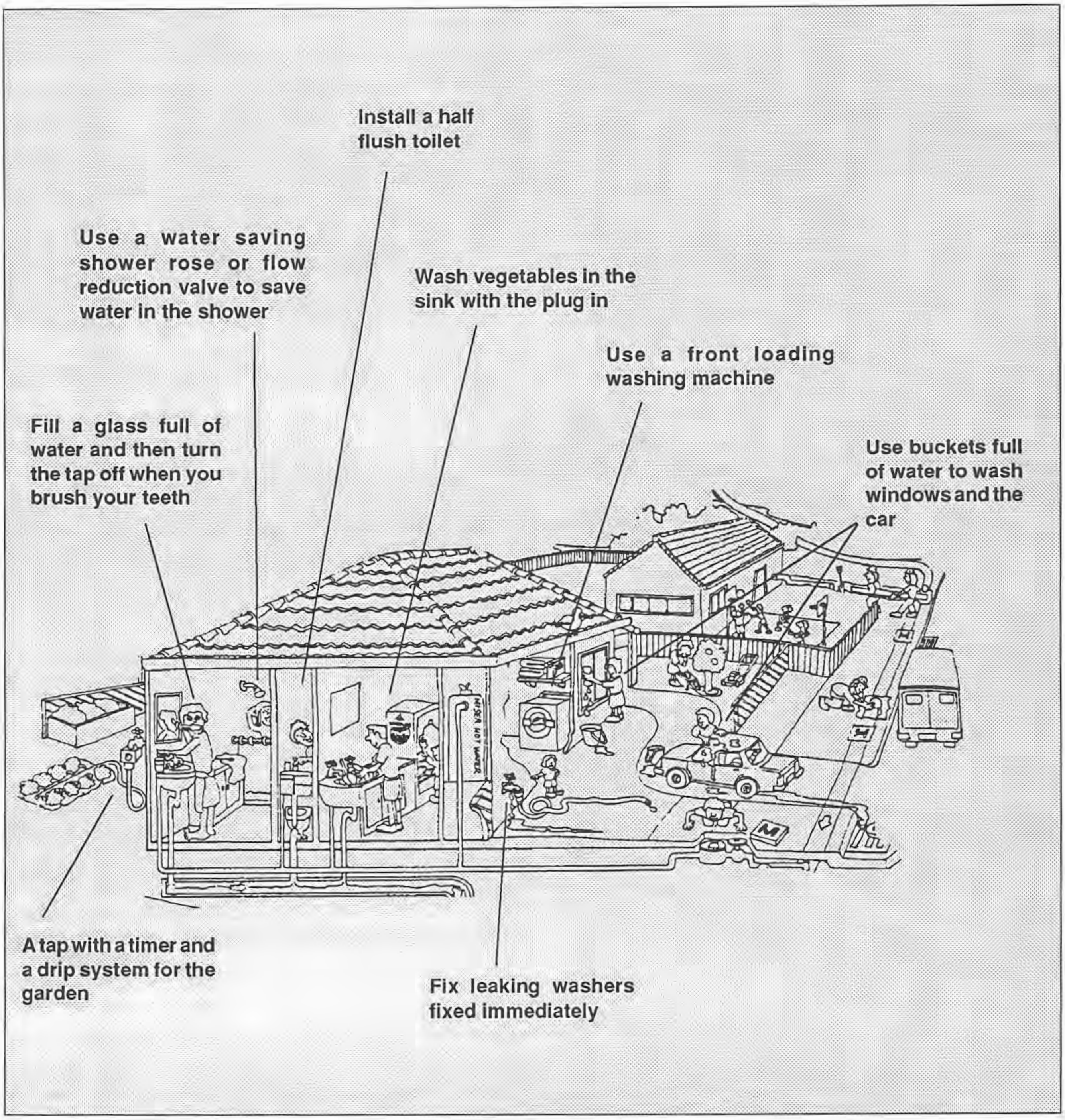


Fig 35 Some water conservation tips

- ★ Hoses are not play things! If you children want to run around the garden squirting water, use water pistols.
- ★ Use a swimming pool cover. Not only will it keep the leaves and children out of the pool, it will reduce evaporation and keep heat in.
- ★ Be careful to water the lawn, not the driveway or street. Design the sprinklers to water the garden and not the concrete. If you want clean paths, use a broom.
- ★ Use a bucket to wash the car and a hose to rinse it.
- ★ Use a trigger hose. This means that you are in control and water is not wasted when moving the hose around. But remember to turn off the tap when finished in case the hose springs a leak.
- ★ Sprinkler days are there to help us keep us all honest. Use the table opposite to determine which days you can use a sprinkler.
- ★ Check for leaks

Saving water in the community

- ★ Turn off drinking fountains and taps in public places.
- ★ Report leaking taps and fountains immediately.

ABC RADIO 91.7 COAST FM Gold Coast City Council

WATER WATCHER

House No.	Sprinkler Days						
	M	T	W	T	F	S	S
Odd		✓		✓		✓	
Even/Un numbered			✓		✓		✓

HOUSEHOLD SPRINKLERS: Banned on Mondays. Hand held hoses may be used at any time. To confirm sprinkler hours PH: 91 9909/31 9310.

Waste water

Some common terms

Sewage	Liquid domestic waste
Sewerage	The pipes and equipment handling the sewage
Aerobic	With oxygen
Anaerobic	Without oxygen
Anoxic	With no free oxygen but with chemical oxygen (chemically bound oxygen)
Clarifier	A settling tank which allows time for solids to settle and scum to float. Scrapers remove the solids from the bottom of the tank.
BOD	Biochemical oxygen demand
Effluent	Treated water flowing out of a treatment plant

What is wastewater?

Wastewater is water from a community of use. In 1979, the Centre for Environmental Research Information in the USA identified that wastewater is actually 99.94% water by weight.

★ They identified the rest - 0.06%, as material dissolved or suspended in the water.

★ The suspended matter is often referred to as "suspended solids" to distinguish it from pollutants in solution.

While "sewage" usually brings to mind human wastes, the term also includes everything else that makes its way from the home to the sewers coming from drains, showers, bathtubs, sinks and washing machines. A generally accepted estimate is that each individual contributes approximately 220 - 275 litres of water each day to a city sewerage system.

Wastewater also comes from commerce, industry, storms or from the ground.

★ Commercial wastewaters from offices and small businesses include both human wastes and water from cleaning or other smaller light industrial operations like photocopier liquids accidentally poured down the sink.

★ Industrial wastewaters may consist of larger volumes of water used in the industrial process like paint thinners, resins, petrol and oil. (Such wastes are prohibited in sewer discharge)

★ Storms wash waste from car parks, backyards, industrial sites into storm water pipes.

★ The ground also can contain toxic wastes dumped from years before that leaches out and infiltrates ground water systems. Seepage also contributes to wastewater where groundwater infiltrates old sewer pipes and adds to the volume of sewage that has to be treated.

Sewer systems

There are three basic types of sewer systems in use to carry waste or storm water.

★ Sanitary sewer systems - a system that carries liquid and water-carried wastes from residences, commercial buildings, industrial plants and institutions together with minor quantities of ground, storm and surface wastes that have been illegally or accidentally connected.

★ Storm water systems - a system carrying water from the roofs of houses and building, carparks, backyards, city streets, parks and gardens, sporting fields, golf courses and industrial sites but excludes domestic and industrial wastewater.

Approximately 220 - 275 litres of water each day to a city sewerage system

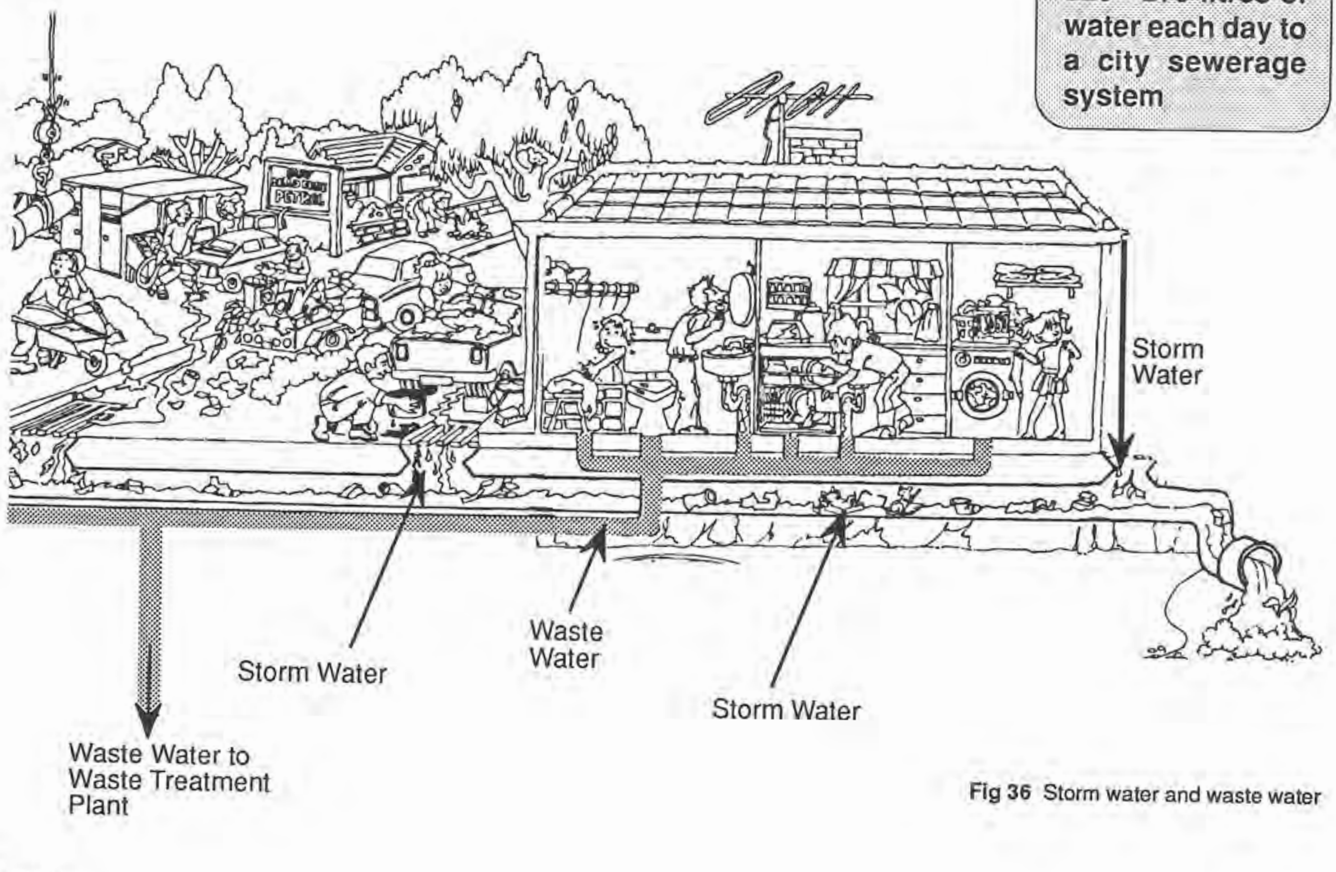


Fig 36 Storm water and waste water

★ Combined systems which receives both waste and storm water

The wastewater components of major concern are those which

★ will deplete the oxygen resources of a water system to which they are discharged

★ will stimulate undesirable growths of plants or organisms such as algae in the receiving of water

★ will have undesirable aesthetic effects

★ will have undesirable health effects on human or animal life

Wastewater pollutants

Waste water pollutants of concern are made up of both organic and inorganic materials. Organic materials contain carbon, so if we take a water sample, evaporate off all the water by leaving it in the sun, and heat off all the carbon in an extremely hot oven (E.g. 550°C), we are left with inorganic materials.

★ The organics in waste water come from both animal and plant kingdoms and the activities of humans who may make new organic compounds such as plastics. Organic materials are usually composed of a combination of carbon, hydrogen, oxygen and in some cases nitrogen. Other important substances such as sulphur, phosphorus and iron may also be present. The US environmental protection association in 1979 identified the main groups of organic substances found in wastewater as being proteins (40-60%), carbohydrates (25-50%) and fats and oils (10%).

★ Inorganics such as sulphides, phosphorus and heavy metals are very important from a pollution standpoint. Mercury for example is a deadly addition to our watery environment. DDT and other pesticides concentrate in the food chain.

Some of the organics and inorganics present in the wastewater exist as suspended matter (i.e. suspended solids) while the rest are dissolved in solution. Most of the suspended matter can be removed by settling the wastewater. The soluble organic and inorganic pollutants require treatment.

Treatment processes

Primary treatment

The major goal of primary treatment is to remove from wastewater those pollutants which will either settle (such as the heavier suspended solids) or float (such as grease).

Plastic bags, needles, rags and wood are removed by bar or rotating screens and burnt or buried. Grease and oils float to the surface of a large tank called a clarifier. Some faecal material settles to the bottom as sludge.

The remaining water usually contains up to 70% of the organic matter. In some areas of Australia, the primary treated effluent is discharged into the ocean. This does not happen in the Gold Coast Region.

Settled sludge is pumped to airtight digesters where it is digested by anerobic bacteria. These are bacteria that live without oxygen and convert the organic matter into methane . This gas can be used as an energy source.

Primary treatment is very similar to the process that occurs in a septic tank. The surface of the tank is sealed by fats and oils creating an airtight environment underneath so that anerobic organisms below the surface can breakdown organic waste.

Primary treatment will typically remove about 60% of the raw sewage suspended solids and if the remainder are released into the environment in small amounts, there is little effect.

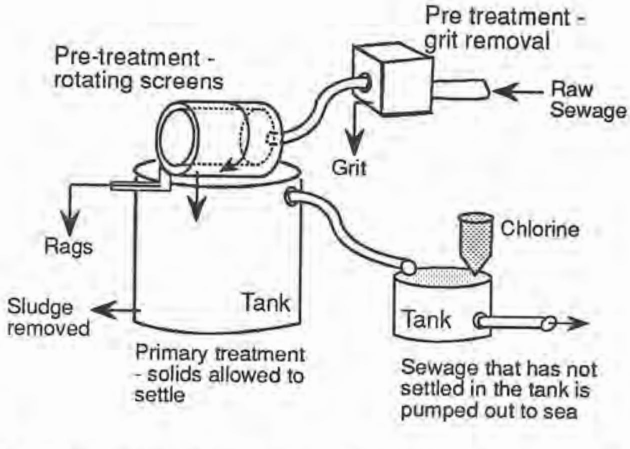


Fig 37 Pre treatment of sewage involves screening and grit removal

However if a large volume of organic matter is released into the water, it provides a rich food supply for aerobic organisms present in natural water. The organisms use oxygen dissolved in the water while digesting this food and deprive other aquatic plants and animals of oxygen. This can cause a problem in inland streams.

Natures secondary treatment sewage system

In a rocky pool or mountain stream oxygen is in abundance. It dissolves in the water from the air and is used by plants and animals to grow.

Animals and plants living in the pond produce wastes which settle out in the mud at the bottom of the pond. Ducks, birds and other aquatic life around the pond also produce wastes which wash into the pond.

Living in the pond and at the bottom are bacteria and small single celled animals called **protozoans**. Collectively they

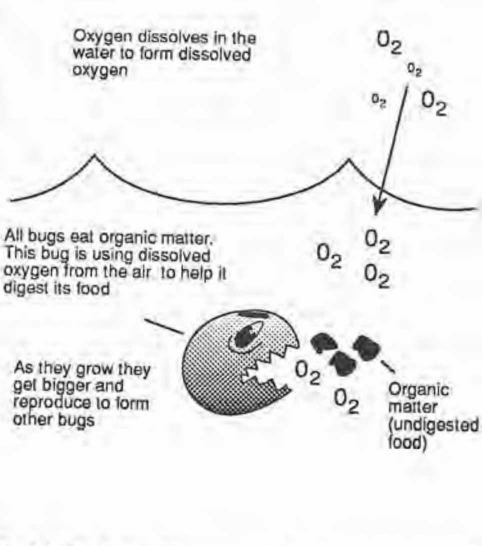


Fig 38 Bacteria and microscopic plants and animals eat organic matter

make up what we could call the **decomposer bugs** which take out the organic matter and nutrients.

These bugs play a vital role in the recycling of nutrients in the pond. Part of their role is to keep the levels of nitrates and phosphates to a level that maintains a good quality of water for animal and plant life.

To do this they require oxygen and so a relationship develops between the amount of available oxygen required by the bugs and the amount of food (in the form of waste) that has to be processed. Obviously the more food that has to be eaten the more oxygen will be required.

In the pond the bugs use oxygen dissolved in the water. In the mud, the bugs extract the oxygen from nitrates and release nitrogen into the air. In certain circumstances, other bacteria can absorb phosphorous into their bodies.

Single and multicelled animals like worms, eat these bacteria and so take in the nitrogen and phosphorus into their bodies. These worms are eaten by crabs and other mud life which move around in this muddy environment. These in turn are eaten by fish feeding off the bottom which in turn are eaten by bigger fish further up in water column. When these fish die, urinate or deficate, the cycle starts again. This is summarised in Figure 39.

So the bottom of a pond filled with microorganisms or sea-bed covered by seagrasses and similar microorganisms, contains natures nitrogen and phosphorus recycling treatment plant.

Secondary treatment - learning from nature

On land, we collect and concentrate our waste in a system of pipes called a **sewerage** system.

In a sewerage system, pipes from the toilet, shower, sink etc., of each house collect to form one pipe which goes into the sewer main. Primary treated sewage contains up to 70% organic matter.

If the bugs that live in nature can be made to eat this organic matter

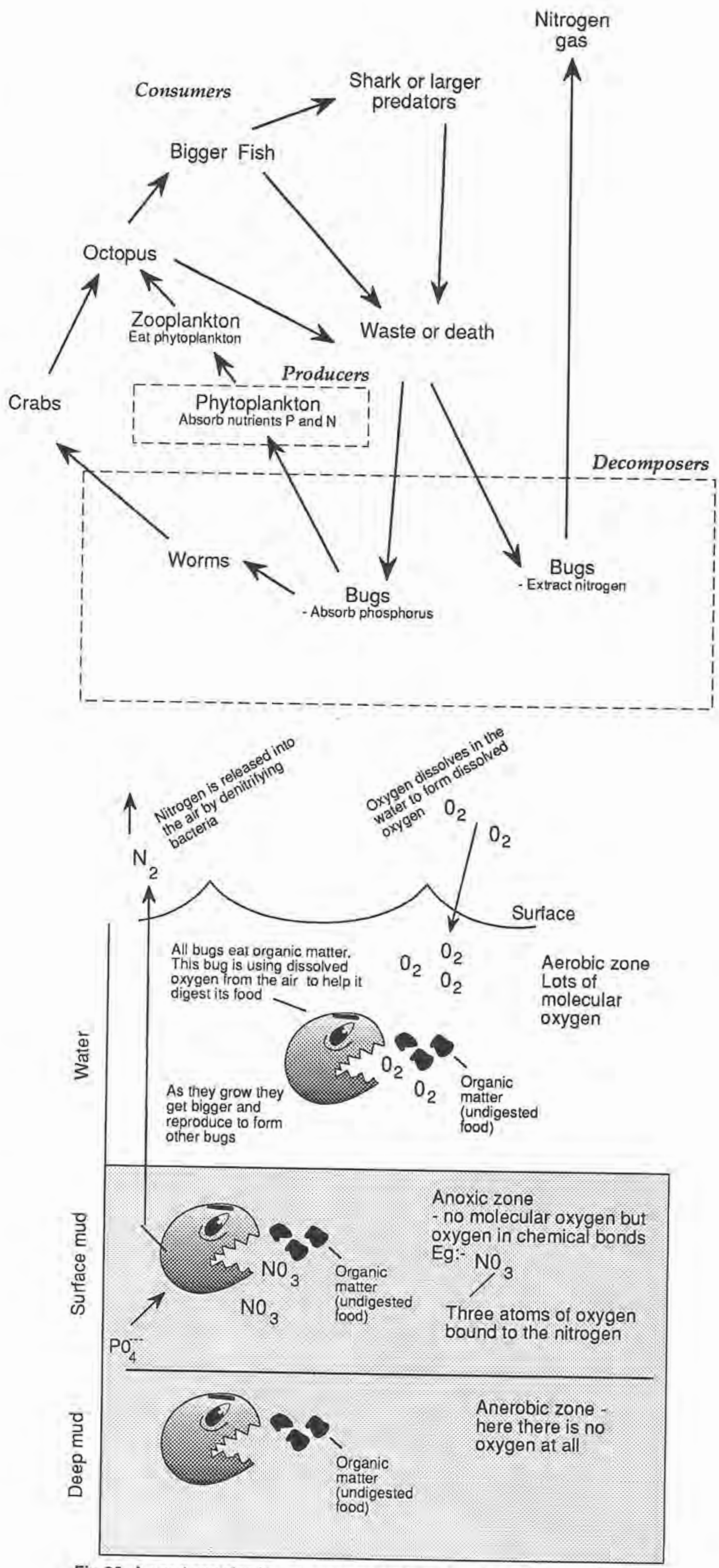


Fig 39 A pond contains its own sewage system involving bugs removing wastes and keeping "pollution levels" down

and sink to the bottom we will have replicated a naturally occurring process.

We can measure how much oxygen is needed for this to occur (i.e. to oxidise this material).

Biological oxygen demand BOD

The **Biochemical Oxygen Demand** or BOD and is the amount of oxygen that a litre of waste water requires to keep the bugs alive.

If a stream has little organic matter the BOD will be low. BOD values of 0-3 mg/L would indicate very little organic matter and a unpolluted stream.

The BOD is taken over a period of five days in the dark at 20°C and allows different wastes to be compared. A litre of clean river water requires a maximum of 5 ppm or 5 mg/litre to oxidise the organic matter completely. This leaves 4 mg/litre for fish and other life to survive. Some typical BOD levels are given below

- Clean river water ....<2 mg/L
- Fish in a pond......... >5 mg/L
- Untreated sewage .... 350 mg/L
- Waste from breweries .... 550 mg/L
- Waste from oil refineries 850 mg/L
- Waste from abattoirs ....2650 mg/L
- Pulpmill wastes .... 25,000 mg/L
- Milk ....100,000 mg/L

Milk has a BOD of 100,000. So if we take a litre of milk and pour it into a litre of water, we would have to bubble 50,000 mg/Litre of oxygen into the solution to keep the fish alive.

So any waste that requires >5 mg/L of BOD requires treatment before release into waterways or fish will be seriously effected.

BOD and aquatic life

Biological Oxygen Demand is critical to the survival of fish and other organisms in the sea or river.

Consider a wave washed pool with clear, sweet smelling seawater. Sea anemones and brightly coloured fish abound. If a litre of water is taken from the pool it will contain bugs and fish. The bugs are bacteria or single celled animals called protozoans.

A litre of water from a pool such as this typically contains 9 milligrams of oxygen dissolved in the water. This can be abbreviated as 9 mg/L.

Once the oxygen is depleted, the animal forms die so the challenge of sewage treatment is to make sure that little organic matter remains in the water after treatment.

Secondary treatment breaks down the suspended solids and dissolved organic matter (measured as BOD). Secondary treatment is a biological process in which, under carefully controlled situations, naturally occurring microbes or "bugs" stabilise the organic material by using it as a food source.

Secondary treatment breaks down the suspended solids and dissolved organic matter (BOD) by combining sewage with activated sludge.

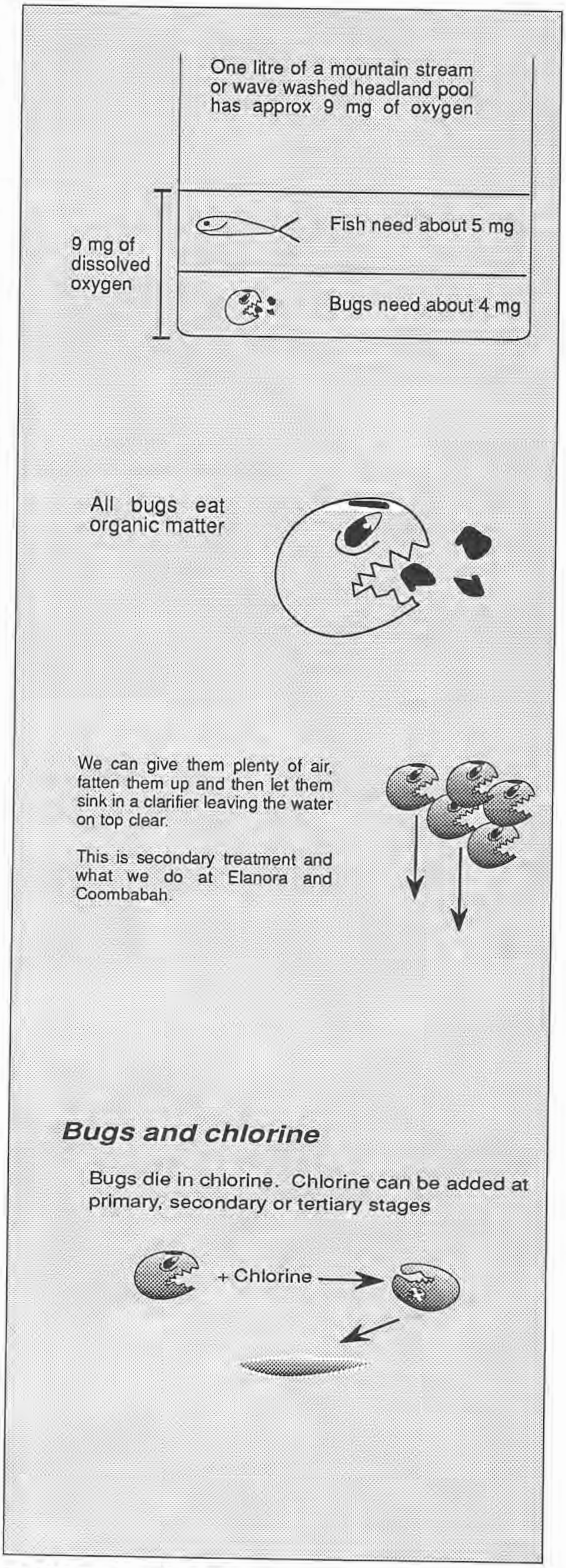


Fig 40 Bugs and their effects

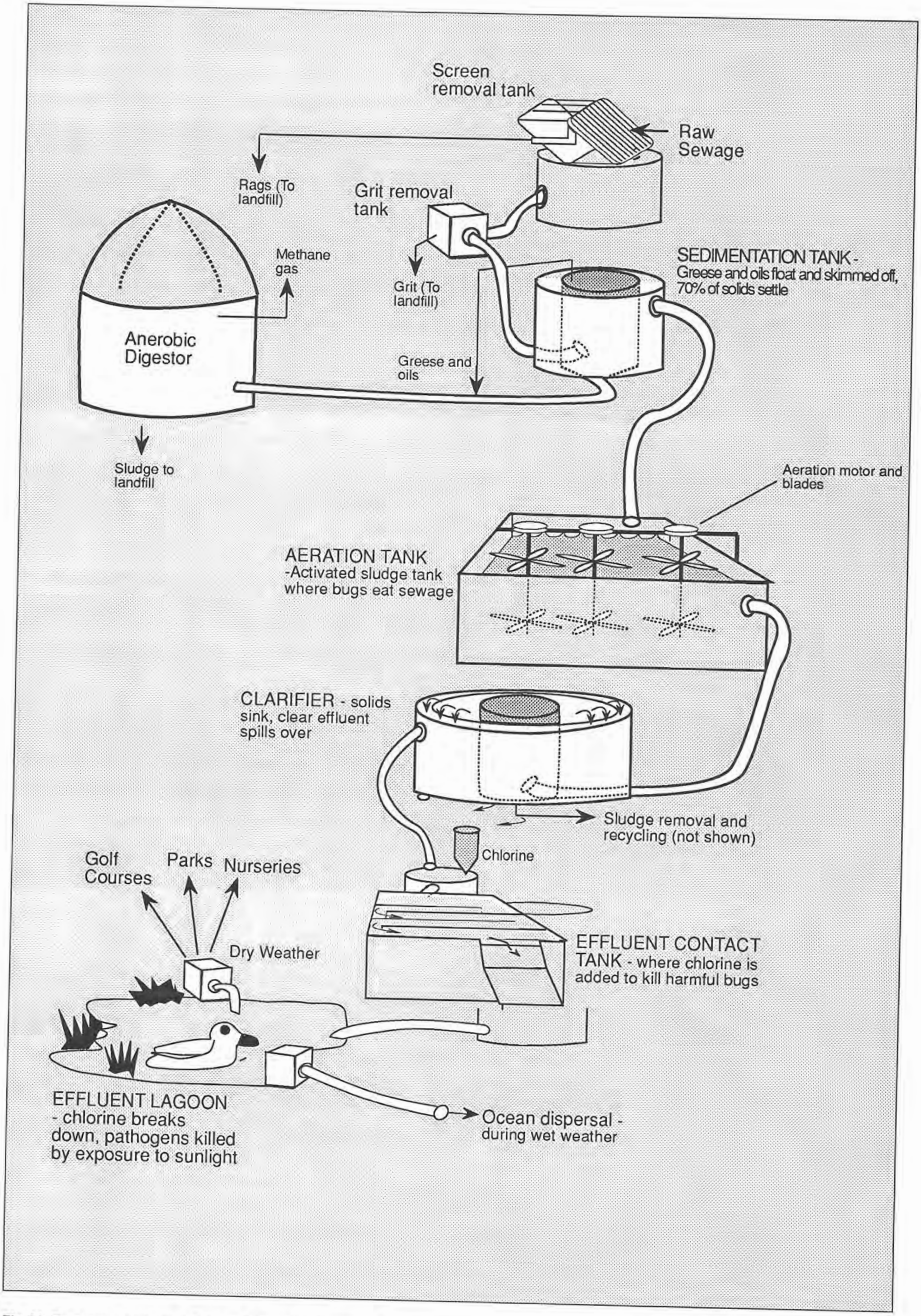


Fig 41 Treatment process at Elanora Waste Treatment Plant

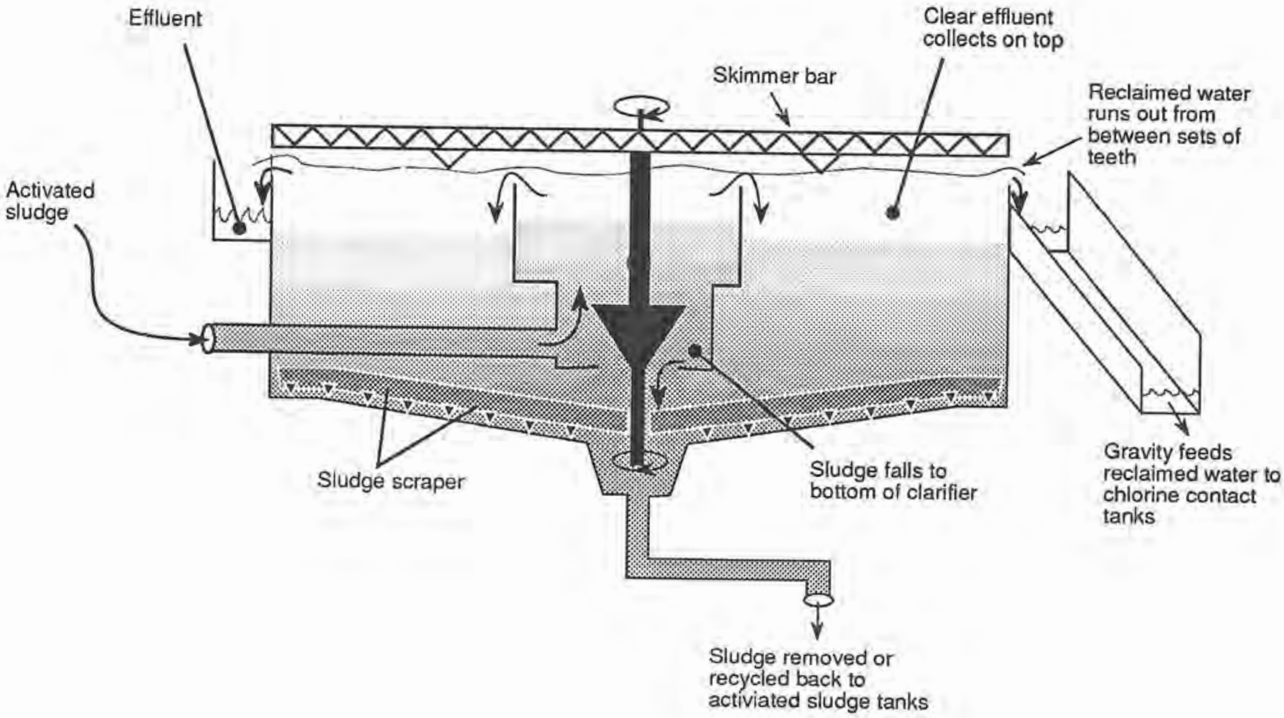


Fig 42 A sewage clarifier - can be used at primary or secondary stages

Activated sludge

Activated sludge is aerated sewage sludge containing protozoa and bacteria which can digest the organic matter in the sewage.

The primary treated sewage is mixed with activated sludge to provide a continuing food source for the bugs.

The micro-organisms breakdown all of the complex proteins, carbohydrates and some fats into simple soluble compounds, mainly nitrates and phosphates.

Some treatment plants discharge the effluent at this stage after chlorinating the effluent.

Tertiary treatment

Tertiary treatment is difficult to define because tertiary treatment plants can be designed to create a situation where bacteria utilize the nitrate and phosphate after secondary treatment. In some plants this can be done in two stages:

Stage 1. Decrease the dissolved oxygen to zero.

The secondary treated sludge now enters a section where no oxygen is added. There is however oxygen still bound up in the nitrate $N0_3$ ions. Where O_2 is bound chemically like this, an anoxic situation is said to occur.

In this anoxic section bacteria seek oxygen from nitrate forming nitrogen as a by-product. This nitrogen is in the form of a gas and bubbles off into the atmosphere.

Stage 2. Raise the oxygen levels up from zero to a critical level and add food

In this situation, the bacteria absorb phosphate through their outer membranes to form long chains of polyphosphate inside their bodies. The bacteria now can be settled out in the clarifier.

Phosphate and nitrates

Tertiary treatment removes the nutrients phosphate and nitrate.

★ Most phosphates come from the breakdown of protein in faecal material. Some Phosphate nutrients in sewage are the tripolyphosphate ion P_30_{10}. from detergents. This breaks down to phosphate PO_4 ions.

★ The nitrogen nutrients exists as either Nitrate (NO_3^-) or Nitrite ions (NO_2^-).

Clarification

This can be used at any stage. All a clarifier does is to provide an environment where bugs can settle leaving the re-claimed water on top. How well this water is reclaimed depends on to what stage the treatment is taken.

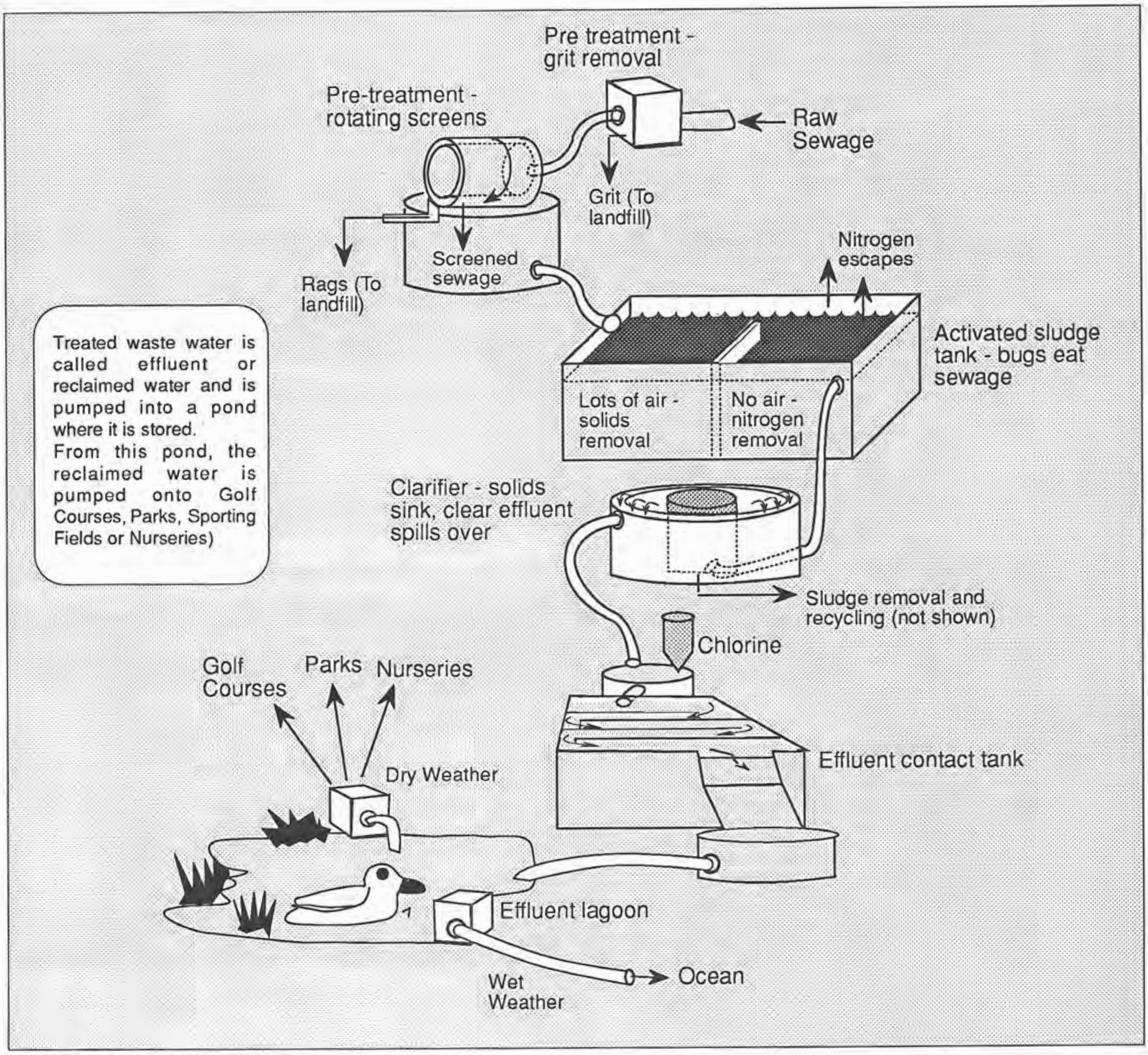


Fig 43 Simplified Coombabah overall process diagram

Disinfection

Effluent from either primary, secondary or tertiary treatment can be chlorinated to kill bacteria prior to discharge into natural waters. So as to reduce the risk of disease the effluent is dosed with chlorine. This is passed to an effluent lagoon where the chlorine is allowed to breakdown. Methods other than chlorination are presently being evaluated.

Use of the sludge

If tertiary treatment is used, the phosphorus would be contained in the sludge and could be removed to form a peat like substance where water can be removed. Mixed with sawdust it could be sold as fertilizer.

Ponding

The disinfected effluent is then allowed to settle in the effluent lagoon. Here chlorine breaks down in sunlight. Sunlight also helps to kill viruses (U-V treatment) and bacteria. Treated waste water is also called reclaimed water and is pumped into a pond where it is stored. From this pond, reclaimed water is pumped onto Golf Courses, Parks, Sporting Fields or Nurseries)

Disposal of effluent

Disposal by land

The effluent in the lagoon makes excellent irrigation water and fertilizer for golf courses, parks, gardens and sporting fields. It is from the effluent pond that golf courses, sporting fields, nurseries, parks and gardens install their pumps to draw off this water. At present the user pays for this and maintains all equipment.

If all organic material, dissolved phosphate and nitrate nutrients are removed and chlorinate we have reclaimed nearly all the water we started with.

If these nutrients are removed and this water then pumped to the Gold Coast hinterland allowing it to percolate through the catchment areas it should end up back in the dam in basically the same state as it was when it fell out of the sky. All we have done is to eliminate the cloud phase. However the golf courses, parks and gardens, sporting fields and nurseries

The Coombabah carousel system

1. Intake point - raw screened and de-gritted sewage enters carousel under pressure
2. Sewage is aerated by paddle wheel
3. Aerobic digestion by bugs occurs
4. First anoxic zone
5. Anoxic conditions prevail, bugs are now eating the nitrates and nitrogen escapes in the atmosphere
6. Bugs get a re-burst of oxygen to make then eat more organic matter
7. Aerobic digestion occurs, bugs increase in size
8. Second anoxic zone begins, bugs now seek oxygen from nitrates and more nitrogen released into the atmosphere

Summary

1. Primary treatment removes
   (a) solids - parts of toys, rags, grit, rings, plastics etc.
   (b) complex and insoluble compounds - grease, oil, fats etc
2. Secondary treatment removes
   (a) suspended solids - colloidal particles
   (b) soluble organics (BOD) i.e. the faecal materials
3. Tertiary treatment removes
   (a) soluble nitrogen compounds (Converts nitrate to nitrogen gas)
   (b) soluble phosphate compounds (converts $P0_4$ to polyphosphate which gets incorporated in the bugs bodies)

The difference between Elanora and Coombabah

Elanora, Merrimac and Coombabah use different combinations. Elanora uses 1a, 1b, 2a and 2b, while Coombabah is slightly different and uses 1a, 2a, 2b and 3a.

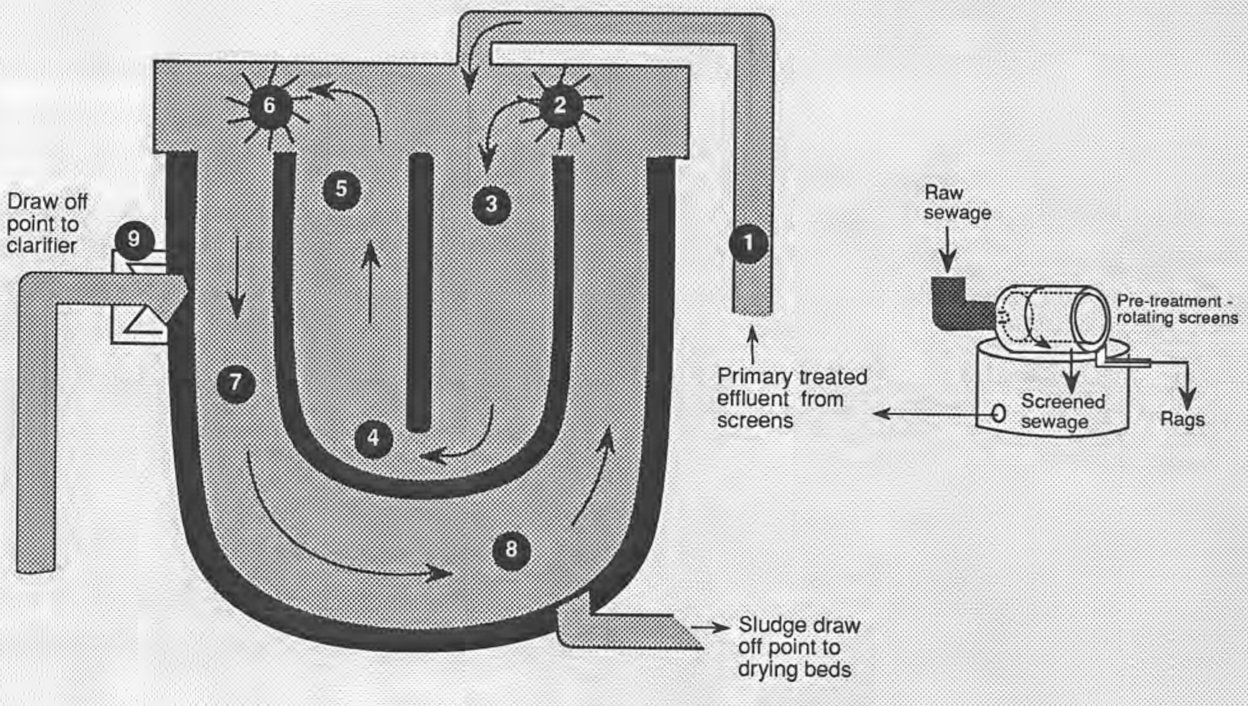


Fig 44 The Coombabah carousel

would then have to add artificial fertilizers to raw water that was treated or rely on dams close by.

Discharge of unused effluent into the sea

Phosphate levels in the effluent pond average 6 mg/L. Nitrate levels in the lagoon average 4 mg/L. Effluent containing these concentrations is pumped to the seaway when the tide is going out and stops one hour before the tide comes in. Mixing occurs in the body of water directly in front of wave break island and in the seaway channel.

Dilution rates

On average, results from two studies over the past 6 years have shown that the following are acceptable values to the Department of Environment and Heritage. This is also based on volume calculations of oceanic waters which all indicate that 1 Litre of effluent mixes with 200 Litres of seawater.

Phosphates dilute on average by 1/200

For example based on this dilution figure values of 6mg/L in the effluent pipe would dilute to:-

At the end of the seaway .03mg/litre

Nitrates dilute on average by 1/200

For example based on this dilution figure values of 4mg/L in the effluent pipe would dilute to:-

At the end of the seaway 0.02 mg/litre

Reclaimed water that is not used on land, is pumped out the seaway from a pipeline that enters the seaway in the North Wall. From here the reclaimed water dilutes with seawater which in turn will evaporate to form clouds and the cycle is repeated.

At present reclaimed water from Merrimac Waste Treatment Plant is pumped into the Nerang River. Reclaimed water from Elanora Waste Treatment Plant is pumped into the Tallebudgerra Creek which flow out at Burleigh Heads. By 1993, the new effluent pipeline will connect these two and pump the reclaimed water in wet weather out into the seaway as shown in Figure 45.

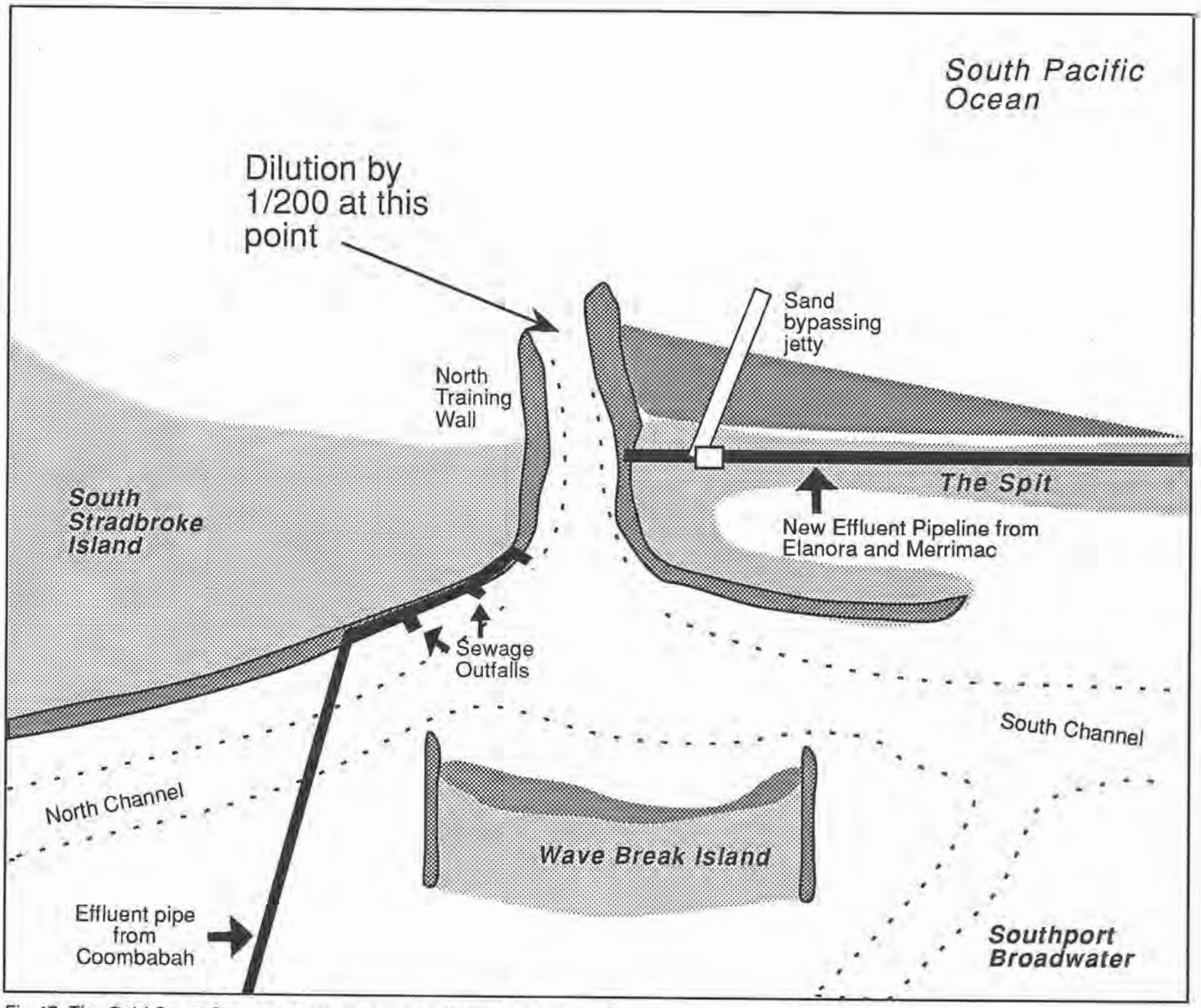


Fig 47 The Gold Coast Seaway and how sewage effluent is discharged

Pollution levels

To gain some appreciation of water quality, we must refer to some type of environmental standards. Two American researchers, Stapp and Mitchell, have presented their results as follows. (See Figure 53, Page 46 for information about these researchers). A pollution index called a Q value, is established to measure water pollution. Q Values are used as follows to indicate pollution levels:-

- 80 -100 indicate excellent water
- 60 - 80 good
- 40-60 poor
- 0-40 very poor

For example, a value of 4 mg/L of phosphorus rates about 15 on the table and 5mg/L about 70 on the tables below. Once diluted to values under 1mg/L, water quality is considered excellent.

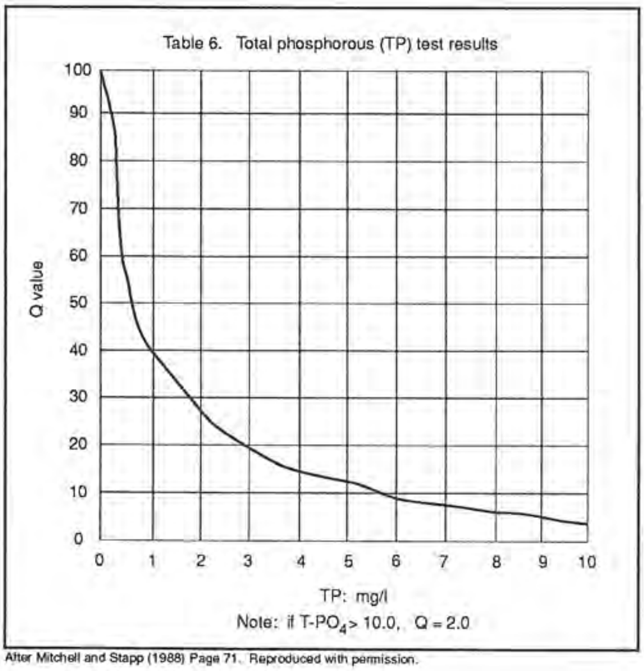


Table 6. Total phosphorous (TP) test results

After Mitchell and Stapp (1988) Page 71. Reproduced with permission.

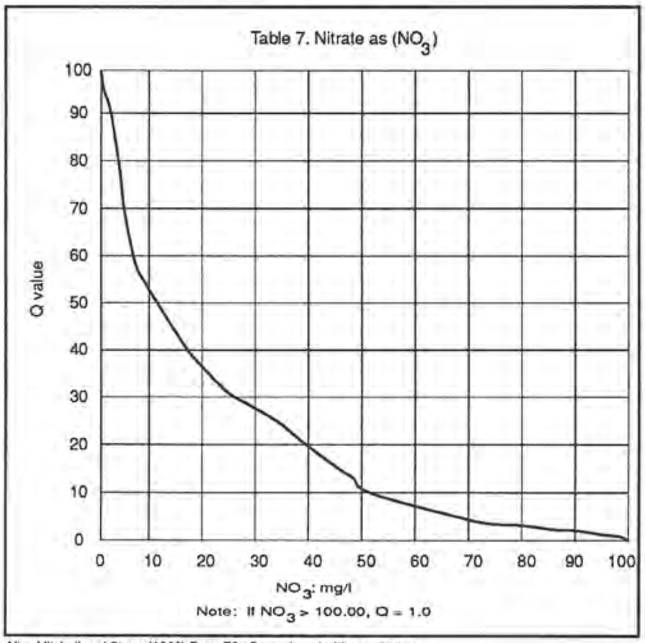


Table 7. Nitrate as (NO_3)

After Mitchell and Stapp (1988) Page 72. Reproduced with permission.

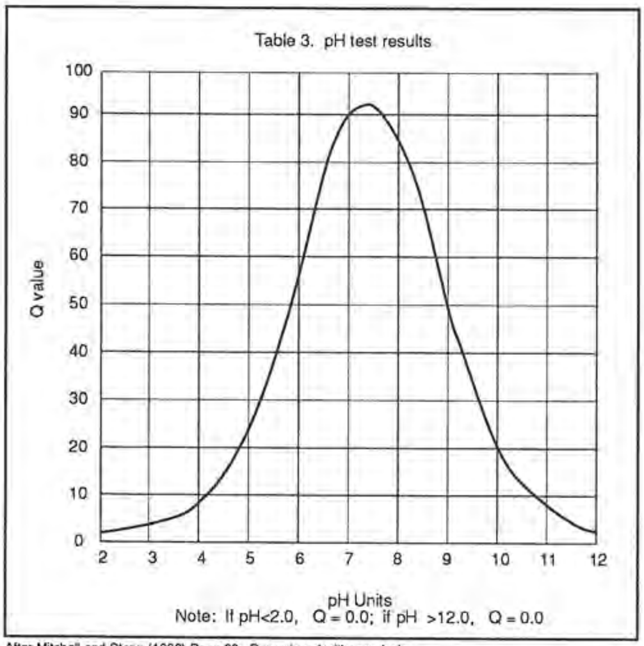


Table 3. pH test results

After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

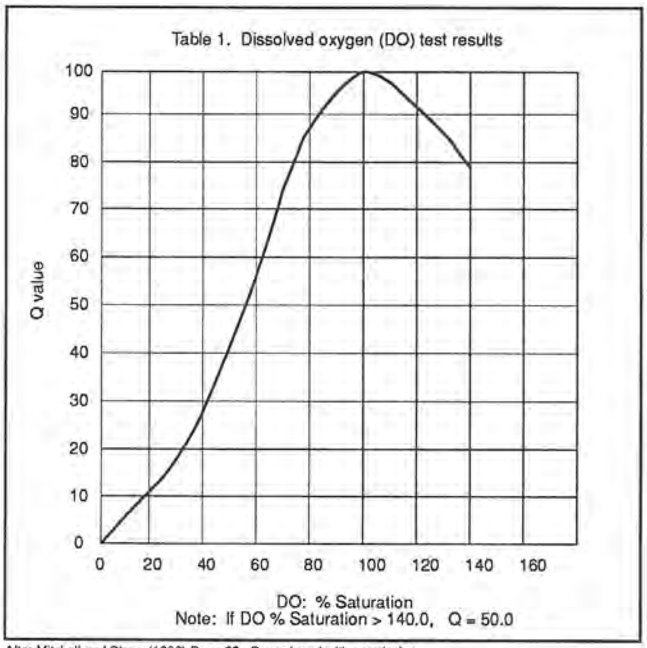


Table 1. Dissolved oxygen (DO) test results

After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

Fig 46 The pollution level tables of Mitchell and Stapp provide a useful guide to pollution levels (Reproduced with permission)

Storm Water

Ideally, storm water should pass through small wetland areas before entering rivers or the sea, so that most of the pollutants could decompose prior to discharge into natural waters. However at present there is no treatment of storm water on the Gold Coast apart from gross screening traps at major pipe intakes in the catchment area.

Whatever we drop on the ground and whatever fluids we allow to be deposited on streets or footpaths washes down the storm water pipes and out into the sea.

It is the responsibility of all who use this sub-catchment to be responsible using this knowledge.

Some storm water pipes enter beach areas. In this case after heavy storms, any rubbish from carparks or the street will get washed onto the beach. Faeces from domestic pets will also be washed onto the beach and into the surf effecting the water quality for beach and surf users.

Compared to other parts of Australia, the Gold Coast coastal catchment would have one of the cleanest coastal zones of all.

Paper and rubbish is continually picked up by council workers called walkers. Beaches are cleaned regularly by beach cleaners. It is up to local residents to help by making sure rubbish doesn't enter drains that lead to the sea and by supervising pet behaviour as outlined below. Our tourist industry depends on clean seas.

Faecal coliforms and water

Faecal coliforms are bacteria derived from the faeces of humans and other warm blooded animals. These bacteria can enter rivers through direct discharge from mammals or birds, from agricultural or storm runoff carrying bird or mammal wastes or sewage discharge into the water.

These are microscopic bacteria which in themselves are harmless, but signify that there may be other harmful bacteria present such as those causing gastroenteritis, dysentery, typhoid

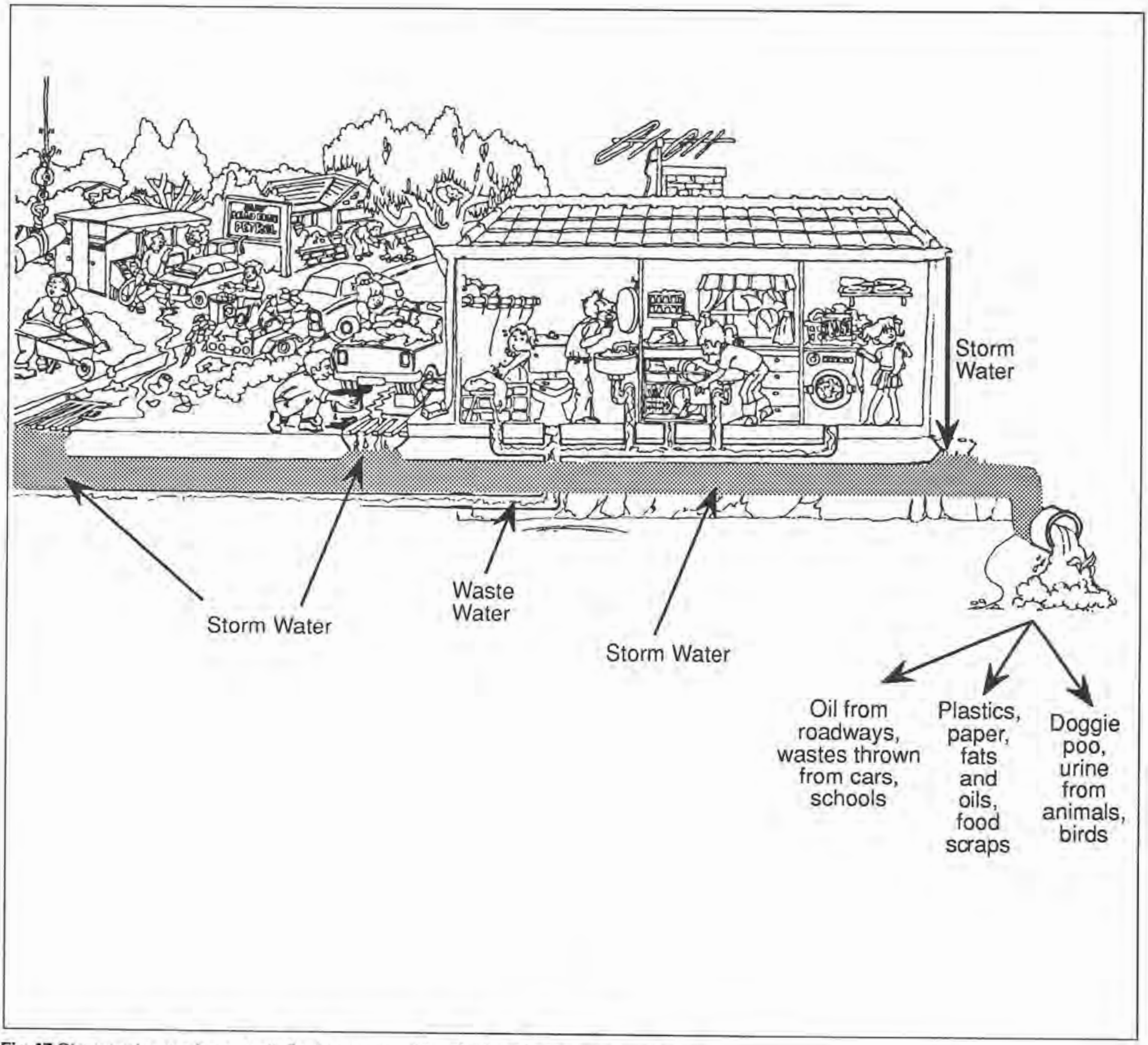


Fig 47 Storm water can be potentially dangerous with attitudes of poor catchment users

fever, hepatitis or outer ear infections. The standards for these bacteria are summarised in Figure 51. Faecal coliform counts are also used as indicators of water quality as shown in Figure 52. The standard taken from the book and information in Figure 53.

A test for coliforms

The aim of this test is to count the number of colonies present in a 100 ml sample of water. This is done firstly by trapping them in a filter and then growing them under controlled conditions in a petri dish. The bacteria grow and multiply into colonies like those shown in Figure 48.

Method

The kit and procedure described here is the Sartorius membrane filter method which involves trapping the bacteria in a filter and then culturing colonies on a nutrient pad set.

The Nutrient pad sets include a sterile petri dish, nutrient and membrane filter. The filter pores are small enough to trap the bacteria but big enough to let the water through. All equipment is sterilised otherwise more faecal coliform colonies than are actually present will result and inaccurate results obtained.

When all equipment has been sterilised, the water sample is added as shown in Figures 47 and 48.

Petri dishes are then incubated at 37°C for 24 hours within 30 minutes of filtering the sample. After incubation the colonies are counted.

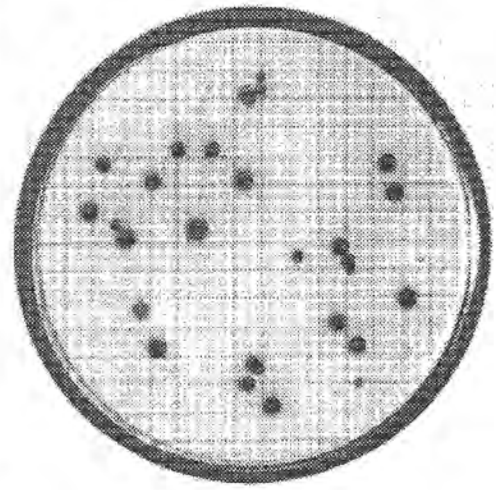


Fig 48 E. coli bacteria colonies growing on a special nutrient medium. The number of colonies that grow are a measure of the pollution level of water

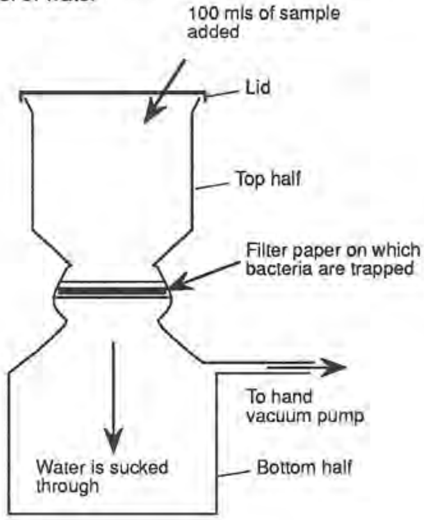


Fig 49 Membrane filter set

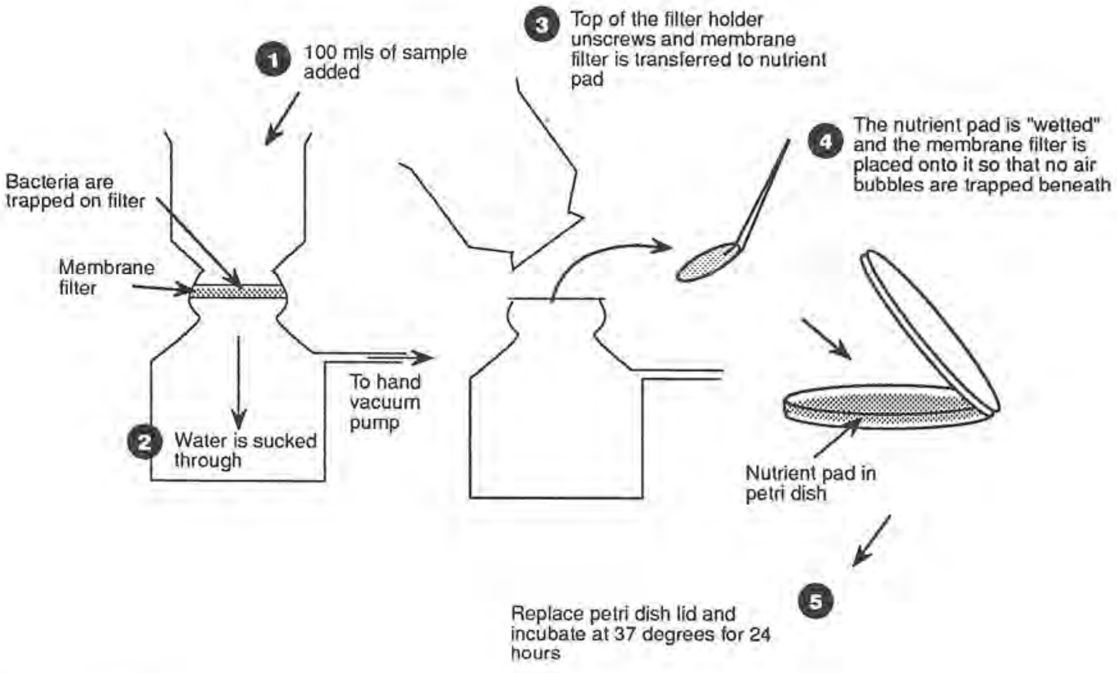


Fig 50 Using the membrane filter set

What values are of concern?

The table opposite gives an indication of the acceptable values for water.

Storm water drains can become clogged and produce quite high levels of coliforms. In such cases, the source of the coliform pollution can be traced and the drain cleared.

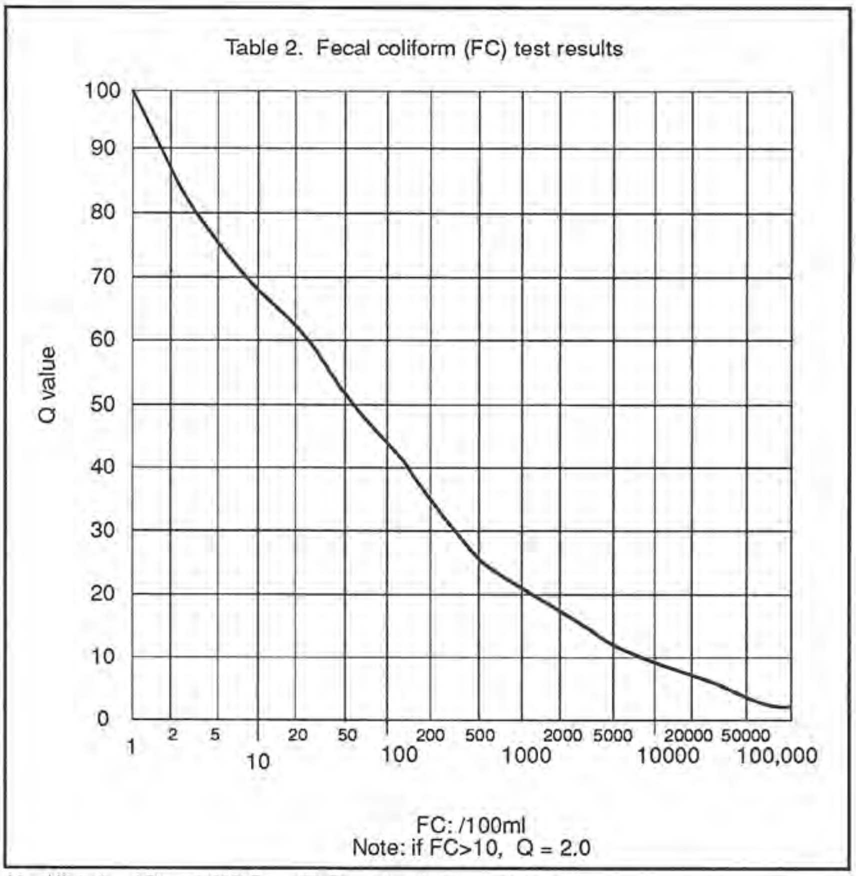
If there has been an illegal connection, local authorities have the power to prosecute and there are many by laws referring to pets in catchment areas.

On the Gold Coast, it is mandatory to carry a "pooper scooper" if you walk your dog. Its a really simple task and it helps prevent coliform numbers increasing.

On surf beaches, there are areas clearly marked, where dogs are prohibited for this reason also.

Plastic bags that blow into the sea contribute to many turtle deaths. Plastic lids from drink bottles also can choke dolphins and whales.

The care of our catchment is a community responsibility and should be shared by all.



After Mitchell and Stapp (1988) Page 67. Reproduced with permission.

Fig 51 Pollution table indicating Q values for bacteria pollution levels

Faecal coliforms	Safe colony numbers
Drinking water	1/100 ml
Swimming/ Surfing	200/100 ml
Boating/ Fishing	1000 / 100ml
Treated sewage effluent	No more than 200 / 100 ml

Data supplied Dept of Environment

Remember its not the coliform colonies that are harmful, its the indication that other more harmful pathogens can be present and alert the water control officer to begin serious testing for these.

Fig 52 Values set by health standards on coliform counts

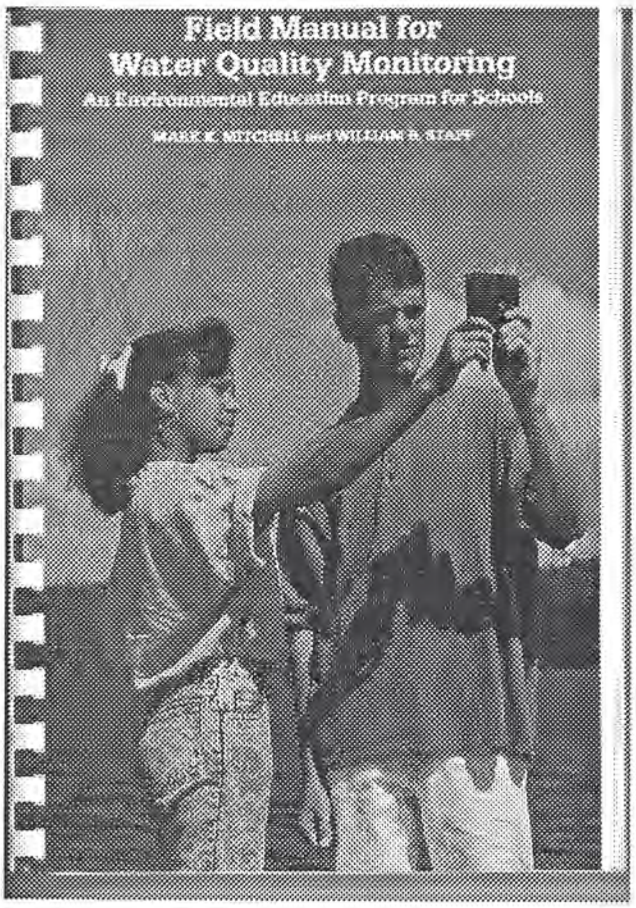


Fig 53 The reference used in this section is the Field Manual for Water Quality Monitoring, by Mitchell and Stapp, and is used in many Queensland and New South Wales schools as part of pollution studies. Copies from WB Stapp, 2050 Delaware Ave, Ann Arbour, Michigan, USA, 48103 $10 US + pack and post.

Part B

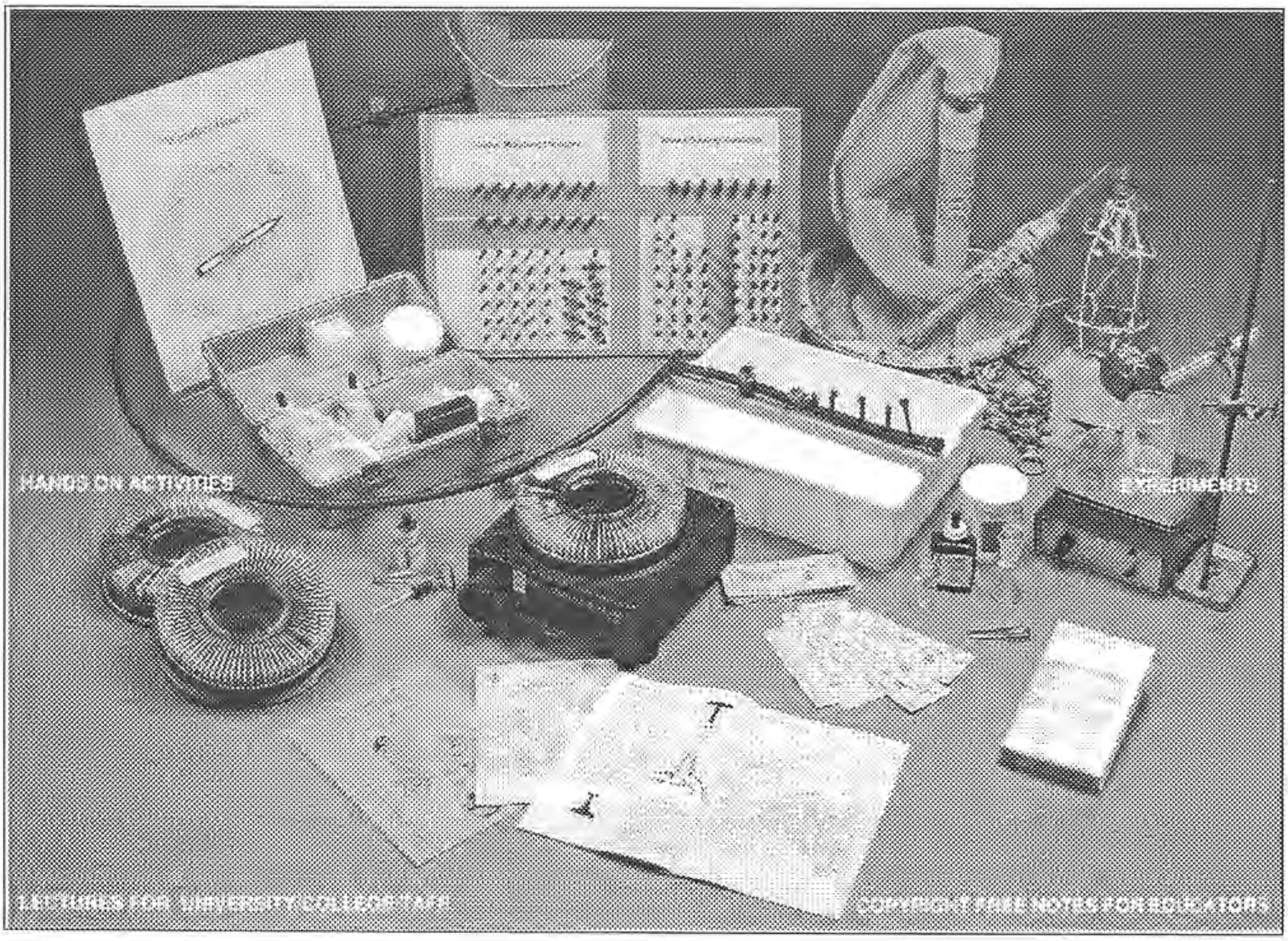
Classroom Activities

Lesson Plans
Lectures
Excursions
Demonstration Lessons

Upper Primary

Lower Secondary

Upper Secondary



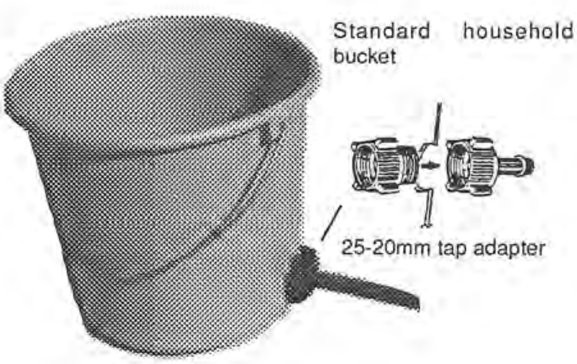
Upper Primary/Lower Secondary Equipment

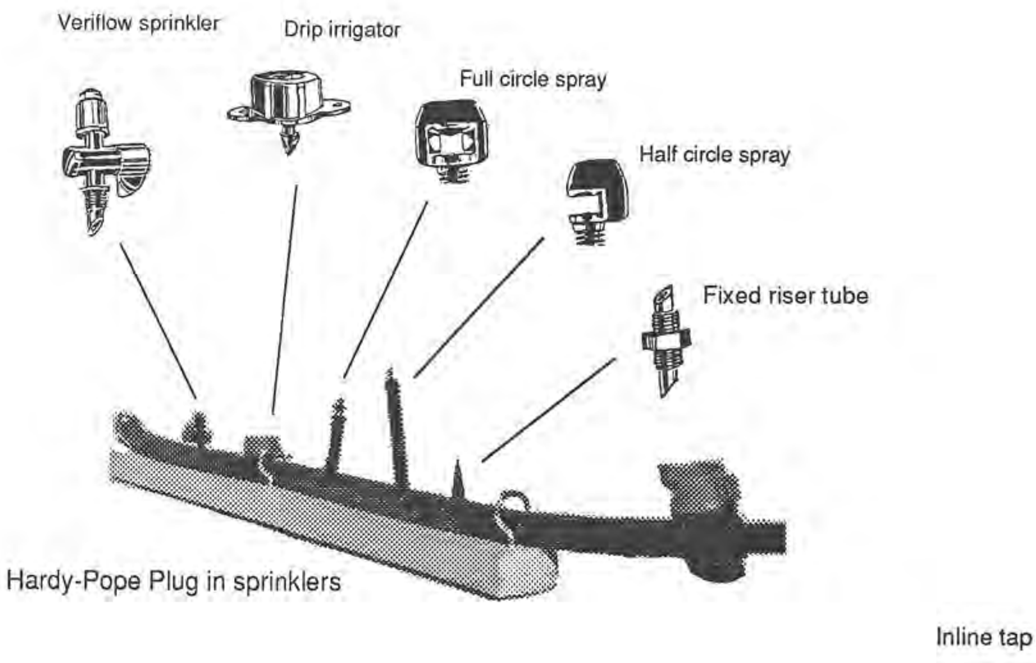
Materials required

The materials you will need are....

★ A flat concrete area where water can be split
★ About ten meters of black plastic irrigation system pipe
★ Several plug in sprinklers (ideally one for each member of the class.)
★ A nine litre bucket and
★ 25 to 20mm tap adapter to screw into bucket as shown right
★ 20mm drill to make hole in bucket
★ Cardboard to build model houses from their nets
★ A hose connected to the water supply
★ Plus additional materials for extra optional activities

All the activities relate back to the construction of a dam to supply town water to a community. In the process the class builds a model of the water supply system by using a domestic sprinkler system to represent the mains water supply as shown in the figure below.



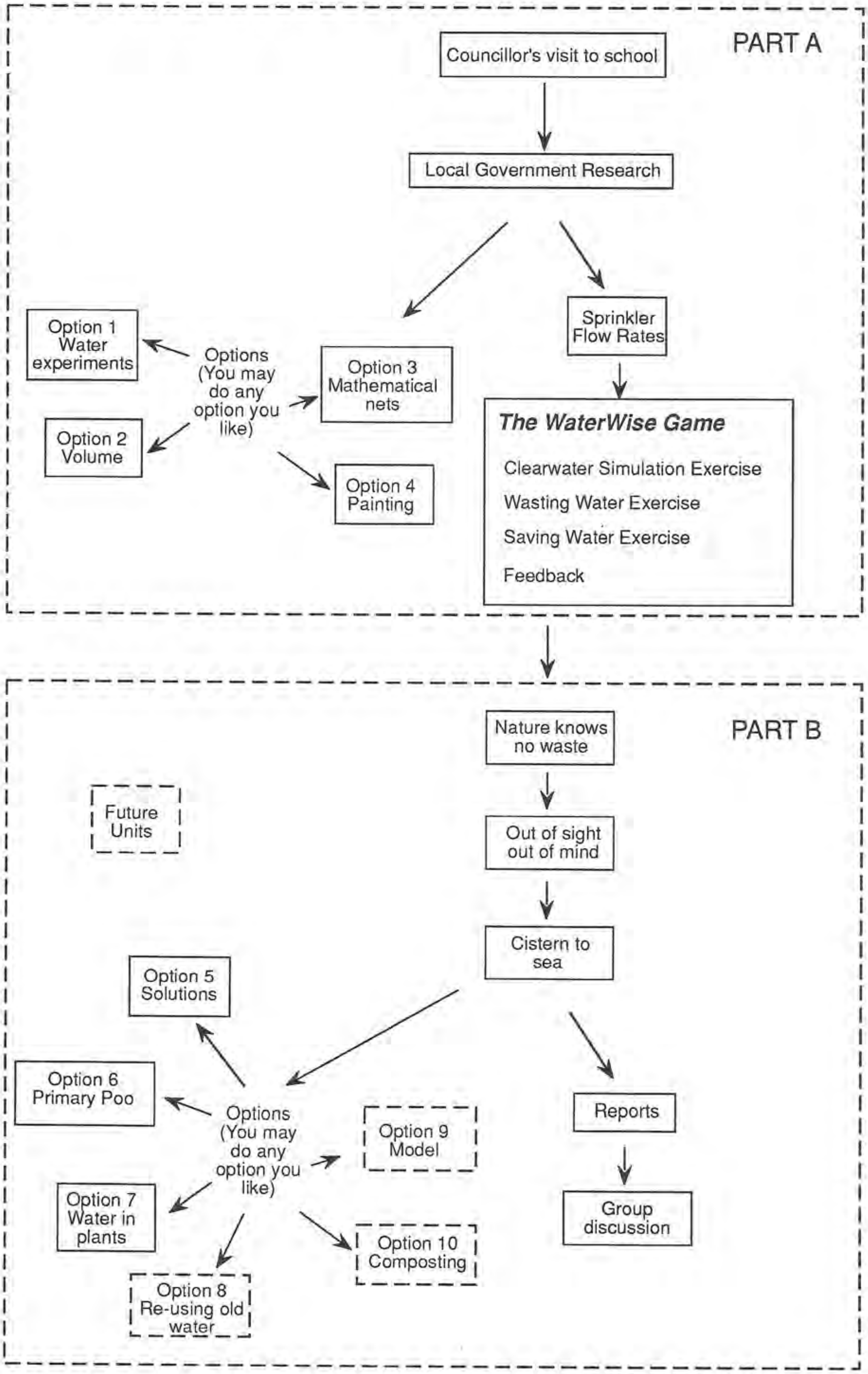


Upper Primary

Suggested Lesson Plans

Program overview

The following table provides an overview of the program.



Part A Water Supply

Sequence	Topic	Activity
1. Councillors visit	Social Studies	The program begins with a visit to the class from a local alderman or councillor to speak to the children about the role of local authorities, and a problem they need assistance with, in particular the assistance of the children in this classroom. The school will have provided the councillor with the information required of him via the notes in the appendix of this booklet. His address will serve to cover aspects of local government structure, and the role local government plays in providing quality drinking water for the shire's residents.
2. Local Government	Social Studies	(Teacher follow up lesson) Teacher reinforces main points of councillor's talk and provides worksheets for student
3. Flow rates	Science	Students experiment with sprinklers to determine flow rates of each

Options

The following options should be attempted at about the same time as the children start planning the construction of their model dam. Great deliberations can be taken in choosing the most appropriate site; gauging steepness of slope, proximity to shade and water etc. Using the same poly-pipe as will be used in the model construction, the children can experiment with the different fittings and attachments so that they are familiar with how everything fits together.

While not essential to the thrust of the unit, these options are highly recommended for general background knowledge and familiarity.

Sequence	Topic	Activity
Option 1. Water experiments	Science	Teacher and students carry out a number of simple experiments with water noting its properties. They can adopt the roles of engineers or scientists investigating the behaviour of water under pressure as it would be in pipelines emanating from the dam. (Refer to Water Experiments in Activities Section)
Option 2 (Volume)	Maths	Using the same containers as in the science experiments, the teacher introduces the units of volume..."litres".
Option 3 Nets	Maths	(Distinguishing between two dimensional shapes and three dimensional shapes. Two dimensions have area. Three dimensions have volume.) Children are given the task of building their own houses out of cardboard. They are firstly introduced to the term "net". In mathematics, net refers to the two dimensional figure which, when folded appropriately, produces a three dimensional shape. Three dimensional shapes have volume. Nets encountered:- (i) rectangular prism (ii) triangular prism (iii) cylinder
Option 4 Painting	Art	Children simply glue and paint their "net"" houses.

The WaterWise Game

This section contains one of the main activities in the program. It gives the teacher the opportunity to regulate the model building to give the desired simulations. Use your initiative to introduce variable factors such as rain fall, how to simulate the use of half flush toilets...etc.

Sequence	Topic	Activity
1. Simulation Game	Language Arts	Role play activity where the teacher divides the class into two, representing the shire council in one group and residents of the shire in another. Each group is given different information about a dam which is to be built in the shire. Neither group is privy to the information of the other group. A simulated public meeting is held where both groups state their cases. (In preparation for the meeting, children write letters back and forth between council and residents, in the process, learning and rehearsing the correct format of a business letter. Children also write a business letter to the visiting councillor thanking him for his visit.) Mock elections are held. The old council is voted out. They become the new residents. The residents now become the new council, and the roles are reversed in another public meeting
2. Wasting water and saving water	WaterWise Game	(Using poly- pipe such as that in domestic irrigation systems, the class build a model city and its water supply and make simple measurements) Class moves to the sand pit or hill side, where they set about building a simplistic working model of a dam, a town and its reticulated water supply. They carry out a number of important investigations. In particular they investigate the factors that affect water consumption in a town and the rate of water loss from the dam when... (i) the number of houses is increased (ii) each house uses more water The students simulate:- (i) the use of full and half flush toilets (ii) time limits on taking showers (iii) time limits on sprinkling (iv) effect of dry weather and drought The students record their results on the record sheets provided (refer to template).
3. Feedback	Language Arts	(Letter writing activity and positive reporting) Children write to the councillor with the findings to part one of their research concerning water supply and consumption.

Students now prepare for the sequence on Water conservation and re-use. This section investigates the pathway taken by water after use...wasted water.

Part B Waste Water

Sequence	Topic	Activity
1. The Water Cycle	Science	Nature knows no waste. The teacher introduces the class to nature's way of reusing its resources whether it be recycling of minerals via decomposers returning minerals to the soil, or the water cycle in the atmosphere. Cycling is important in Nature, since the Earth is like a giant space ship floating through space. It has no garbage bins. There are no petrol stations or food stops along its journey. It has a limited number of resources, and cannot afford to waste them. Nature knows no waste.
2. Out of sight out of mind and into trouble	Social Science	Class considers the impact on the sea) Water doesn't disappear after it goes down the drain in the shower, or is flushed out of the toilet. The class follows the pathway of water from the home / school to its ultimate destination... the sea. Mixed with the water may be other substances that people have washed down the drain, or flushed down the toilet. These substances may not be part of a natural cycle and need to be removed, before they enter the sea. This can be very expensive to do.
3. Cistern to sea	English	(creative writing). Children are set the task of writing a short story in the first person. They take the part of a water molecule as it journeys from ... "Cistern to Sea".

Sequence	Topic	Activity
Option 1 Solutions	Science	(Dirty solutions may still contain pure clean water) Solutions... class carries out a number of experiments, dissolving various solids including salt, sand, sugar, soaps and detergents, and their recovery by evaporation and condensation. (Solar still) Water recovered is pure clean water.
Option 2 Primary Poo	Excursion	Class visit to a sewerage treatment works. Sewerage consists of pure clean water mixed with other material. Some materials are toxic in large concentrations and must be removed. Other materials mixed with the water make it ideal for use as fertilizer since it contains minerals needed by plants for growth. Sewerage treatment removes the dangerous substances. In a dry continent such as Australia, it would be silly not to reuse the water after some of the other substances have been removed.
Option 3 Water in plants	Science	(The needs of growing plants are investigated... viz minerals and water etc.) Investigating transpiration. Children tie a plastic bag around an actively growing branch of a tree to collect water transpired from its leaves. They consider where the water has come from. The children also consider what other raw materials the plant needs for survival other than water, and where it gets them from. Plants can act as natural water purifiers.
Option 4 Re-using old water	Language Arts	The class is given a number of modified newspaper articles about the use of .... (i) Grey water reticulation. (ii) Effluent water for irrigation of golf courses, city parks and gardens. (iii) Composting and use of manure in gardening. Students complete worksheets on each and write an addendum to their short stories, renaming the story... "From cistern to celery".
Option 5	Model	(Modelling with poly pipe again) Using the same polythene piping that was utilized in the model from part one, students simulate a grey water reticulation system.
Option 6	Organic Gardening	The class establishes a compost bin for collection of food scraps. After some time they investigate the end products.... soil. They discuss the importance of bacteria, fungi and other decomposers, and how they can be of benefit in the garden for improving the quality of soil
Concluding	Exercise	To draw the unit to a cohesive finale, the teacher reviews the activities of the whole unit with the class using the worksheets and question sheets provided. The main points are summarized thus: ★ Freshwater is necessary for life ★ Like all commodities, you can run out of freshwater if you are not careful ★ Although freshwater can be stored in dams for use in cities, dams are expensive to build and cover a lot of valuable land that could be used for other things. ★ Care must be taken to conserve water and not to waste it. ★ There are a number of ways to conserve water in the home, such as by the use of half flush toilets, special shower fittings, time limits on sprinkling and showering, rain water collection and grey water reticulation. ★ Effluent used on gardens and lawns is not only a means of reusing what was once considered waste water, but can also improve growth in plants. ★ Sewage contains many useful products, not the least of which is pure, clean, freshwater. It should not be wasted.

1. Councillor's visit to school

The unit starts with a visit from a councillor. If this cannot be arranged, the teacher could play this role. In any case the following notes should be given to the councillor prior to the visit.

Aims of the visit

★ To introduce the topic of water conservation to the children and what the Councils input to water supply and conservation should be.

★ To enlist the student's assistance in a matter of great importance... helping to identify the main reasons for water use and water loss.

★ To discuss the role of dams in the council's water supply strategy.

Main points to raise in the councillors address to the class

1. There are three main types of government responsible for making laws, building roads and supplying water and services- *Federal, State and Local*
2. There are several types of local government
   (a) Municipal or Town Councils
   (b) City Councils
   (c) Shire Councils
3. The Council is responsible for ensuring its residents and rate payers are provided with quality drinking water, free from diseases, impurities and poisons.
4. To do this, the council has built a number of dams to store water, and treatment works to clean the water. Pipelines and pumps are also needed to move the water from the dams to the residents' houses.
5. Too much water is being wasted by the people. If we are not careful there may not be enough water for the future unless another dam is built.
6. It is very costly to build dams and a lot of valuable land is flooded when a dam is constructed. It would be good if no more dams were needed.
7. The council needs the help of its future citizens (the students) to make some important discoveries, and some crucial decisions. "These decisions will effect the way you (the students) live, so you are the best people to make them." The council wants the class to investigate how water is used and wasted in their city / shire, and to report back to the council what their findings are, and as citizens of the future, what should be done to ensure enough fresh clean water to drink for the rest of their life and the lives of their children.

Some notes about the audience

The children the councillor will be addressing will be aged between ten and twelve years, and consequently will not be familiar any technical information about water supply and treatment.

As far as most children are concerned the following misconceptions may be held....

1. Water is free.
2. You can use as much as you like, it never runs out.
3. Water comes from taps.
4. Apart from the above and unless the teacher has done some preparatory work, the children will not have thought a great deal about where their water comes from or how it is stored and distributed, As far as the children are concerned it's always been in taps... ever since the day they were born. Turning on a tap for a glass of water is as natural as breathing and just like breathing, it is taken for granted.

Most important

1. Keep your language simple. (There is no need to talk down to the children. Just be aware that their vocabulary may not be as advanced as yours.)
2. Keep the concepts simple.
3. Keep it short....no more than fifteen minutes, or twenty at the most.

What to bring

1. Councillor should bring multiple copies of WaterWise brochures for distribution to students and copies for the school library.
2. Don't take the wrap stickers, balloons and a poster.
3. Donation to school of some sought. It makes for a nice ending.

After the visit

2. Students can complete the following worksheet on their Local Government or ask questions during the councillors visit.

2. Worksheet - Local Government

(To follow up from the Councillors visit)

Students Name ______________________

Teachers Name ______________________

In Australia there are three main types of government responsible for making laws, seeing that the laws are carried out, building roads, supplying water and providing lots of other services so that the people of Australia can have a suitable standard of living. These governments are Federal, State and Local.

1. ***The Federal Government.*** This government looks after things of importance to the whole nation.

2. ***The State Governments.*** This government is responsible for things of importance to each of the states that make up the nation of Australia.

3. ***The Local Governments.*** Within each state there are a number of districts, cities and towns. The people elected to run these localities represent the Local Government. There are several types of Local Government. namely

(a) Municipal or Town Councils (for small towns)

(b) City Councils (for large cities)

(c) Shire Councils (for shires or districts). A shire is a large area often with a scattered population.

1. Find out which local Government type is responsible for the community in which your school is located. (Choose (a), (b) or (c) from the above list. What is the name of this council ?

____

2. Find out which local government type is responsible for the community in which your house is located. Choose (a), (b), or (c) above. What is the name of this council ?

____

3. The leader of a Shire Council is called a "Shire Chairman". What is the leader of a City Council called ?

____

4. The people elected to serve in a City Council are called "aldermen". What name is given to the people elected to serve in a Shire Council ?

____

5. Who is the elected leader of your local Council ? (Use his correct title)

____

6. Use the brochures provided by your local council to find out who is responsible for supplying water to your local community.

7. Draw a sketch in the space below showing where your water comes from

Sprinkler Flow Rates

The following experiment is necessary for students to determine the different flow rates of the different sprinklers.

Materials needed (per group)

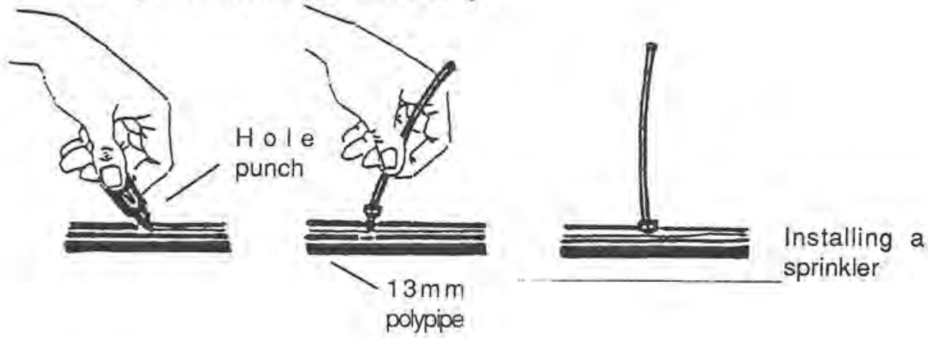
Note: The maximum number of households for a 9 litre bucket is 4. You can however have more, but a reservoir system is advised.

★ 1 X Plastic Bucket (Refer back to page 6 for details on how to set up your dam bucket)
★ 1 X Tap connector (A) to suit 25mm tap ; with a 20mm screw- in adaptor (B); and 13mm tail (C).
★ 2 metres of 13mm polytube
★ 1 x in-line tap
★ 1 x 300mm of13mm polytube
★ 1 X end Stopper (for end of 300mm pipe)
★ 1 X full circle spray mounted on a 300mm rigid riser with a riser connector
★ 1 X half circle spray mounted on a 300mm rigid riser with a riser connector
★ 1 x drip irrigator
★ 1 x veriflow sprinkler
★ 1 X Hole Punch
★ 4 test tubes

Making a bucket dam and a sprinkler system flow rate test kit

(Teachers note - You will need to make a connection to attach the polypipe to the plastic bucket. Make this up before hand - your manual arts department will have a 25mm drill bit to make the holes in the buckets)

1. Make the 25mm hole in the side of the plastic bucket near the bottom.
2. Push the 20mm tap adaptor (2C) through the hole from the inside. (This should be a very snug fit...use silicon sealer if necessary).
3. Now screw on the 25mm tap connector and tail. Screw it all the way until the tail is firmly held and no leaks occur around the connector.
4. Connect the 2 metres of polytube by sliding it over the tail. Don't slide it on too far or you will have difficulty getting it off.
5. Now connect up the in-line tap.
6. Now put a stopper in the end of the 300mm poly tube and connect this up to the tap.
7. Add a sprinkler to the system simply by punching a hole in the polytube with the hole punch and screwing it in.
   Note: To install the drip irrigator, you need to make a hole and push in firmly - this one does not screw in)
8. Add the other sprinklers to the 300mm test strip.



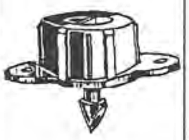
What to do

1. Fill the bucket and put it on a chair.
2. Arrange the test tubes under each of the sprinklers and turn on the tap.
3. With a watch with a second hand, record the time it takes to fill each of the test tubes. Record this in your note book.
4. Record also which sprinklers you can control water flow and which sprinklers over which you have no control.
   Now of the sprinklers you have no control over, which type has the highest flow rate and which had the smallest flow rate. Record your results on the worksheet on the next page

Sprinkler flow rate worksheet

Complete the following worksheet.

1. Circle the sprinkler that uses the most water-i.e.. the one that fills the test tube the fastest. (Write the word "wasteful" beside it.
2. Draw a square around the sprinkler that uses the least amount of water i.e. takes the longest time to fill the test tube. Write the words - "WaterWise" beside it.
3. Write the words "can be turned on or off as you wish" beside the appropriate sprinkler.

Sprinkler	Water efficiency	Type of control
		
		
		
		
		
		

Analysis of results

In a house you have many water appliances. Some you have control over like the shower tap or the outside tap, while others you don't. A washing machine or a dishwasher uses water at a fixed rate. However some machines use water more efficiently than others.

You are to now to analyse your results in accordance with water saving or water wasting devices by studying the table below and completing the worksheet on the previous page.

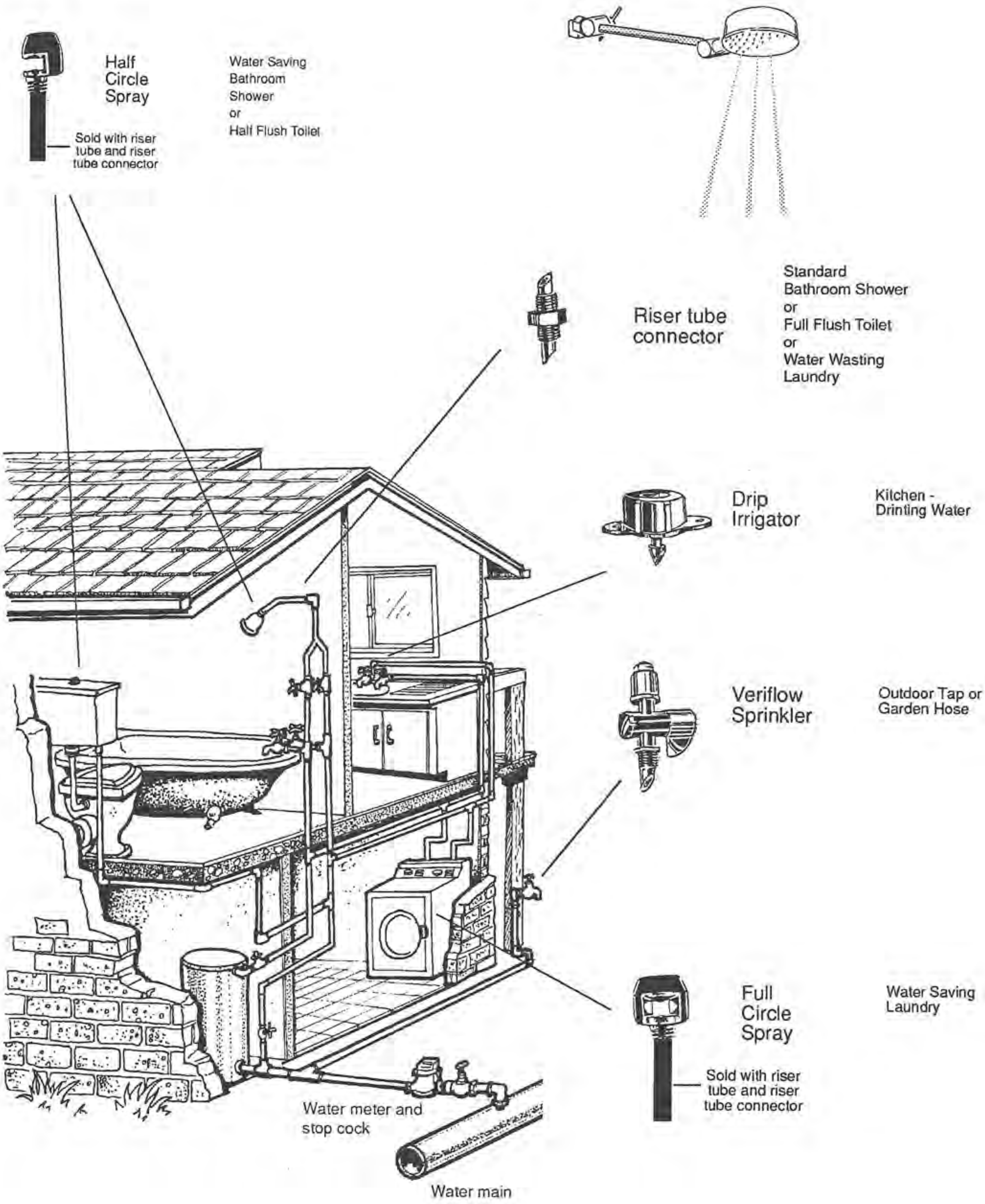
Item	Description	Represents
	Riser tube connector With riser tube and riser tube connector	Represents water wasting appliances. A standard bathroom shower head, or a full flush toilet or a dishwasher half full or a washing maching half full
	Half Circle Spray With riser tube and riser tube connector	A water saving appliance. It could also be a water saving shower head which restricts the flow of water. Water Saving Bathroom Shower or a half flush toilet.
	Full Circle Spray With riser tube and riser tube connector	A water saving device. It could be a front load washing machine or a dishwasher that only gets turned on when full.
	Veriflow Sprinkler	Outdoor Tap or Garden Hose. Represents the water used in sprinkling lawns. Each household can have as many of these a they like. The taps can be turned on and off to indicate the freedom of choice most people have to keep their gardens green.
	Drip Irrigator	Kitchen tap - Each household is allowed only one of these. The constant slow drip representing the essential and constant daily requirement for drinking water.
	Cap	Water Stop. Use to remove unwanted water wasting appliances.

Household plumbing is represented by Hardy Pope Sprinklers

Students use their knowledge of the appliances in a urban household to distinguish between the appliances which use uncontrolled and controlled amounts of water.

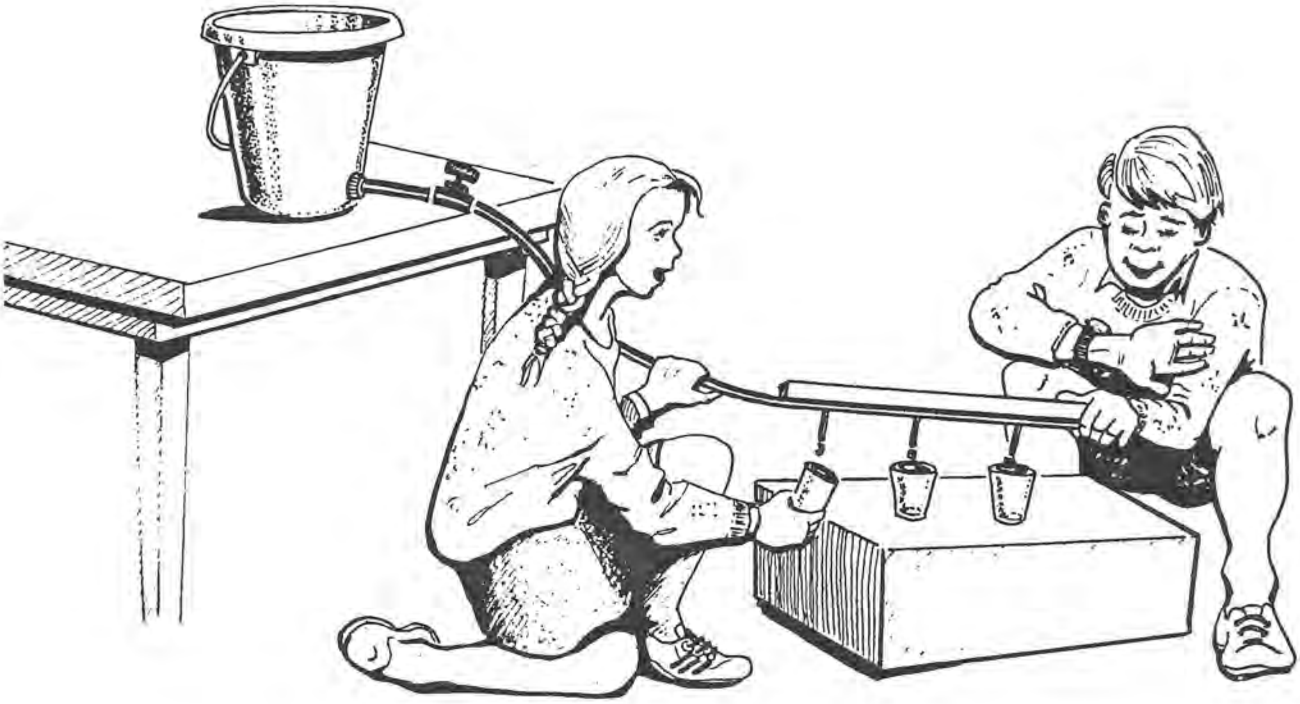
They then select Hardy Irrigation sprinklers to represent these appliances.

For example:



Students have now learnt which sprinklers are the best water savers

In this activity students connected up a number of sprinklers.



Students experiment to discover which sprinklers use the most and which use the least amounts of water

Additional activities

★ Experimentation with height, and rates of fall, diameter of apertures, number of outlets etc. form the science component of the exercise.
★ Class roll plays and simulations about the interaction between council and residents form part of the local government component of social studies.
★ Letter writing and compositions about various aspects of the dams construction are dealt with in English expression.
★ Mathematics is employed in the construction of model houses from their geometrical nets, as well as a basic introduction to volume, area, and rate.

3. The WaterWise Game

The game is played in class with 20 to 30 students. There are three stages in the game namely:

1. A simulation exercise where the suburb of Clearwater, has been identified as having the highest excess water consumption in the town. The council has already visited the school to explain the situation and the class is going to debate this issue in a simulation exercise.
2. Wasting water. In this activity, the students play the roles of residents who waste water and are encouraged to waste water with the incentive of a reward system of jelly beans. They are not told however that if the dam runs dry, they will have to pay back all the jelly beans to build a new dam. They are given the option of turning back the time to replay the game to see if they can conserve water.
3. Conserving water. Having realised their wasteful ways, the residents use their new watersaving knowledge to redesign their model houses to save water and keep their jelly bean rewards.

Simulation Exercise - To dam or not to dam

(a) Divide the class into two groups. One group to represent the Local Authority (City or Shire Council), while the other represents the residents of the locality called "Clearwater" where a dam is about to be built.

(b) Give each group their respective information sheets (see information for council group - and information for residents group) It is important that only one set of information is given to each group and that neither knows the information available to the opposing group.

(c) Explain to the class that the simulation takes the form of a public meeting held to discuss the council's recent decision to survey a particular area near the town of Clearwater for the possible construction of a dam. By the time this public meeting takes place, the council has the results of surveys conducted in a number of other localities, but the indications are strong that the site at Clearwater looks to be the best for cost effectiveness.

Lead Up Time

There should be some lead up time before the game (meeting) is scheduled to start. The teacher could divide the class into the two groups, preferably by allowing the children to make their own choice, but more probably by allocation to balance the numbers. This could be done prior to a morning tea or lunch break.

(d) Allow about half an hour after the split so that both sides have the chance to read through their information and discuss a strategy for the public meeting scheduled for after the break or first up the next morning. During this time, the residents

(i) The "residents" draft a letter to the "council" expressing their concern and setting a time for the public meeting to debate the issue.

(ii) Meanwhile the "council" prepares a public statement as a press release and stating that, 'at this time no final decisions on the dam site have been made, but the council is considering a number of possibilities"

(e) The Public Meeting

The teacher should chair the meeting.

It can be organised along appropriate debating lines or a less formal approach depending on the class and the teacher's preference.

It is important that the teacher appoint the same time limits to both sides.

It is also important that no winners or losers result. It must be pointed out that both sides are interested in the best quality of life for the residents.

The Council is attempting to plan for the future, the residents are fearful of the effects these plans will have on their lives.

Outcomes

★ Ideally a stalemate should be reached with neither side winning.

★ Reverse the roles of each group by holding a mock election whereby the residents get voted in as councillors and the councillors now become residents.

★ Now repeat the public meeting with the reverse roles.

★ It should be pointed out that dams have an important role to play but there is a cost to be paid. These costs must be weighed against the perceived benefits.

★ It is also important to consider the alternatives. For example... Would the dam be necessary if the residents changed their water use practices.

Would the dam be necessary if every resident conserved water, or the council recycled water?

Information for the "Council" group

The following information is given to the group who have been allocated the role of the local authority responsible for the decision on siting and building the dam. As responsible members of your community, as well as councillors, you have an important decision to make based on the following information.....

1. Your community is gradually consuming more and more water.
2. Research has indicated that within a very short time if consumption continues as it has done, your community will not have enough water to drink let alone water for other uses. Your council must act soon to avert a future disaster.
3. Construction of a dam will ease the existing water problems and solve a number of foreseeable problems in the future. It will keep the people supplied with good quality water well into the next century if all goes well.
4. There will be some environmental damage done to the dam site wherever it is built, and there will always be a number of people who are unhappy with the choice of dam site.
5. A team of fully qualified surveyors and other experts have been employed to find the best possible site for the dam.
6. There are other alternatives to building a dam, but they may cost more than the council is prepared to pay, and will take a lot of time and effort to re-educate the public and these alternatives have not been adequately investigated or trialled before. A dam could be built much faster.
7. Five different locations have been found to be satisfactory for a dam site, but the one at Clearwater will hold more water than all the others, and will cost less to build. There are also fewer people living at Clearwater than at the other sites. Most of the area to be flooded will be unused bush land. At all the other sites, many people will have to be moved off their land, and their houses removed prior to dam construction. This will be very costly and will lead to a lot of public outcry.
8. The rate payers who support the council deserve to have fresh clean water. It is their right to expect that the council will ensure that it is supplied to them both now and into the future. The council therefore has an obligation to choose the best site for the dam, and the most cost effective (Least expensive so that ratepayers money isn't wasted).
9. It will cost 50 million dollars to build the dam at Clearwater. Compared to over 80 million dollars at the other locations. The cost of the surveys and preliminary studies at Clearwater has so far amounted to 5 million dollars, and it is expected that an extra 30 million dollars will need to be spent on clearing, and purchasing the land from the existing landholders. This could go higher if the project is delayed by unforeseen interruptions.
10. There is a "Tectonic aberration" in the geological strata of the area which may be a problem. (Put simply there is something unusual about the layers of rocks in the place where the dam is to be built). However, your scientific advisers say that it won't affect the dams construction. You aren't entirely sure what this means but you are prepared to accept what the scientists are saying, i.e.. that it is alright and doesn't represent a major concern. In fact they say there is absolutely no risk. They ought to know since they are fully qualified scientists.

Information for the "Residents" group

The following information is given to the residents of Clearwater. There have been many reports that a dam may be built in the area. If so, it is likely that the dam will flood a number of their homes. They are calling on the council to attend a public meeting to discuss the situation.

1. If a dam is built at Clearwater, many people will be forced to sell their houses to the council and move elsewhere.
2. Thousands of hectares of beautiful bushland will be lost. This bushland is the home of a rare mammal called the Clearwater Marsupial Mouse, and much of its habitat will be flooded after the dam is constructed.
3. Because of its sheer beauty, thousands of tourists flock to the area bringing a substantial amount of money and work for the local population. Most of the beautiful places, the gorges, the waterfalls, and part of a National Park will be under water if the dam goes ahead.
4. Wilderness such as this is very rare and disappearing at an alarming rate. It is important to preserve unique areas like this for recreation, and as a wildlife habitat.
5. There is a "Tectonic aberration" in the layers of rock underneath where the dam is to be built. Perhaps with the pressure of the extra water building up behind the dam, the rocks might give way causing a crack in the dam wall an possible loss of life should the dam collapse and flood the town just below the site.
   No one can be sure what will happen despite all the scientific measurements... .scientists have been wrong before.
6. The dam will cost too much. It is understood that it will cost in the order of 85 to 90 million dollars. Based on the council's own figures (50 million for construction; plus at least 30 million, possibly as high as 35 million, for clearing and land purchases; plus 5 million in survey and preliminary studies. {50+35+5=90})
   Five other dam sites studied in different localities would cost less than 80 million dollars. It would be cheaper to build the dam at one of those sites than at Clearwater.
7. Why is the dam necessary ? There is already a number of other dams providing water to the community. Surely there is more than enough water to go around, why spend millions of dollars of ratepayers money on a dam ? Why not spend it on upgrading and improving the roads ?
8. If a dam is built, it might encourage developers to move in. The people of Clearwater are peaceful quiet residents who want to get away from the hustle and bustle of city life. They don't want development. It would seriously affect their quality of life.
9. Has the council looked at other alternatives to building a dam ?
10. What about the cost to the environment ?

Write a letter to the council inviting them to attend a public meeting to debate the issue. Choose a number of people to act as spokespeople at the meeting so that you can argue your case against the dam's construction.

The effect of a water wasting suburb

Having considered the advantages and disadvantages of siting a new dam in the community, the class now sets about modelling that community and that dam. The model has two alternatives. First, what will happen if the water is wasted and second, what will happen if water is conserved. That is, can the community ensure that the dam will not run dry by exercising water conservation practices.

In the first exercise the students build their suburb and are encouraged to use as much water as possible without constraints. (Jelly beans are the incentive for water use.)

Divide the class into the following groups....

★ Four householders	3-4 people
★ Time keeper	1 person
★ Rainperson	1 person
★ Sprinkler sellers	2 people
★ Jelly Bean Judges	4 people (one per household)

Each pair of householders is responsible for one house as per the following setup....

Each house is initially allowed...

- ★ One drip irrigator representing drinking water services.
- ★ One riser tube and tube connector representing bath and toilet.
- ★ One riser tube and tube connector representing washing facilities.
- ★ Ten dollars for the purchase of additional water connections such as sprinklers, baths and toilets etc.
- ★ One tray to collect and measure the amount of water used.
- ★ If the students have constructed nets from the options section, these can be used as jelly bean storehouses....one house net per household.

Aim

The aim is for each household to use as much water as possible by purchasing additional devices. A jelly bean is given for every 500ml of water used in each household. The householders try to get as many jelly beans as they can. The jelly beans are placed in their storehouses...NOT EATEN, because if the dam runs out of water some of these beans must be repaid for repairs and maintenance to the dam and pipelines. (It is recommended that all the storehouses be placed under the teacher's supervision!)

Householders equipment

- ★ 1 X 30mm x 20mm x 520mm pine (to hold household sprinklers)
- ★ 1 X 450mm x 330mm x 90mm box (from the top of a box that the school photocopier paper comes in (to catch the water from the sprinklers)
- ★ 12 pegs
- ★ 1 X plastic garbage bag to fit into photocopier box
- ★ 3 X 25mm cup hooks (to hold household pipe in place)
- ★ 1 x T piece (To connect up to other households. But note only four will be required)
- ★ 2 metres of 13mm polytube

Each householder is issued with the necessary items to construct one household as per the setup on the previous page. Any additional sprinklers etc. must be bought with the money for the recommended retail price.

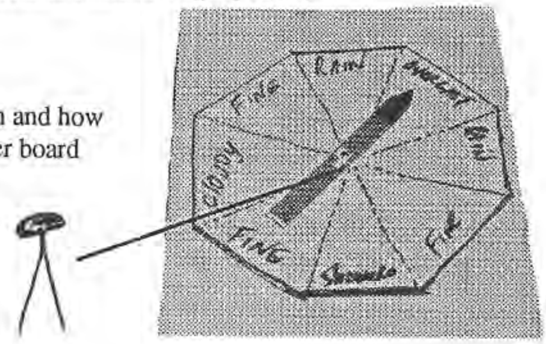
All water going through the household must be collected and measured.

Every 500ml of water collected earns the household one jelly bean placed in that household's storehouse. The jelly beans can only be eaten at the end of the game because some of the jelly beans may need to be repaid if the dam becomes empty.

Time keepers equipment

The timekeeper and the rainperson determine the weather, i.e.. when and how often it rains. They do this with the aid of a stopwatch and a weather board as shown opposite.

- ★ 1 x 500mm x 380mm cardboard (for backboard)
- ★ 1 x felt pen
- ★ 1 x masking tape
- ★ 1 x scissors
- ★ 1 x paper split pin (as shown below)



What to do

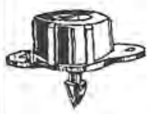
1. Make up a weather board as shown in the photograph on the page below
2. Every thirty seconds, timekeeper gives a spin of the board. If rain comes up he or she shouts "Rain!". This means that 500ml of water is added to the dam (bucket).
3. After 10 minutes, time keeper shouts "Time !" to signify the end of the game. If the dam runs dry before 10 minutes, the game finishes and the householders pay the appropriate number of jelly beans to timekeeper, rainman, and the sprinkler sellers.

Sprinkler sellers

Two sellers are required to sell sprinklers, riser tube connectors etc. as listed in the table below. They must keep everything tidy and in order and collect dollars (disks) for payment. They must sell out all their stock before they are entitled to any jelly beans at the end of the game. The teacher determines their reward. A copyright free sheet is opposite.

Sprinkler Price List

To Householders

Item	Description	Represents	Price	Allotted
	Riser tube connector	Represents water wasting appliances. A standard bathroom shower head, or a full flush toilet or a dishwasher half full or a washing maching half full	$1	1 with a maximum of 4
	Half Circle Spray Sold with riser tube and riser tube connector	A water saving appliance. It could also be a water saving shower head which restricts the flow of water. Water Saving Bathroom Shower or a half flush toilet.	$1	1 with a maximum of 4
	Full Circle Spray Sold with riser tube and riser tube connector	A water saving device. It could be a front load washing machine or a dishwasher that only gets turned on when full.	$1	1 with a maximum of 4
	Veriflow Sprinkler	Outdoor Tap or Garden Hose. Represents the water used in sprinkling lawns. Each household can have as many of these a they like. The taps can be turned on and off to indicate the freedom of choice most people have to keep their gardens green.	$2	As many as you want
	Drip Irrigator	Kitchen tap - Each household is allowed only one of these. The constant slow drip representing the essential and constant daily requirement for drinking water.	Free	1 Only
	Cap	Water Stop. Use to remove unwanted water wasting appliances.	Two for $1	As many as you want

Sprinkler sellers kit

- ★ 16 X riser tube connectors with a 300mm rigid riser tubing
- ★ 16 X full circle spray mounted on a 300mm rigid riser with a riser connector
- ★ 16 X half circle spray mounted on a 300mm rigid riser with a riser connector
- ★ 4 x drip irrigators
- ★ 16 x veriflow sprinkles
- ★ 32 X caps
- ★ $40 of WaterWise money in one dollar bills (turn to page 73)
- ★ Boxes to organise sprinklers in (suggest empty margarine containers or tackle boxes

What to do

You organise the money for the teacher to hand out to the households.

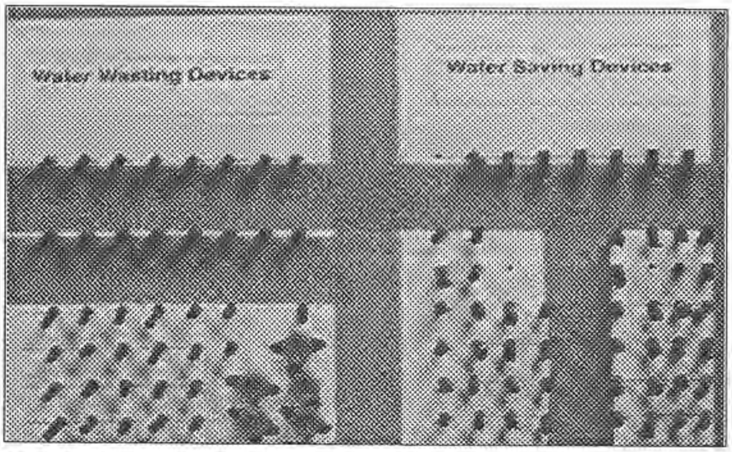
Then you are to sell to the households the sprinklers they want keeping note of the maximum they can buy

Jelly Bean Judges

Five jelly bean judges take each and every 500ml of water collected by the householders, and give them to rainman. They ask the teacher to place a jelly bean in the storehouse of the householder whose water they have received. They also watch carefully in case any body is breaking the rules. They have their own jelly bean storehouses and each receive a jelly bean for every 500 ml they collect from the householders. They must also pay out if the dam runs dry before the allocated time.

Teacher

This activity should be structured so that it is virtually impossible for any of the householders to keep any jelly beans. The dam must run out before the allotted time so that all the beans are repaid. The teacher looks after all storehouses complete with jelly beans, and determines how much is to be paid to the timekeeper, rainman and the sprinkler sellers. Start the clock when all the groups have their set ups complete, and the dam has been filled.



A useful storage technique is to make up a sprinkler board to keep track of items

The effect of a WaterWise suburb

The set up for this exercise is exactly the same as before, except that this time the students are encouraged to use as little water as possible; to practice restraint and conservation for the long term benefit of all. Consequently an extra jelly bean is given to each student for every 500ml of water ***remaining in the dam*** at the end of ten minutes.

The roles of all the participants remains the same. Don't swap the groups over just yet.

Once again each householder receives a jelly bean for every 500 ml of water collected and once again they can only keep (eat) the jelly bean provided the dam does not run dry by the end of the time limit.

Householders

The students must use the same households as before; i.e. they do not start all over again. Instead they must consider replacing existing, wasteful, water using devices with water conserving devices. (Many will have purchased open ended riser tube connectors for the previous activity. Hopefully, this time they will purchase veriflow sprinklers to replace them.) The ten dollars (or disks) are replenished, but no other equipment.

Sprinkler Sellers

Seller now receive additional stock for sale. However, a new law requires them to place a high sales tax on devices that use lots of water. Consequently open ended riser tube connectors now sell for five dollars each instead of the old price of one dollar.

Continuous flow sprinklers are now worth two dollars. Veriflow sprinklers are considered to be water saving devices, so their price does not increase.

Teacher

This activity should be structured so that the students, provided they practice water conservation, will always be rewarded. You can add your own ideas as you go along. For example.... you may consider imposing sprinkling bans or fines for excessive water consumption. Most councils charge for excess water use. You may like to levy a similar charge on students whose water consumption is excessive and consequently likely to earn more jelly beans by taking advantage of others' conservation practices for maintaining the level of water in the dam.

Notes:

1. The above activities are only two suggestions. You may have already thought of many more possibilities for the polypipe system. Experiment a little for yourself and you may be able to see lots of additional applications.

2. As well as demonstrating conservation practices, there are many social issues that have been modelled in the above activities... eg. the effects of imposing levies, fines and taxes to encourage householders to conform to desired community standards and practices. Once again with a little imagination you may be able to expand the model to include many more curriculum and extra-curriculum goals.

Water Wasting and WaterWise Suburbs

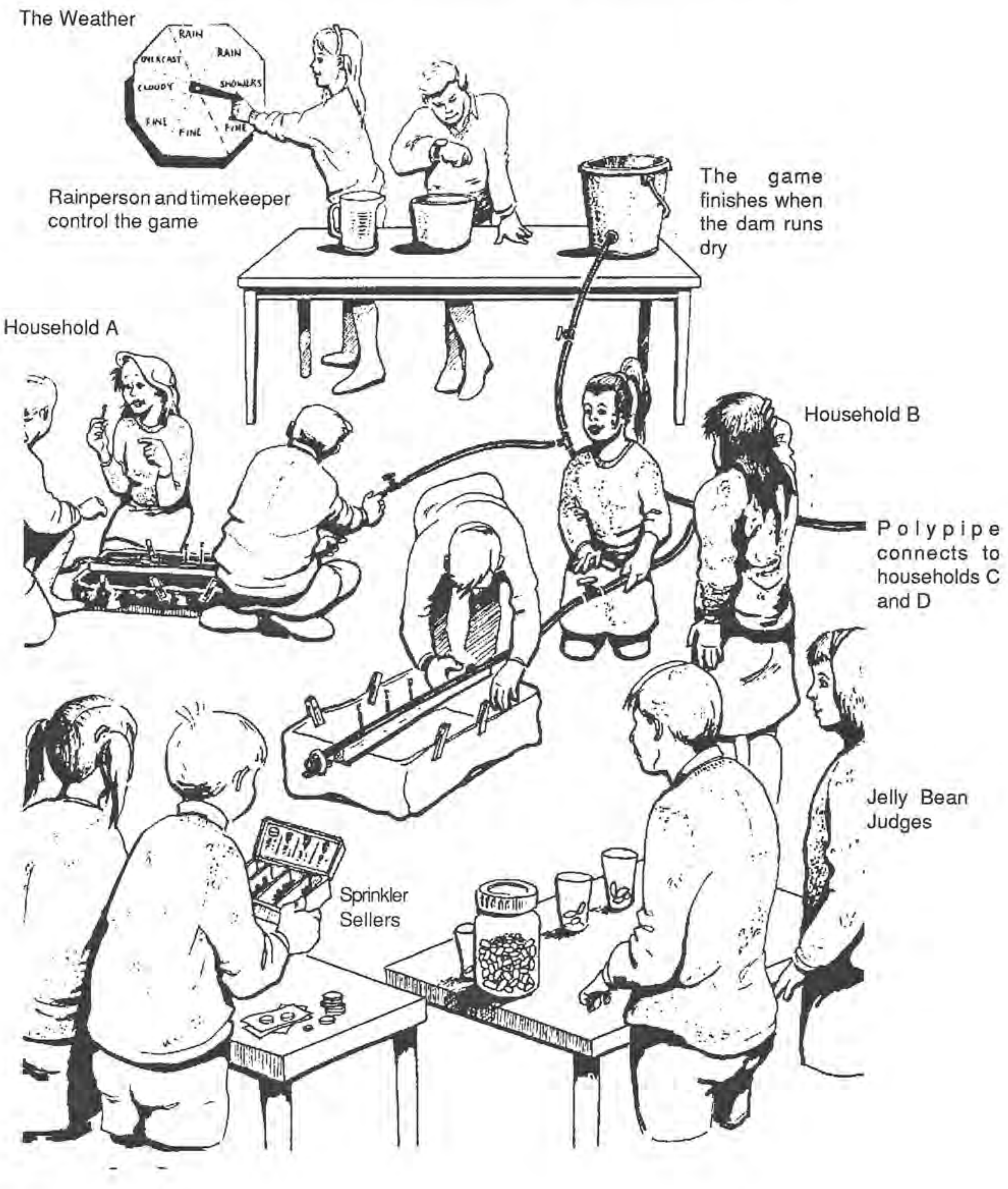
Summary

Students divide up into different roles to play a game which shows the effects of wasting water on a community. Their water supply is controlled by a dam which is influenced by the weather. Two students control the weather by a weather board and bucket.

Householders build their new houses and fit them out with new appliances but do so in the knowledge that they will be rewarded with jelly beans for the most amount of water they use. The idea being that people are rewarded in life by green lawns and nice long showers.

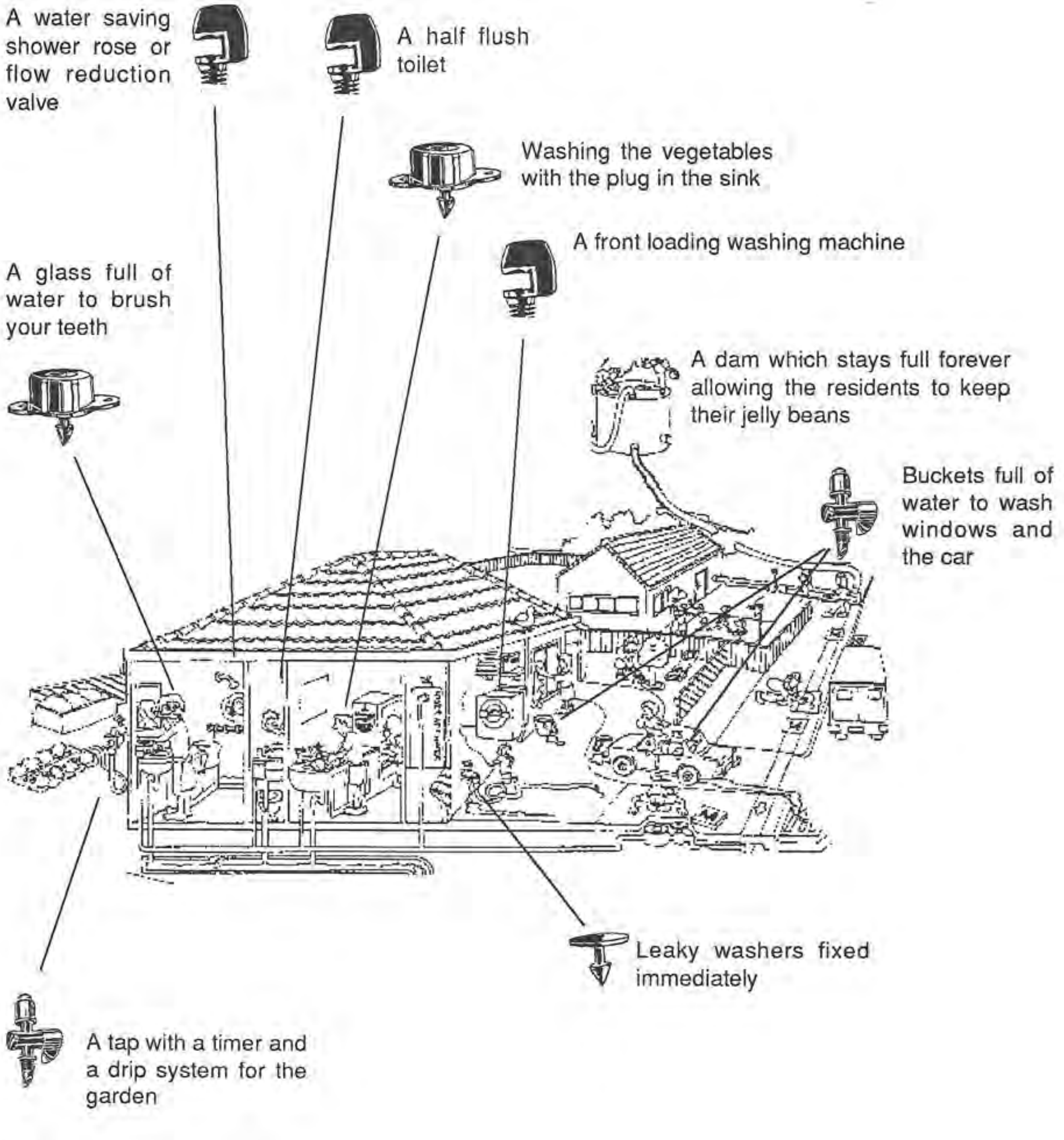
The appliances are sold by the sprinkler sellers who collect up to $10 from each household.

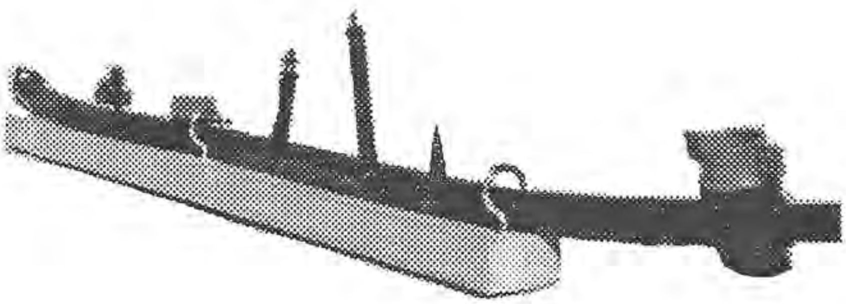
Four students called jelly bean judges, scrutinise the water collected. The game finishes when the dam runs out of water and the council comes to build a new dam. Of course we know how this will be funded....



The WaterWise suburb is the one which keeps the Jelly Beans forever

The community all agree that water conservation can be achieved by changing attitudes to water use without affecting the quality of their lifestyles.





In the game students redesign their model house using the most water efficient Hardy Pope sprinkler kits.
If the dam still has water after 10 minutes, the households get to keep the Jelly beans.

Student record sheet

Water flow

Your teacher will show you various attachments for building a model city water supply, and explain what they represent. Sketch them in the spaces provided and record their use.

This attachment is a

____

and represents a

This attachment is a

____

and represents a

This attachment is a

____

and represents a

This attachment is a

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and represents a

This attachment is a

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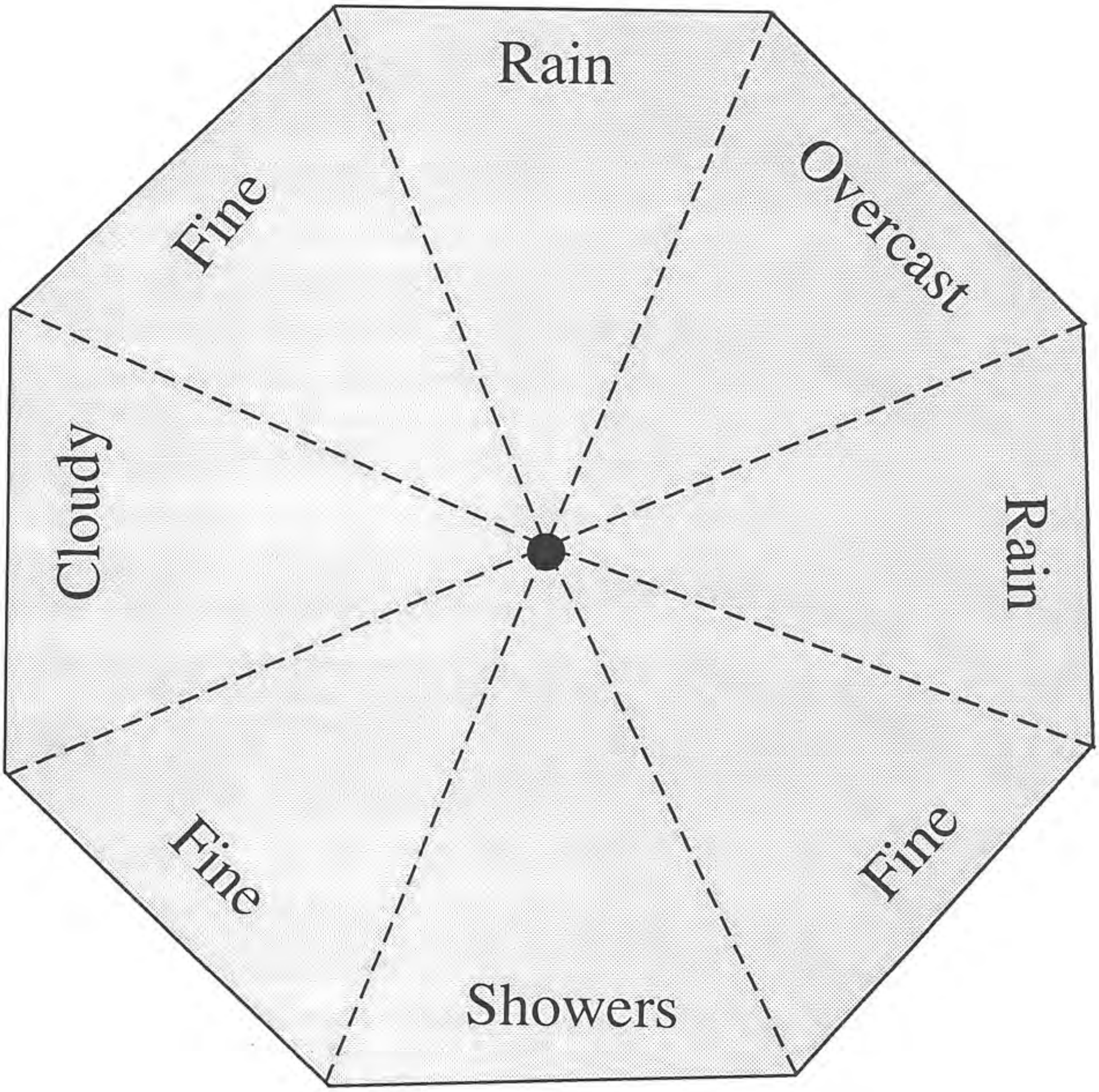
and represents a

Use this page to make a student worksheet

Use this page and a A3 enlargement to make up your weather board

Weather Board



Photocopy this to make your WaterWise money

One Dollar

$1

WaterWise

WATERWISE
QUEENSLAND

DON'T TAKE THE WRAP $1

One Dollar

$1

WaterWise

WATERWISE
QUEENSLAND

DON'T TAKE THE WRAP $1

One Dollar

$1

WaterWise

WATERWISE
QUEENSLAND

DON'T TAKE THE WRAP $1

Lower Secondary

Suggested Lesson Plans

Lower Secondary

The effect of water saving devices

Background

In a house, a number of water wasting appliances and practices combine to place a drain on a cities reservoir.

Some water wasting appliances are:-
★ A big shower rose
★ A top loading washing machine
★ Leaky taps

Some water wasting practices are
★ Long showers
★ Leaving the tap run while brushing your teeth
★ Sprinkling the lawn in the middle of the day
★ Washing the car with the hose
★ Hosing the path to remove the leaves
★ Washing with only a half load

Aim

To compare water wasting devices with water saving devices

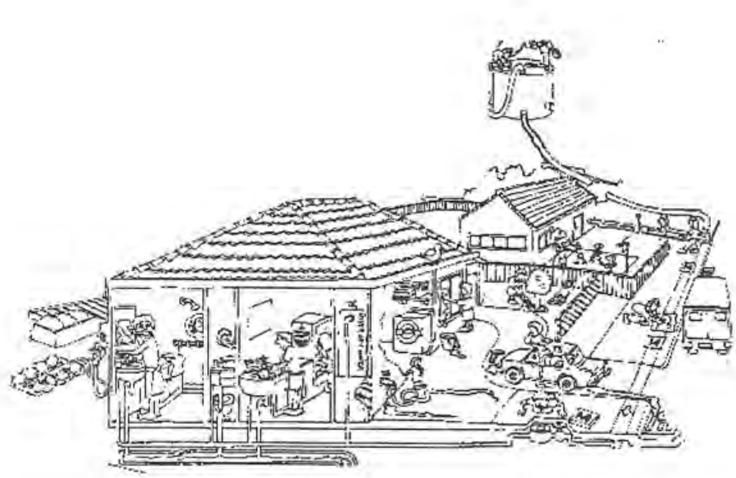
Equipment per class

Hardy pope sprinkler kit (see page opposite)

Buckets

Poly pipes

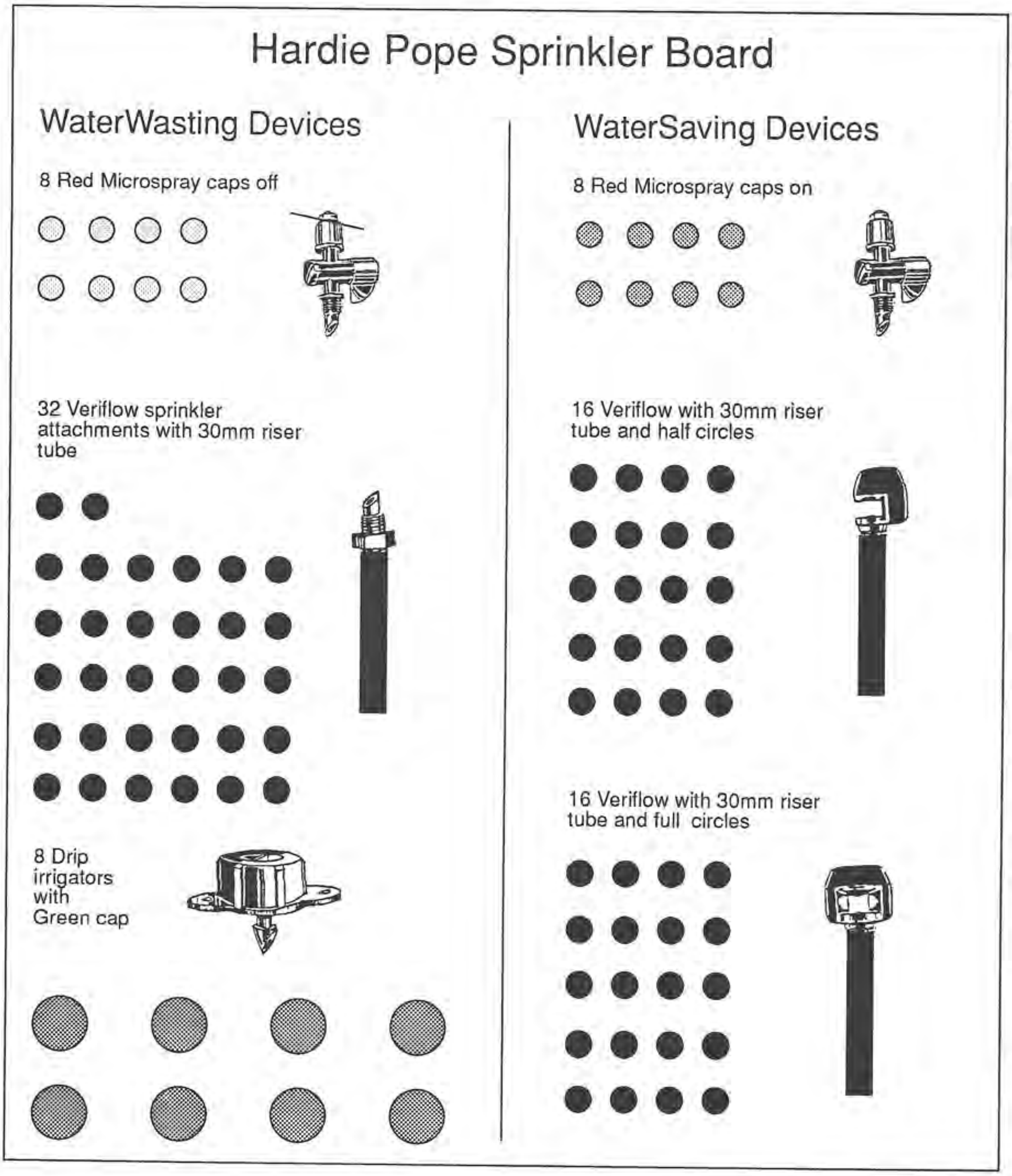
Tidy boxes



Sprinkler kit

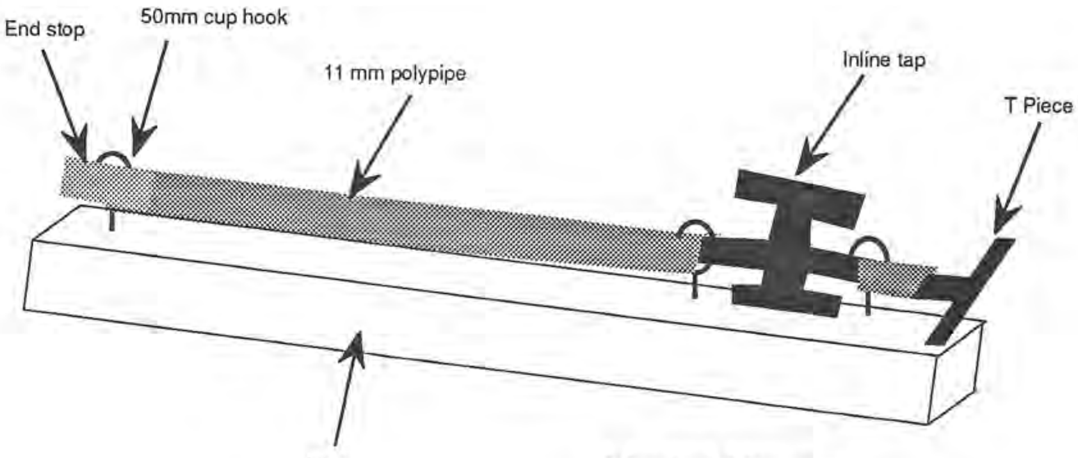
This kit is based on the hardy Pope Set of Sprinklers.

1. Each sprinkler represents a water use.
2. Arrange this kit so that you make sure you get back all the sprinklers you give out.
3. This is a very structured lesson.



The model house

A model house is made from a piece of approx 435 mm, 30 mm x 20 mm pine to show water wasting and then water saving situations.



Model House

Lesson sequence

The lesson begins with a discussion of how water gets into a house. The teacher identifies that:

1. Water comes from a reservoir under pressure to the streets through a council main.
2. The house is connected to this main through a water meter. Water to the house is turned on from the stop cock.
3. Water flows to a number of appliances in the house located in the laundry, kitchen, shower, toilet, vanity basin, outside tap.
4. Establishes that the aim of this lesson is to talk about water conservation and that students are going to use a model house which is shown above. The T piece is the council main, the in-line tap - the stop cock and water meter and the sprinklers on the board different appliances or attitudes in the household.
5. The lesson in three parts.
   a. An experiment to see how quickly water wasting appliance and attitudes empty a reservoir.
   b. A repeat experiment using water saving devices and attitudes to see how much water can be saved in the reservoir if attitudes and appliances are changed,.
   c. A discussion on practical applications of these in the home with the handout of pamphlets on ways to save water.

Classroom hints

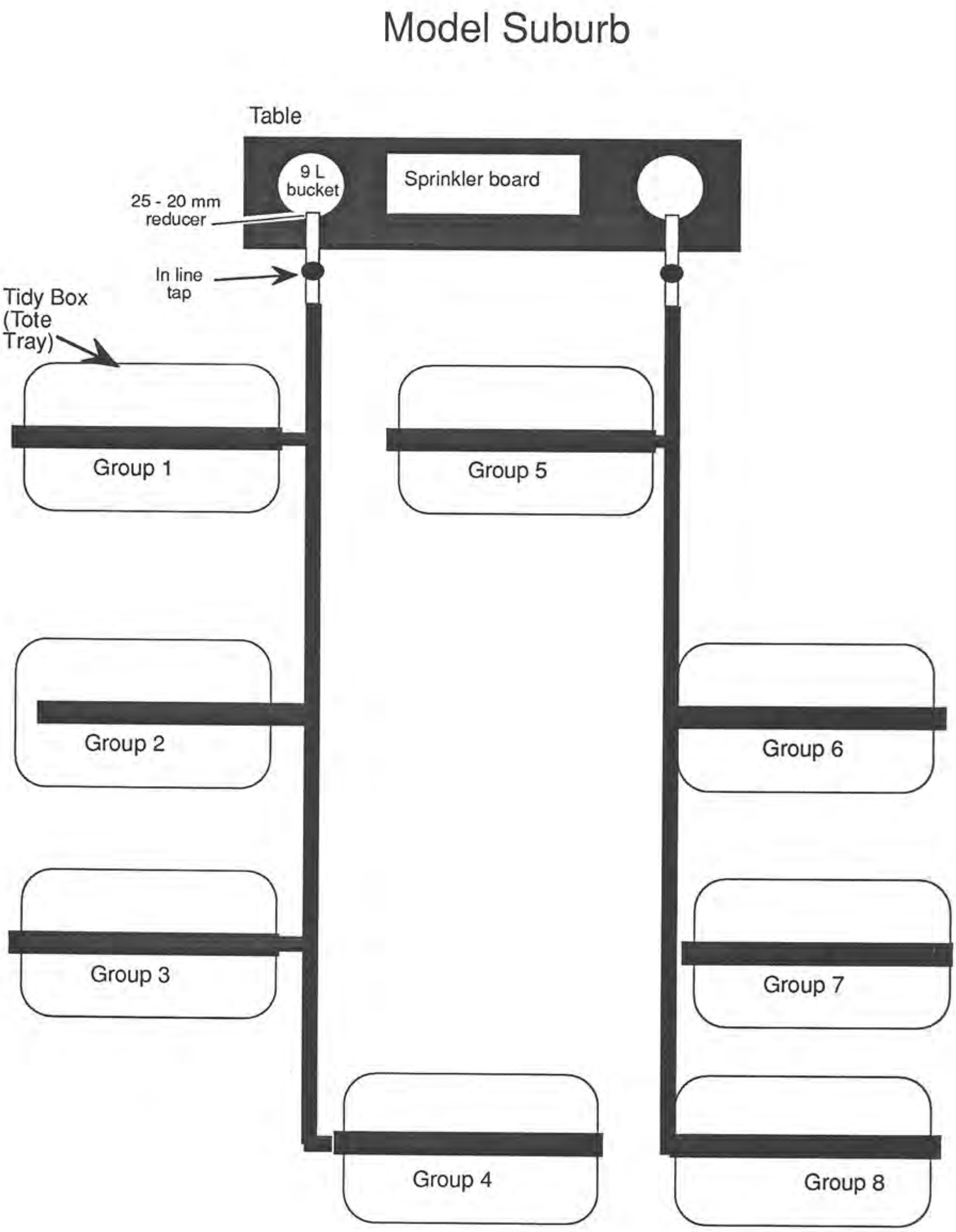
The lesson is conducted outside and establish some rules for discussion. The excellence in teaching technique for when the teacher raises his or her hand with other students following suit until all the students hands are raised and students are quiet is not a bad technique. Remember the students are playing with water and this seems to create that added discipline dimension.

The layout should be done beforehand if you only have 35 minutes. Ideally a double period will allow more scope for experimentation.

Outside layout

Assuming you have a class of 32, divide the class into 8 groups of 4.

Make two reservoirs and connect half the class to one and half the class to another. The reservoirs are the same as described in the Primary School game.



Part A Water Wasting

The layout is ready for the students at the beginning of the lesson.

- ★ The polypipe has six holes already punched in.
- ★ The in-line tap is off, the T piece has been connected to the polypipe that connects the other suburbs together and the last house has an extra short piece of tube with an end stop so that the system is closed.

The houses are introduced to the water wasting situation and then students are given the following from the water board:-

- ★ 4 riser tubes with veriflow sprinkler attachments
- ★ 1 microspray with the top removed
- ★ 1 drip irrigator with the green tap off

Students screw these in and when all is ready and the teacher has reinforced the situation with a few more questions, the tap at the reservoir is opened and the time noted.

Students observe the water flow and the note the time it took for the buckets to empty.

Part B WaterWise

Students disconnect all but the drip irrigator and bring these back to the board. They are then given the following:-

- ★ The green cap to the drip irrigator - this could represent a change in attitude E.g.: turn the tap off when you brush your teeth.
- ★ 2 x half circles representing a half flush toilet, shorter showers, drip system in the garden
- ★ 2 x full circles representing full loaded dishwasher or washing machine
- ★ 1 x microspray - water saving shower, platypus valve in system

The reservoirs are filled, the experiment repeated and the time taken.

Students then calculate how much extra time/volume of water they could get from a reservoir as a result of a change in attitude or water saving device.

Students then return the devices to the board, return to the classroom and record their results and findings

Part C Class discussion - experimental write up

Students complete and Aim, Apparatus, Method, Results for homework or class time and then participate in the following discussion

1. Make a list of water saving devices or attitudes you could employ in each of the following places:
   (a) Shower
   (b) Toilet
   (c) Vanity Basin
   (d) Kitchen sink
   (e) Laundry
   (f) Backyard
   (g) Front Yard

2. How do you wash a car?
3. How do you make a plants roots grown deep into the ground?
4. How does a water saving shower work?
5. Why do we need to conserve water?
6. Why does a drip system save water?
7. What is a Platypus valve and how does it work?
8. What is a microspray and how does it work?
9. How many litres of water do we use daily?
10. By how much % do we need to reduce our water use to defer building any more dams forever?

WaterWise Activities

These activities are designed for a multiplicity of purposes. It is recognised that each class will be different and each activity can be used in a different way. It is believed that by increasing knowledge and awareness over time, the attitudes of students will change in the home so that as urban water users of the future they will display the following characteristics:-

1. When purchasing a first home will install water reduction flow plumbing.
2. When landscaping their first home will choose a drip system and plant a garden that uses low volumes of water.

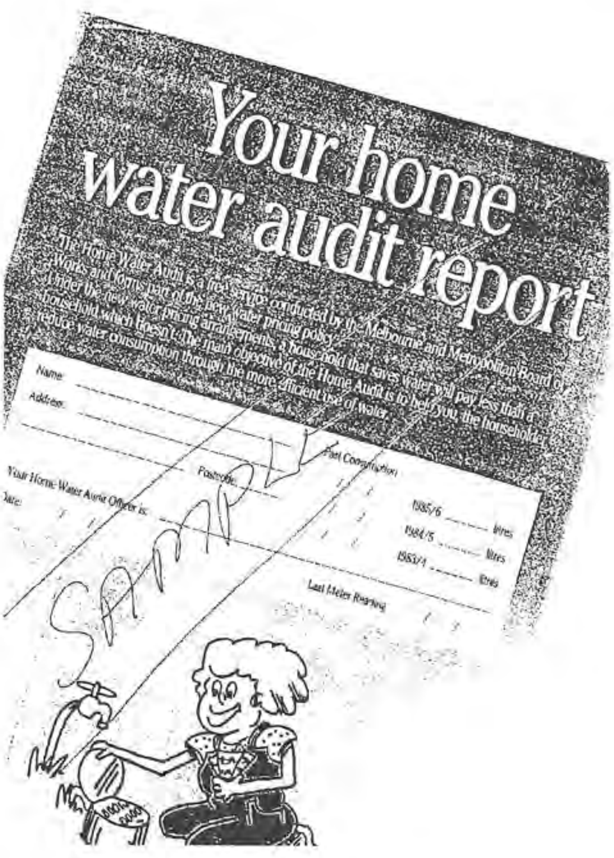
It is hoped also that present attitudes will change to water use and we hope students will

1. Take shorter showers and turn off the tap when they clean their teeth
2. Use buckets to wash their or their parents cars
3. Encourage their parents or grandparents to adopt water conservation behaviours such as:
   Watering the lawn in the morning or in the evening on low wind speed days

The home water audit

With schools now paying for excess water use, this activity should increase the awareness of school Principals who will pay for water use shortly from their school budgets.

Students learn how to read the school water meter, detect if their are leaks in the system and then calculate the water use at various times during the school day.



By using an in line water meter, students determine how much water is used by a sprinkler using normal flow followed by experiments with a water reduction flow device.

The home water audit activity is an activity that is designed to estimate how much water your home is using providing the background knowledge for conservation attitudes.

1. How to read your water meter

Students locate their water meter at home and experiment to see how it works, how it is read and how accurate it is. By turning off all taps in the house they determine if they have a leak or not. If so get it fixed and they continue with the experiment.

2. How does your house plumbing system work?

Students use worksheets and direct observation to work out how water gets to their house. They examine cutaway diagrams of taps, toilets, baths, showers, dishwashers and sinks to understand how each of these components uses water and describe how each functions and what additional requirements are added to water. Finally they look at the ways the waste water is removed from each of these and research the use of chemicals.

Aims

- To directly observe water pipes in the sink, toilet, shower, laundry, dishwasher and garden.
- To distinguish between waste and storm water.
- To understand the use of a water trap in a toilet.

3. How much water do you use.

In the bathroom. Using the water meter, students measure, in litres, how much water a

- 5 minute, 10 minute and 15 minute shower uses.
- half flush compared with a full flush
- how much water is used to clean your teeth if you leave the tap on
- how much water is used in a bath

In the kitchen. Using the water meter, students measure, in litres, how much water

- a dishwasher uses
- is used by washing up by hand
- is drunk by a child and by an adult

Washing the car or hosing the lawn

4. Home Economics

What are the costs involved in setting a house up with el chepo tap fittings and washers. What are the regulations required for local areas and the setting up of new home. Students investigate the

5. Train your plant

Use a moisture meter to see how little water a plant can do without.

6. How waterwise is your plant.

Students experiment with a variety of plants to see which plant uses the most water.

7. What makes a tap drip?

Students make up a model tap and investigate

8. How does a tap work?

Students get an old tap from a plumber and pull it apart to see the washers and other parts that go into making up a tap. They suggest ways that a tap can drip and how pressure influences performance.

9. When to water?

Students investigate water evaporation of a controlled volume of water under a variety of conditions such as low humidity, high humidity, low temperature, high temperature, low wind velocity, high wind velocity to determine under what conditions water will enter the ground and be available for a plant.

10. The drop test

Waterwise community decides to test to see if there are any leaks in the system and agree to shut down all water use for 4 hours to see if their reservoir drops.

11. Which plant uses the least amount of water?

Students experiment with a variety of plants to see if some are more resistant to others to receiving less amounts of water.

Students see if they can determine the critical dosage of water needed to grow the biggest plant with the least amount of water

12. How does a plumbing system on a house work

Students examine their house plumbing system and create a drawing of where water pipes and waste water pipes go. Be careful of spiders and snakes.

13. Does your neighbours house have a leak?

Having examined a number of places where leaks can occur, students investigate their neighbours house for leaks and make a report.

14. Does your own house have a leak.

Students investigate, potential places for water leaks in a house.

15. Does water soak into soil at different rates/

By using a set profile of soil students measure the absorption rates of water in soil by drips, spray, bucketful.

16. Does mulching have any effect on water evaporation from soils?

Students create a control and experimental situation with soil and by using a water moisture meter, to determine which condition holds water for the greatest amount of time.

17. How much water does a drip system deliver?

Students experiment with a drip system to see how much water is used in 20 minutes

18. How does a timer work on a drip system.

Students pull apart an old timer system to see how it works

19. What plants use water ....??

Students set up a control and experimental plot to investigate which grouping of plants are most successful

20. What creates problems for sewage systems/

By interview at the waste treatment plant, students discover what materials create the greatest problems for treatment.

21. Pressure in water

By using a bucket etc. as shown in the diagram below, students discover aspects about water pressure.

22. Why is there water in the bottom of the toilet bowl?

This activity looks at some basics of how a toilet works and the importance of half and full flush mechanisms. It includes and article from WA situation.

Using the water meter, students measure, in litres, how much water household appliances use.

23. WaterWise plants

Can you invent a new plant? Use natural and human materials of any type to create a plant which will do at least one of the following:

- can live in shade or sun
- is lawnmower proof
- can store water
- can catch insects
- can put up with strong winds
- can hold onto rocks in fast moving fresh or salt water
- can grow on a perfectly smooth surface
- does not require watering
- does not require clean air
- is pretty to look at

Now have a display of your plants. Did any 'invention' have all of the above characteristics?

25. WaterWise art

1. Movement in Water Mural.

Each member of a small group watches an area of water - flowing or still, thinking about the idea of movement in water. Each student then makes a design based on water movement.

The group then combines the designs to construct a mural for class display.

The mural can use textures and colours from the water, (students could make rubbings or drawings of suitable shapes and textures), and can use paint, cellophane, plastic, string, pebbles, glass, paper, and any other medium. Display.

2. Water Sculpture.

As water provides such a sculpturing agent, smoothing, moving, grinding rocks, boulders and wood, it can provide much inspiration. Students can make 3-dimensional sketches to use as the basis for sculpture.

Rubbings on paper or textures can be prepared using crayons, chalk, boot black or shoe polish. Then students can prepare sculpture in clay, dough or to present their own idea about water.

26. School water day

Declare, with permission from your principal and teachers, a "Water Day" in your school. Initially, groups should brainstorm the types of message about water which they see as important to explain, and work out the types of activities which will best suit these aims.

Jobs then need to be allocated, venues selected and the procedure explained to both staff and the school to get full support.

At the end of the day, have an evaluation session

- what worked?
- what was popular?
- what caused the most discussion or debate?
- what was accepted and what was rejected by the school?
- what was the most bother to arrange?
- who is going to carry out the further actions needed to implement some of the changes?
- would you do the day again?

Some suggested activities include:

1. Prepare posters showing different aspects of the water cycle, water pollution, treatment of waste water, human impacts on the water cycle, and personal action required to save water and decrease water pollution. Display around the school.
2. Prepare and produce a drama production with the theme of water. The production needs to be suitable for ' street art'
3. Arrange for some outside speakers to visit school and give seminars or lectures. Planners and environmental officers from the City Council and from the Gold Coast Conservation Council and Wildlife Preservation Society (Gold Coast Branch) may be able to help.
4. Individual students prepare talks of about 5 minutes and stand on soap boxes around the school yard to give their opinions. Be prepared to argue with the listeners! Justify your opinions.
5. Design a placard stating something like" This is wasting water", or "This pollutes". Hang the placards at various places around the school drawing attention to environmentally unfriendly practices. Places could include dripping taps, leaking toilets, basins or troughs without plugs, hoses being used instead of brooms to clean up the yard, over watering of non-native plants, spraying pesticides on lawns, single flush toilets, wide nozzle shower heads in the swimming sheds etc.

   Having drawn attention to the problems, design some action to solve them! For example, draw up a petition to the school authorities to fix the wasteful practices, provide plugs or new tap washers; approach the groundsmen about using hoses and sprinklers; produce notices in the showers and at the wash troughs to save water.....
6. Appoint some official photographers for the day and see if they can capture on film/video good and bad practices involving water. These can be shown later.
7. Approach the local newspaper and see if a reporter can attend the Water Day.
8. With the assistance of the science staff, design and display some experiments involving water and water pollution. Aquaria could also be specially prepared with extra displays.
9. Organise a clean up campaign in the local creek, beach foreshore or stormwater gutters at the school. Remove and carefully dispose of all litter items, remembering that every piece of nylon line, plastic bag and foam could land up in the sea and affect wildlife. You could record the rubbish collected and sort it into different types to see which is the most common.
10. Have a staff versus student race carrying mugs of water while being tied together 3-legged. Or try a race carrying buckets of water to water individual trees around the school. Competitors spilling their water are penalised.
11. Arrange for a tree planting ceremony: Approach the Council or Greening Australia for assistance with plants which are suitable for your school grounds. Parents and Friends Associations may also help. You may also be able to collect see from native plants around the school and propagate these for later planting. Local plants always do better than 'exotics'. Each plant in should be accompanied by a long lasting label stating the type of tree and date.
12. Prepare a collage or mural on the theme of water and be prepared to explain it to other students.
13. Ensure that the tuckshop has plenty of cold water on the day - then you could ban the sale of commercial soft drinks, and donate the proceeds of those lost sales (shoppers get a drink of water instead) to a charity organisation involved in supplying drinking water to developing or Third World countries. (eg Freedom from Hunger, Action for World Development, Save the Children Fund, and several local church groups.)

Upper Secondary

Lectures and demonstrations

Lectures and demonstrations are available by contacting:

Bob Moffatt
14 Milbong Tce
Ashmore 4214

Telephone or Fax

(075) 39 4187

Lecture 1

Water supply and conservation

Objectives

At the conclusion of this lecture you should have knowledge of:

1. What a catchment is and its importance in the collection of high quality drinking water.
2. The local water cycle and how dams interrupt this cycle
3. How trees in the catchment area filter rain and contribute materials to dams
4. The structure of a local dam
5. The water quality problems associated with damming water
6. The overall structure of a water treatment plant
7. How a clarifier works in treating water
8. How anerobic bacteria in a dam obtain oxygen
9. The difference between summer and winter dams
10. Some dam chemistry involving microorganisms
11. The difference between summer and winter bugs
12. How nitrogen and phosphorous levels are monitored and how the ratio effects algal populations

Timing

25 minutes

Key concepts during lecture

1. The water cycle when interrupted by a dam, creates special problems in a catchment.
2. Sub-catchment management above the dam is important to maintain good quality raw water for treatment. Point out roles of trees, grasses, human activities
3. Less energy can be expended in the treatment process if raw water is well maintained. Point out in the treatment process that a lot of effort is expended in removing suspended matter and manganese. The best water is found in the upper layers.
4. Chlorine is added to the water supply to kill bacteria in the pipes as they carry water to the home. Ozone is being experimented with to replace chlorine as it is harmful tot he environment.
5. Water could be conserved in a house by installing a rain water tank or water saving devices such as showers, taps or valves

Thirty questions around the class for whatever reason may be appropriate

1. Why are trees in the dam sub-catchment important in purifying water?
2. Why doesn't a dam leak?
3. Where do dam bacteria live and what do they do with dissolved oxygen in winter?
4. How does oxygen get down to the bottom of the dam in winter?
5. How do bacteria use this oxygen in the winter dam?
6. When summer comes, how do bacteria behaviour change?
7. What is the effect of this depleted oxygen supply?
8. Where does the phosphorous and nitrogen go?
9. What is the effect of this release of nitrogen and phosphorous in the upper layers of the dam.
10. What is the N/P ratio to cause this algal bloom?
11. What is the effect of an algal bloom?
12. How are algal populations monitored in the water supply?
13. How does water get to the treatment plant from the dam?
14. When it enters the treatment plant what happens it the raw water is of high quality? Of Low quality?
15. What is the name of the large tank with the rotating arm that provides a place for the water to settle?
16. What is collected at the bottom of the clarifier?
17. What happens to this mud?
18. What is the name of the water that is collected off the upper layers of the clarifier?
19. Where does this clarified water go?
20. What is added before it is filtered?
21. Why is chlorine dioxide added?
22. What is the substance formed called?
22. How is this manganese dioxide removed?
23. How often does back washing occur?
24. What happens to the backwashed materials?
25. What is added to the filtered water and why?
26. Where does the filtered water go?
27. Why do we have to pump the water to a reservoir?
28. How does water a suburban street?
29. How is water turned off in the street and name one purpose?
30. Where does water enter the house and how is the flow rate measured?

Lecture 2

Water Reticulation and Conservation

Objectives

At the conclusion of this lecture you should have knowledge of:

1. The overall process and purpose of water reticulation and domestic water use with particular reference to:
   (a) domestic water use
   (b) tap components and function
   (c) water flow and flow rates
2. Water distribution to the community in general with specific reference to the local area

3. How leaks are detected inside and outside a house
4. How some household water appliances work including a
   (a) shower
   (b) toilet
   (c) washing machine
   (d) dishwasher
5. The difference between full and half flush toilets
6. What a composting toilet is and how it works
7. The difference between waste water and storm water
8. How a water meter works and how to read it

Timing

35 minutes

Key concepts during lecture

1. A tap controls the flow rate of water
2. Water is distributed in a house by a series of pipes
3. Water is heated in the house by a hot water system (solar, gas, electric)
4. After connection to a tap, water can be used in an uncontrolled manner in water using appliances (washing machines and dishwashers)
5. Humans are rewarded for the use of water by seemingly pleasurable experiences reinforced by attitudes from a non-conservationist era. The lush green lawn ethic and long hot showers are examples of this ethic.
6. The price urban dwellers will pay for overuse of water will be measured in terms of environmental degradation.
7. Water conservation is just one part of a total change in attitude people need to adopt to maintain our present lifestyle future generations.
8. Water can be conserved inside and outside the home by water saving appliances and a change in attitudes.

Questions around the class for whatever reason may be appropriate

1. Name five places what goes to after entering the house.

Bathroom questions

2. How does water in a shower get hot.
3. How can the pressure in the shower be controlled?
4. How does a water saving shower work?
5. How many litres a minutes does a shower use?
6. If you had a five minute shower, how much water would you use?
7. When you have a shower, what do you wash of your bodies?
8. Where does this waste water go?
9. IS there any need to send it tot he wastewater treatment plant?
10. Where could you send it?
11. What are the two parts of a toilet called?
12. How many litres flushes in a full flush?
13. A family of five goes to the toilet each day three times. How much water do they send to the sewer pipes?
14. Do you think you need to full flush a toilet all the time?
15. How do you feel about a waterless toilet? How doe you think it would work and what precautions would you have to take?
16. What is the composition of our solid human waste? Our liquid human waste?
17. How can we save water when we brush our teeth?
18. How can we save water when we take a shower?

Laundry questions

18. Washing machines are connected to cold and hot water taps. Why?
19. Which uses more water? Front or top loading washing machines?
20. Why have washing machines with a AAA and AA and A rating?
21. Name four things that come of clothing when they are washed.
22. Where does this dirt, sand, fluff, bacteria etc. go?
23. How can you save water with washing machines?

Kitchen questions

24. How does a dishwasher work to clean dishes?
25. How much water does it use compared to washing dishes in a tub
26. What is added to water to clean dishes?
27. Where does this wastewater go?
28. When preparing vegetables, how can we save water?

Garden questions

29. A sprinkler runs for an hour how much water does it use?
30. If 1000 litres are used by one sprinkler, 1000 homes on a hot summer afternoon using the same rate would use how much water?
31. What is a microspray and how is it used?
32. Which will deliver more water - a full circle or half circle dripper?
33. What is the effect of using a dripper system on a plant?
34. What is wrong with hosing on a windy day around lunchtime?
35. If you want to encourage plants to develop shallow root systems which require a lot of watering, what should you do?
36. What's wrong with hosing the path to remove leaves?
37. How do you WaterWise wash a car.
38. How is mulch made and how does it prevent water loss from the ground?
39. Why are weeds bad for conserving water?
40. Why is a trigger hose better for watering a lawn?
41. How do you check for leaks around the house?

Lecture 3

Waste Water Management

Objectives

At the conclusion of this lecture you should have knowledge of:

1. Some common terms associated with sewage
2. Wastewater and its composition
3. Sewer Systems
4. Wastewater pollutants
5. Primary and secondary treatment processes and the "bugs" role in activated sludge
6. The effects of chlorine
7. Tertiary treatment
8. Clarification
9. How local sewage treatment plants work
10. The roles disinfection and ponding play
11. How effluent is disposed of
12. Storm water

Timing

35 minutes

Key concepts during lecture

1. Sewage is liquid domestic and industrial waste
2. Sewerage systems have been constructed to manage the health of the urban community
3. Waste water pollutants create problems for waste treatment plants
4. The less water we use, the less has to be treated
5. Primary treatment involves the settling of solids, secondary treatment involves the removal of solids, tertiary treatment involves the removal of dissolved nutrients
6. Removal can be by biological or membrane filtration techniques
7. Removal by biological means involves controlling microbiological processes
8. Reclaimed water from secondary treatment can be used on the land for irrigation
9. Reclaimed tertiary treated water can be returned to the domestic water supply and consumed by householders
10. Reclaimed secondary or tertiary treated water can be pumped to the sea and diluted with seawater. Nitrates and phosphates dilute in the sea to about 0.1 or less mg/litre

Questions around the class for whatever reason may be appropriate

1. What is sewage and what is sewerage?
2. Why have sewerage systems been constructed in urban communities?
3. Name four places sewerage comes from in the house.
4. About what percentage of wastewater is actually water?
5. What is the remaining 0.06% composed of?
6. Approximately how many litres of wastewater each day does each individual contribute to a city sewerage system?
7. What happens in the Pre-treatment process in a wastewater treatment plant?
4. What is the difference between a storm water system and a sewerage system in terms of treatment?
5. What are the four wastewater components that are of major concern to us?
6. Wastewater is made up of organic and inorganic materials. Name three organic materials and three inorganic materials that require treatment.
7. What is the principle in removing solids?
8. What is the principle involved in removing soluble inorganic nutrients
9. What happens in the pre-treatment process at a wastewater plant?
10. Why is chlorine added?
11. In the Elanora treatment plant, settled sediment is passed to a digester. What happens here? What gas is given off?
12. Why don't we use the gas from Elanora to power council buses?
13. In natures "sewerage system" bacteria in the mud remove any organic and inorganic materials.

    (a) how do they remove the organics and under what conditions?

    (b) how do they remove the inorganic nitrates and phosphates and under what conditions?
14. When we referred to bugs, what organisms were involved?
15. Under normal conditions, the bugs will eat organic matter. How much dissolved oxygen in mg/litre is required?
16. For fish to live, 5 mg/litre is a generally accepted value. What is the effect of placing organic matter in a stream that will exceed this value?
17. When bugs extract nitrogen from the nitrates, where doe it go?
18. When bacteria become anoxic what do the eat?
19. In secondary treatment, what do bugs eat and what assists them?
20. What does chlorine do to bugs?
21. Is chlorine harmful tot eh environment and what is its effect?
22. What happens in the activated sludge ponds at Elanora?
23. What happens in clarification?
24. What is another word for reclaimed water?
25. What colour is this effluent?
26. Does clear water necessarily make it safe to drink? Why?
27. The reclaimed what from Elanora contains what concentrations of nitrate and what concentrations of phosphate?

28. Reclaimed water from the clarifier is passed to a disinfection tank. What happens here?

29 The chlorinated reclaimed water flows to the ducky pond where it is stored before release into Tallebudgera Creek. Why?

30. Where is reclaimed water used on the southern end of the Gold Coast?

32. The new pipeline will pick up this reclaimed water and pump it where?

33. Along the way it will pick up further reclaimed water from Mudgeeraba. Why?

34. Coombabah has specially shaped activated sludge tanks. Why?

35. Where are the anoxic stages in the carousel at Coombabah?

36. What happens in the aerobic zones of the carousel at Coombabah?

37. What happens in the anoxic zones?

38. The bugs with their organic material and nitrate pass into the clarifier. What happens here?

39. After clarification, the reclaimed water is disinfected. What with and what environmental problems does this create?

40. Which golf courses draw water from the ponds at Coombabah?

41. Where does the rest of the reclaimed water pass from Coombabah?

42. How much nitrate does Coombabah reclaimed water contain in mg/l?

43. How much phosphate does Coombabah reclaimed water contain in mg/l?

44. This reclaimed water dilutes by 1/100 by the time it reaches the end of the seaway wall. What are the percentages of nitrate and phosphate now?

45. $64,000 question ... Is this harmful to the environment and if so why or why not?

Excursions

Hinze Dam

Contact:
Alan Butler
Senior Park Ranger Hinze Dam
Upper Gilston Rd Advancetown
Telephone: 817 645

Little Nerang Dam

Contact
Col Gallagher
Park Ranger Little Nerang Dam
Nerangwood via Mudgeeraba
Telephone: 817 640

Mudgeeraba Water Treatment Plant

Contact
Chris Moustoukas
Supervising Engineer Mudgeeraba
Waterworks Rd Mudgeeraba
Telephone: 817 150

Molendinar Water Treatment Plant

Contact
Bob Burness
Supervisor Molendinar Treatment Plant
Harper St Nerang
Telephone: 817 013

Elanora Waste Treatment Plant

Contact
Tony Sharry T
Technical Supervisor Headworks
John Connolly
Technical Supervisor, Pump Stations
Tallebudgera Dr
Palm Beach
Telephone 35 2555

Merrimac Waste Treatment Plant

Contact
Les Miller
Treatment Plant Operator
Boonaggon Rd
Merrimac
Telephone: 304382

Coombabah Waste Treatment Plant

Contact
Jim Minnet
Technical Supervisor
Sewage Treatment Plant
Telephone 817 102
Ted Cusak
Senior Engineer, Process Control
Telephone: 817 108
Brisbane Rd
Labrador
Fax 817 124

Beenleigh

Stan Stevenson
Treatment Plant Operator
Logan Rd
Beenleigh
Telephone: (07) 2872848

General Enquires

Gold Coast
The Water Supply and Sewerage
Telephone:
Howard Karl
Supervising Engineer 816 252
Albert Shire
Shaun Cox
Water Supply and Sewage Engineer
Telephone 780 313

Hands on experiments and demonstrations

These can be performed at your school using class sets of equipment from Moffatts Consultancy. School pays for breakages only. All other equipment is supplied.

1. Dissolved Oxygen

Objectives

Students should have knowledge of:-

1. The reagents used to measure the volume of dissolved oxygen in mg/litre
2. The accepted levels for a healthy estuary and the values that indicate pollution of oceanic water.

Timing

35 minutes

2. Total nitrogen

Objectives

Students should have knowledge of:-

1. The reagents used to measure the volume of nitrogen in mg/litre
2. The accepted levels for a healthy estuary and the values that indicate pollution of oceanic water.

Timing

35 minutes

3. Total Phosphorus

Objectives

Students should have knowledge of:-

1. The reagents used to measure the volume of phosphorus in mg/litre
2. The accepted levels for a healthy estuary and the values that indicate pollution of oceanic water.

Timing

40 minutes

4. Faecal coliforms

Objectives

Students should have knowledge of:-

1. The reagents and equipment used to measure total coliforms per 100ml of water
2. The accepted levels for a healthy estuary and the values that indicate pollution of oceanic water.

Timing

50 minutes

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