Drainage

Plumbing Services Series

3rd Edition

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R.J. Puffett, L.J. Hossack

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Contents

Preface

This text provides an overview of how we deal with the collection, treatment and disposal of waste. We look at the common collection and treatment of sewage and the processes involved with these, and then, we explore alternative methods of disposal, for example, where a municipal facility is not available. The text then progresses through the processes of 'laying up' a drain from excavation considerations and levelling procedures to drainlaying principles and practices. Treatment of trade waste on-site is also discussed and, as with most things, it varies from area to area. Your local manufacturers are a great resource in this respect. They have already done the groundwork as to authority requirements to provide products that meet their needs.

The final chapters deal with what happens above ground, namely 'stackwork' and installation of fixtures. The basis for the regulatory information in this text has been the standard AS/NZS3500 which is applicable to most areas and adopted by most authorities.

New to this edition

This latest edition is an update of the earlier editions prepared by Bob Puffet and Len Hossack and brings the text into the twenty-first century, although it must be said that many concepts and principles are timeless. As already stated, the basis is AS/NZS3500, and as such, the references to items such as 'maximum lengths', 'depths' or 'grades' have been sourced from this document. Many of the figures from past editions have been recreated as they still apply to today's requirements, and photographs have been added to further illustrate and support the text.

So what is new? Even though 'it still flows downhill', how it gets there is changing, with new materials such as polyethylene becoming more popular and venting arrangements becoming more progressive. It was not so long ago that air admittance valves were only used where open venting was not practical, now it is an accepted alternative method of venting highlighted in the standard (provided there is at least one open main vent). We researched the latest products and we sustainable practices, such as aerated wastewater treatment systems and greywater re-use systems.

This book is intended to be a guide to supplement your on-the-job experience. Given the limitations on what could be covered, we have repeatedly recommended that you check with your relevant local authorities as to their specific requirements in plumbing and drainage, as these do vary. Enjoy the text!

Rob Kavanagh and Peter Miles

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- InSinkErator (Figs 9.28a, 9.28b)
- Southern Cross Stainless Steel (Fig. 9.34b)

About the authors

Bob Puffett

After serving as the Head of School of Plumbing and Sheetmetal in NSW, Bob Puffett went on to be Director of Staff, Principal and Assistant Director General, TAFE. Bob was made a Member of the Order of Australia (AM) for his contribution to Technical Education as Director of the Sydney Institute of Technology. Following his 'retirement' Bob became National Chairman of WorldSkills Australia. He now serves on local community organisations and is a Board member of a NSW plumbing training organisation.

Len Hossack

Len Hossack is a former Head of School of Plumbing, South Australian Department of Technical and Further Education and has been actively involved in his local community and with the plumbing industry in South Australia for many years.

Robert Kavanagh

Robert Kavanagh contributed chapters 1, 2, 6, 7 and 8 of *Drainage*. He currently holds the position of Training Co-ordinator at the Plumbing Industry Association of South Australia. Robert has been a VET plumbing teacher since 1987 and is a qualified Master Plumber with a lifetime of plumbing experience, having entered the industry at the age of 17.

Robert's qualifications include the Advanced Certificate in Plumbing, a Bachelor of Teaching in Adult Education, Certificate IV in Workplace Education and Certificate IV in Training and Assessment. He was responsible for introducing a Certificate I in Plumbing to high schools throughout Adelaide in partnership with the Department of Education and Children's Services (DECS). He is also the author of *Basic Skills* in the Plumbing Services Series.

Apart from his extensive plumbing experience, Robert has also been teaching sailing for many years at North Haven in South Australia. After many years of sailing and study he gained his Master V Certificate in Maritime, which allowed him to gain a position as Second Officer on the sailing ship the *One and All*, sailing in Australian waters.

Peter Miles

Peter Miles contributed chapters 1, 3, 4, 5 and 9 of *Drainage*. He is currently the Head Teacher of Plumbing at North Sydney TAFE and has been teaching since 1988. Peter entered the plumbing industry at the age of 15, as the trend at the time for those wanting a trade was to leave in Year 10 and enter the workforce. He later moved into the teaching profession after being inspired and encouraged by several of his teachers.

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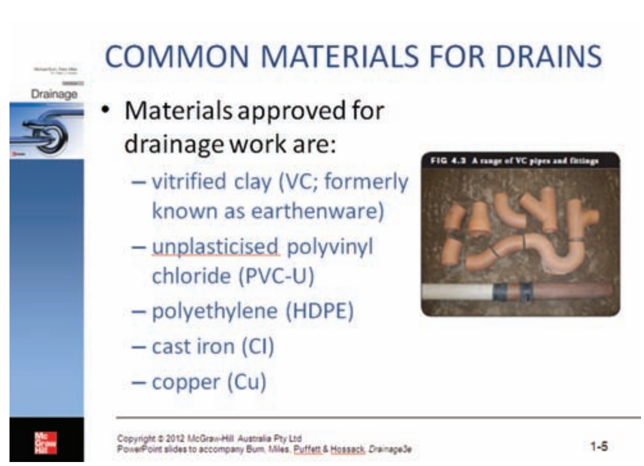

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All the illustrations from the text are provided in a convenient ready-to-use format.

Solutions Manual

The solutions manual contains worked solutions to the chapter exercises provided at the back of the book.

LEARNING OBJECTIVES

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1.2	Sanitation in Australian cities	2.2	The types of sewage treatment processes
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PART 1 INTRODUCTION TO DRAINAGE

Plumbing Services Series

layout

CHAPTER **ONE**

The history of sanitation

LEARNING OBJECTIVES

In this chapter you will learn about:

1.1 sanitation in ancient times

1.2 sanitation in Australian cities

1.3 plumbing regulators in Australia.

INTRODUCTION

Good health and economic prosperity in large populations are only possible where proper drainage and sewerage are provided, and their importance should not be underestimated. In fact, it is said that plumbers ensure the health and prosperity of a nation. To prove this we need only look at the great civilisations of the past and how they were able to grow because they learned how to provide this basic but essential service.

In this chapter, we take a brief look at the history of sanitation, from ancient times to modern, highlighting the important roles of plumbing and draining. We refer to the plumbing industries in both Australia and New Zealand and discuss the history of drainage in Sydney and Adelaide. The chapter concludes with a discussion of plumbing regulators.

SOME DEFINITIONS

- **Drainage** is the method by which the proper disposal of unwanted and hazardous waste products is achieved.
- **Sewerage** is the method by which an effective drainage system is established.
- **Sanitation** is the term used to describe the provision of effective measures to remove human waste products.

A BRIEF HISTORY OF SANITATION

Throughout history attempts have been made to institute proper methods of water supply and disposal in cities and towns. These varied in their success, although the Romans appear to have been particularly ingenious, developing advanced methods of water engineering to provide clean water for drinking, washing and bathing. In general though, as soon as the first cities were established, the accumulation of filth and its consequent diseases, such as cholera, became a problem. Water supplies became polluted and devastating plagues were inevitable.

Before the nineteenth century in Australia, plumbing and drainage were uncommon in towns and cities, and urban life was very different to today. However, in the early nineteenth century, with the coming of the industrial age and new technologies, governments responsible for municipal health began to call for improved sewage removal infrastructure to be established. Drainage systems began to be installed across cities and a vital industry was born.

Ancient civilisations

Evidence has been found of the existence of sometimes surprisingly complex sewerage schemes in ancient civilisations, such as those of Babylon, Greece and Crete 3000 years ago, and in Rome up to AD 455. The Romans expended great energy building aqueducts that could channel clean water from mountain areas to cities (Figure 1.1). They also used lead-tube systems to prevent water from being stolen on its long journey to the cities. In India, in the Indus Valley, standardised earthen plumbing pipes with broad flanges and lined with asphalt to prevent leakage have been found in archaeological ruins dating back to approximately 2700 BC. Although the technology is impressive for its time, it should be remembered that towns were not so densely populated and waste disposal was a less complex problem to solve than it is today.

FIG 1.1 A Roman aqueduct

The Middle Ages

During the Middle Ages, from the fifth to the fifteenth century, England and Europe were the most densely populated areas of the world and sanitation was poor. Streets were narrow, with buildings corbelled out, limiting the access of sunlight and fresh air.

Sanitation was practically non-existent, with all household slops and excrement thrown out into the streets. In houses of more than one storey, chamber pots and commodes were used for human waste, and it was the custom to throw their contents out into the streets. Where sufficient open space was available an earthen closet, consisting of a seat mounted over a hole in the ground, sufficed as a toilet. Unsurprisingly, life expectancy was low, at around 35 years. It was not until the industrial revolution, in the late eighteenth and early nineteenth centuries, that any serious attempts were made to introduce effective drainage and sewage disposal systems.

The eighteenth century

Improvements in plumbing systems were very limited during the eighteenth century, with virtually no progress made. The sewers of this time were very similar to those of ancient civilisations, consisting of flat stone slabs on the tops and bottoms of trenches, with sides made of brick and masonry. They were intended to serve as stormwater drains from streets and buildings but soon became odorous and foul from sewage and garbage dumped into streets.

Many cities around the world at this time installed stormwater collection and disposal systems, but people living in overcrowded conditions continued to dump their rubbish, fouled water and filth into the stormwater channels. This created a 'sewer and stormwater' or 'combined' system. Most of the older cities had such an arrangement.

The nineteenth century

In the nineteenth century, public health authorities began pressing for the installation of better waste disposal systems. Eventually the development of separate, underground water and sewage systems eliminated open ditches and cesspools.

During this century, considerable thought was invested in sewerage design. The authorities, accepting that people must dispose of their wastes, installed separate sewage and stormwater conduits. In newer cities, separate schemes predominated and are linked to more modern internal facilities.

The reasons for establishing separate schemes included:

- Stormwater is comparatively pure and may be discharged into rivers without treatment. It can also be harvested for re-use.
- Depending on rainfall, sewage may constitute the lower volume of waste in a separate scheme, and this lower volume is a major advantage, requiring less money to be spent on treatment facility construction.
- In combined schemes, overflow outlets must be provided when heavy rain occurs to prevent flooding of treatment works. Some cities, such as Chicago, situated on the Great Lakes in the United States, must purify all storm and sewage water to prevent the fouling of the nearby lakes and rivers that are also their sources of drinking water.

THE PROGRESSIVE IMAGE OF SEWERAGE SYSTEMS

The development of sewerage systems, resulting in cleaner, more pleasant and attractive cities, had a significant impact on urban growth. Where a city was in competition with others for population and investment, it was generally recognised that connection to a sewerage system increased real estate values. In the nineteenth century, sewerage works and water supply were considered business investments because of this effect on property prices. Today, no urban development, whether domestic or commercial, is even possible without this largely invisible but crucial service.

A FOCUS ON SYDNEY

Sydney grew at a phenomenal rate through the nineteenth century. In the nearly 20 years between 1861 and 1880 the city endured a population explosion, placing huge demands on the infrastructure. The impact of improved sanitation on health, although clear in other cities, was not so marked in Sydney until after 1880 when development was able to catch up with population growth.

The first city sewers were constructed in the 1850s and discharged raw sewage directly into Sydney's harbour at Fort Macquarie (now Bennelong Point, the site of the Opera House). By 1875 there were sewage outlets at five different points in the harbour. The discharge caused a major nuisance to the city and to the harbour, rendering all occupations along its shores offensive and increasing the prevalence of illness. It also contributed to the silting up, year by year, of the navigable water.

In 1877, the Sydney City and Suburban Sewage and Health Board recommended that the city sewage be intercepted and diverted. As a result of their proposal, the city's north-draining sewage was piped to Bondi and discharged into the sea, and the south-draining sewage, including that of Surry Hills, Redfern and Newtown, was piped to a sewage farm near Botany Bay.

In 1900, an epidemic of bubonic plague in the poorer parts of Sydney killed 103 people. The disease thrived where dry closets were shared by too many people living in

FIG 1.2 The Sydney City and Suburban Sewage and Health Board, 1875

unventilated housing with little or no drainage, and where night soil collection was not properly supervised or regulated. This highlighted the urgent need for improved sanitation.

Robert Sutherland Thompson was assigned the task of finding a solution. Two years earlier, a Frenchman working in India, Paul-Louis Simond, had suggested that bubonic plague was transmitted by fleas living on rats. Although initially his theory had gained few supporters, one of them was Thompson. His careful observations of the epidemic in Sydney proved Simond's theory correct and resulted in the construction of the modern sewerage systems that are still in use in Sydney today.

FIG 1.3 Nightsoil men on their rounds emptying toilet tubs in the 1950s

PLUMBING REGULATORS

There are approximately 60 000 registered or licensed plumbers in Australia, the majority of whom are principally registered for water, drainage, sanitary work and gasfitting. Plumbers are very committed to and aware of their obligations because their work must always meet rigorous plumbing trade standards. The plumbing trades are recognised and respected for the sophistication of their technical training and for their unique responsibility for systems of public and environmental health, including water sustainability and greenhouse issues. The plumbing industry regulates and supervises its training, assessing and registration of plumbers so that they can carry out a wide range of functions in identifiable trade sectors of the industry.

The regulation of plumbing work, the licensing of plumbers and the monitoring of compliance with product quality standards has traditionally been the responsibility of government and semi-government bodies and corporations. These are also responsible for overseeing the protection of public health and safety, the environment and consumer rights. In Australia and New Zealand some uniformity of plumbing standards was achieved through the introduction in 2003 of AS/NZS 3500–National Plumbing and Drainage Code.

Plumbing Code of Australia

In 1999, a proposal emerged for the establishment of a national plumbing regulators forum. Following a review, the Board of the Australian Building Codes supported the development of a Plumbing Code of Australia (PCA). The PCA is now incorporated into the Building Code of Australia (BCA) and is titled the '*National Construction Code Volume 3*' (NCC Vol 3). This code incorporates:

- water certification of plumbing products
- alternative solutions for plumbing projects to a set criteria
- the individual state variations to the Plumbing Standards AS/NZS 3500.

FOR STUDENT RESEARCH

Research the history of the sanitation system used in your city, town or suburb.

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www.plumbingcareer.com.au/index.php?option=com_content&task=view&id=13&Itemid=91

SUSTAINABLE PLUMBING: THE PUSH TOWARD SUSTAINABILITY

Environmental concerns are given greater importance today than ever before. If we are to achieve the ideal of a pollution-free environment we must consider the long-term effects of all waste-disposal methods. Plumbers need to keep abreast of both changing attitudes towards waste-disposal procedures and developments in plumbing science and regulations. There is an increasing interest in sustainable practices, such as greywater recovery and treatment systems, which are designed to protect our fresh water supplies and our oceans.

The principles of sustainability are increasingly guiding the way we make many of our life choices and form the basis of changes to plumbing and building regulations and codes. The delivery of water and sewerage services to our communities is governed by legislation aimed at conserving water and reducing the quantity of waste released into the environment. Systems such as Basix, Greenstar, WELS (Water Efficiency Labelling Scheme) and NABERS (National Australian Built Environment Ratings System) all work towards the implementation of more sustainable building practices and, consequently, more water, energy and waste-efficient buildings. Plumbers have a key role in raising awareness in their communities of sustainability issues and in increasing the uptake of new technologies and practices.

CHAPTER **TWO**

The principles of sewage treatment

LEARNING OBJECTIVES

In this chapter you will learn about:

2.1 how the sewage treatment process works

2.2 the types of sewage treatment processes

2.3 sustainable sewage practices.

INTRODUCTION

'Sewage' is the term used to describe the waste matter carried off by sewer drains and pipes, and 'sewerage' refers to the infrastructure sewage flows through (e.g. pipes, lift stations, and treatment and disposal facilities). The aim of sewage treatment is to remove the bulk of suspended organic matter and provide an end product that is environmentally acceptable for disposal or re-use. This chapter discusses sewage treatment processes and sustainable sewage practices.

HOW THE SEWERAGE SYSTEM WORKS

Sewage enters the sewerage system from the toilet, kitchen, bathroom and laundry drains of homes and businesses. The sewerage system consists of a network of pipes located in the ground that run along underneath property boundaries and streets. This is known as the 'reticulated sewerage system' and these pipes link to larger pipes and tunnels, known as 'main' or 'trunk sewers'. One of the largest sewers in Melbourne is the Western Trunk Sewer which, at its maximum width, has a diameter of 4.4 metres and lies 40 metres below ground level at its lowest point.

Pumping stations

Most sewers are designed so that the sewage is kept moving and carried by gravity as it travels downward along a continual slope. Eventually the sewage has to be pumped back up to the surface for treatment. This is undertaken by a pumping station. The Hoppers Crossing Pumping Station in Victoria is one of the largest pumping stations in Australia. The plant is fitted with eight pumps, each standing 4.5 metres high and weighing 45 tonnes. They are capable of pumping more than 5000 litres a second (Figure 2.1).

FIG 2.1 Hoppers Crossing Pumping Station in Victoria is one of the largest in Australia

TYPES OF SEWAGE TREATMENT PLANTS

Various methods are adopted to treat sewage in Australia and it is therefore impractical to describe *all* schemes. However, the methods adopted in the majority of schemes are similar in principle. There are two types of sewage treatment plants:

- those that combine a mechanical and a biological process (Figure 2.3)
- those that use a sewage purification system (Figure 2.4).

Treatment works combining mechanical and biological processes

A typical sewage treatment system combines mechanical and biological processes and is broken down into four main processes:

- primary treatment
- secondary treatment

- tertiary treatment
- sludge treatment.

Primary treatment

The first stage in the treatment is to remove debris by passing the raw sewage through screens that are 2 m wide and consist of vertical bars with 25 mm openings. Automatic rakes remove material caught on the bars and pass this to disintegrators where it is finely ground and pumped back into the flow.

FIG 2.2 The Bolivar WasteWater Treatment Plant in South Australia

The screened sewage passes into the two grit removal and pre-aeration tanks. Air is pumped into each of the three bays of these tanks. In the first bay, the air sets up a circular motion that carries all sand and other grit to one side, where it is removed. The air has a freshening effect on the sewage by providing oxygen and assists in the removal of fats and greases.

The sewage then enters the four primary sedimentation tanks. The sewage travels very slowly through this stage to allow the suspended solids to settle out to the tank floors. This is known as 'raw sludge' and is scraped automatically to one end and pumped to the sludge digestion tanks (see 'Secondary treatment' section below for more on the treatment of sludge).

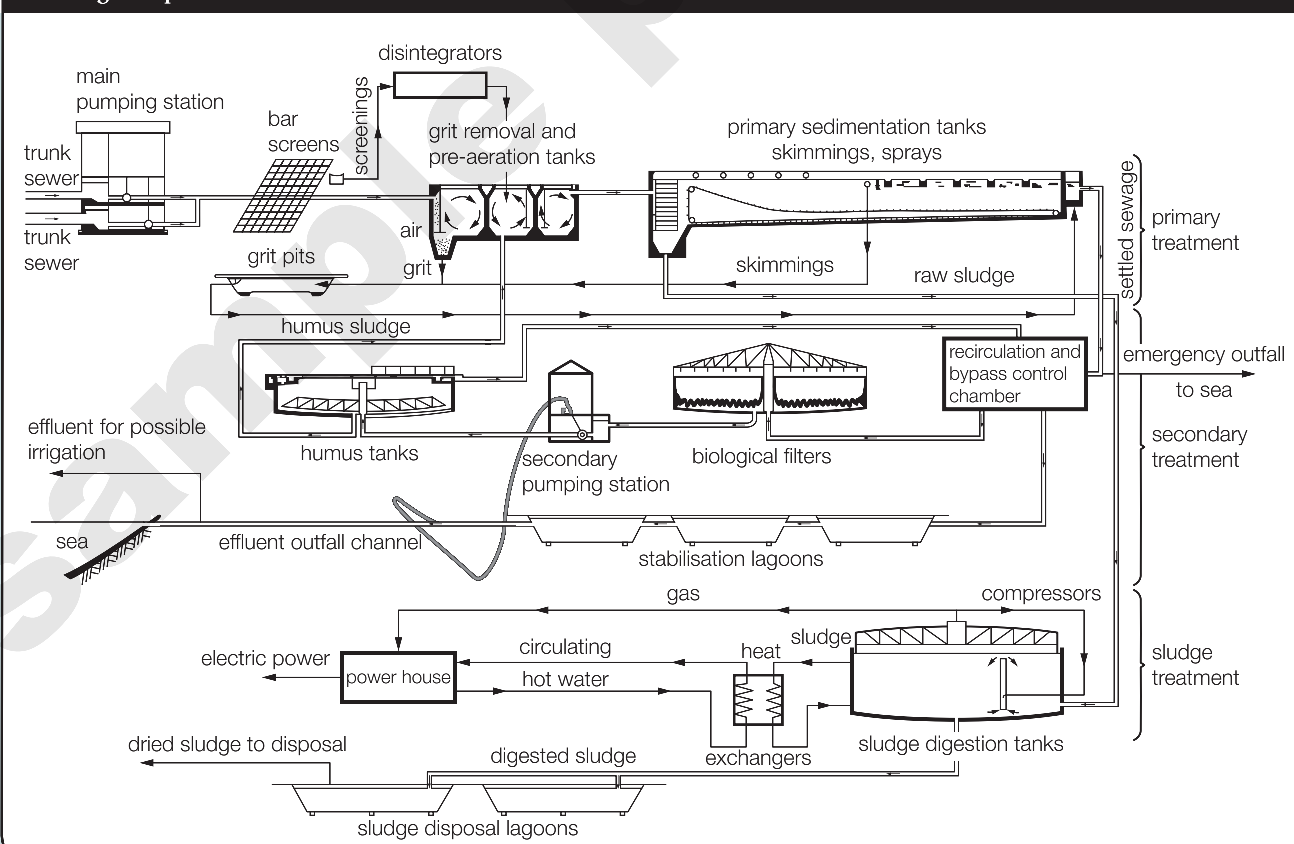
At this stage, floating material is skimmed off using water sprays and pumped to lagoons, together with the grit removed in the pre-aeration zone. The sewage that passes over the weirs at the end of the primary sedimentation tanks is called 'settled sewage', which is again aerated before moving to the next stage.

Primary treatment removes up to 40 per cent of the organic pollution load and 60 per cent of the suspended solids.

Secondary treatment

In secondary treatment, aerated settled sewage passes via a recirculation and bypass chamber to the biological filters. These filters are filled with graded stone supported on a grid

FIG 2.3 The steps involved in sewage treatment works that combine mechanical and biological processes



floor, which allows air to pass upward through the stones. These stones are covered in a slime of microorganisms called 'zoogloeal slime'. With the upward flow of air supplying the necessary oxygen, these microorganisms digest the organic matter in the sewage.

As the slime grows, some is washed off and the filtered effluent is pumped to humus tanks where the slime particles settle as humus sludge. This is pumped back to the pre-aeration zone.

This treatment stage removes approximately 60 per cent of the organic pollution load remaining after primary treatment and 30 per cent of the remaining suspended solids.

Tertiary treatment

The final stage of treatment is carried out in stabilisation lagoons with a detention time of between 30 and 35 days. The lagoons contain bacteria, protozoa and algae that use natural biological processes (such as photosynthesis) to remove 75 per cent of the organic material entering the lagoons.

Sludge treatment

Raw sludge is removed from the primary sedimentation tanks and moved to the sludge digestion tanks where they are heated by the exhaust and cooling systems of the engines used to power the site. Air is excluded from the tanks and, under these anaerobic conditions, bacteria breaks down the raw sludge into a stable digested sludge that releases carbon dioxide and methane. The methane is used as fuel to drive 900 kW engines which in turn drive alternators, providing all the necessary power for the plant. The digested sludge, called 'biosolids', is pumped into sludge lagoons that are filled and allowed to dry out. The dried digested sludge is sold for use as a fertiliser base or landfill.

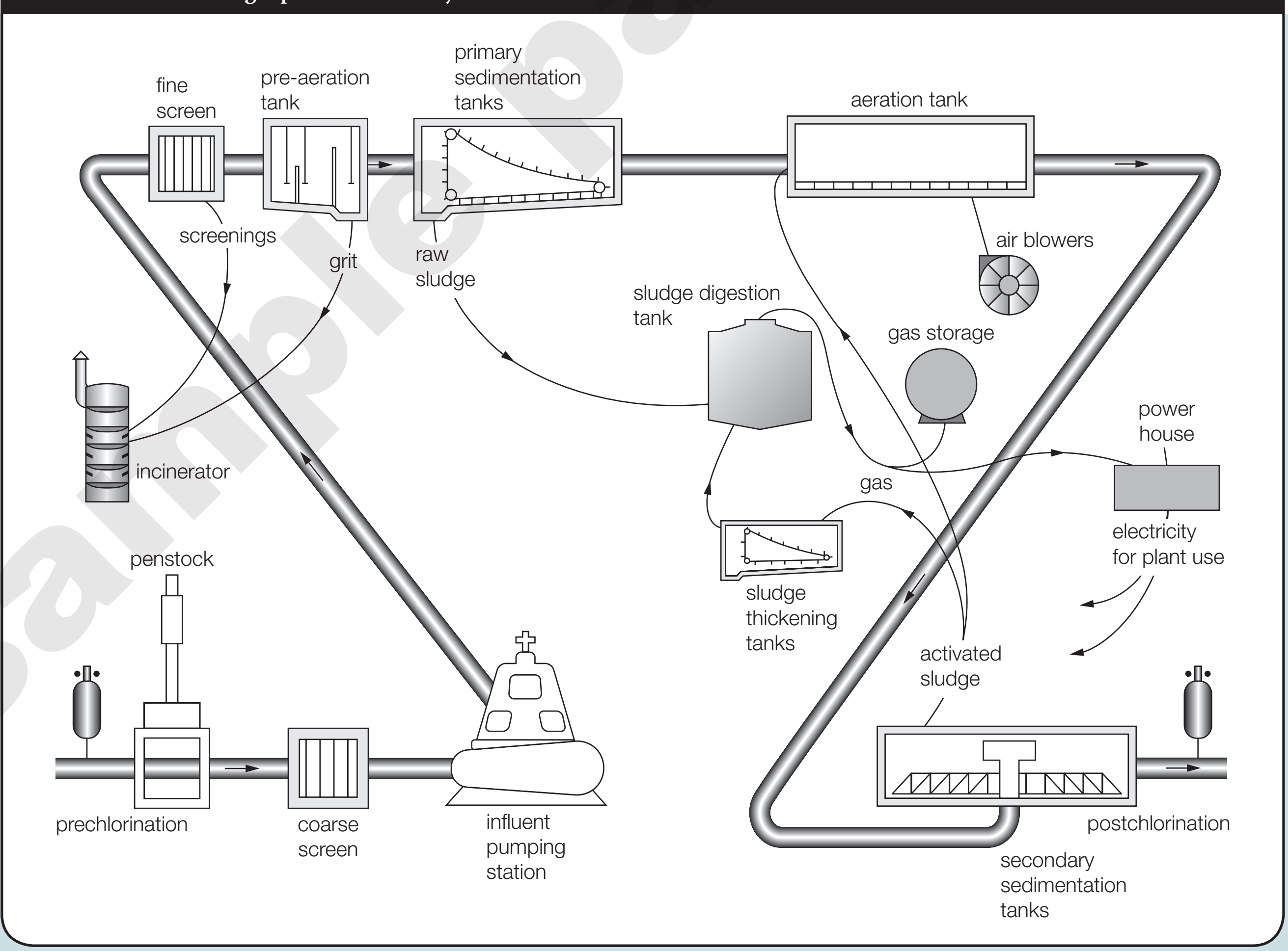
Sewage purification system

Figure 2.4 illustrates a type of sewerage system that combines both mechanical and biochemical processes to purify sewage (using a chlorination process). This process has four main areas:

- primary treatment
- secondary treatment
- sludge processing and gas utilisation
- effluent disposal.

Separable and settleable solids are removed mechanically in the primary treatment. Remaining wastes are biologically oxidised in the secondary treatment. Sewage entering the plant is chlorinated to suppress odours.

FIG 2.4 A sewage purification system



Mechanically cleaned screens eliminate large objects to prevent possible damage to the plant's influent pumps. The sewage is then passed through fine screens to remove larger remaining solids.

Primary treatment

Sewage flows into pre-aeration tanks where air is introduced to assist the treatment process and remove odours. Grit is separated out and settles out by the action of currents set up by rising air columns. The grit is removed and incinerated.

Degritted sewage then passes into primary sedimentation tanks where over half of the suspended solids settle as sludge on the tank floors. The tank floors are continuously swept into hoppers and the sludge is pumped into heated sludge digesters. Low-pressure air jets are used to remove floating scum that is then pumped to an incinerator.

Secondary treatment

Sewage from the primary sedimentation tanks flows to rectangular aeration tanks where the remaining finely divided and dissolved pollutants are removed biochemically by the activated sludge process. This process involves aeration of a mixture of settled sewage and activated sludge known as 'mixed liquor'. Air in the form of fine bubbles rises from the tank floor and passes through the mixed liquor in the aeration tanks. The mixed liquor is then transferred to circular sedimentation tanks where the activated sludge settles out and is continuously removed by rotating suction sludge collectors.

The majority of this sludge is returned to the aeration tanks for continued processing of pollutants with the excess moving on to thickening tanks then to heated digestors. The overflow from the secondary sedimentation tanks, which is purified effluent, is then discharged over collecting weirs and into the covered effluent channel.

Sludge processing and gas utilisation

Sludge from primary sedimentation tanks, with thickened waste-activated sludge from the secondary sedimentation tanks, is digested in heated circular tanks. The process causes organic breakdown, producing a sludge gas (mainly methane) which is collected in steel tanks and used to fuel the plant's generators.

Digested sludge is stored in large holding basins where it thickens and is further stabilised: a slow continuation of the digestion process. When each basin is filled, it is allowed to stand for some years, then drained, allowed to dry and finally removed. The stable, solid material which remains, called 'biosolids', looks and smells like damp earth and makes ideal soil conditioner.

Effluent disposal

Purified plant effluent from the secondary sedimentation tanks gravitates to the outfall pumping station or to holding basins for temporary storage during high flows due to wet weather. The effluent is chlorinated at the outfall pumping station then passed to the outfall sewer where it discharges into the sea.

TREATMENT PLANT LOCATIONS

In Australia, there are many large treatment plants located inland where treated sewage needs additional treatment before discharging into a river or lake. These plants are also overseen by environmental protection agencies to perform at the highest level of treatment. Some plants vary in treatment procedure or use other methods, depending on the location of the plant and whether its final disposal method is to be into the sea, a river or lake, or for irrigation purposes.

Ocean disposal of treated wastewater

Most of the major cities in Australia are situated along the coast and governments have allowed treated sewage to be discharged into the sea for decades—a wasteful method of disposal of a potentially useful resource. The wastewater is discharged into the deep ocean several kilometres offshore where the action of currents, waves and sunlight continues to break down small particles.

Located on the North Head peninsula, at the entrance to Sydney Harbour near Manly, North Head Wastewater Treatment Plant is Sydney's second largest ocean treatment plant and discharges treated effluent through a deepwater ocean outfall into the Tasman Sea (Figure 2.5). The plant serves over one million people and treats approximately 300 million litres of flow a day. North Head is typical of the plants in Australia that are being upgraded to meet the growing inflow demand and, more importantly, the recycling of wastewater. Recent improvements include:

- the first hydroelectric plant in Australia to generate power from treated sewage
- a co-generation engine that reduces carbon emissions by turning methane produced during the treatment process into green energy
- a new biosolid management facility to improve waste handling
- two new primary sedimentation tanks to improve the removal of organic solids, oil and grease from wastewater.

FIG 2.5 Sydney's North Head Wastewater Treatment Plant

The Water Corporation of Western Australia has a wastewater treatment plant south of Bunbury. Domestic and industrial wastewater is treated via mechanical and biological processes to make it suitable for the ocean environment. The waste is primarily fresh water, therefore less dense than seawater, and the rising water column mixes with the seawater, known as 'near-field mixing'. The outlet diffusers are designed to maximise dilution of wastewater through small diameter ports that increase the velocity of the treated wastewater (Figure 2.6).

Over time the wastewater outlets have become encrusted with an array of marine life (Figure 2.7), which provides evidence that the disposal of treated wastewater to Perth's coastal waters is at a sustainable level.

FIG 2.6 The ocean disposal process

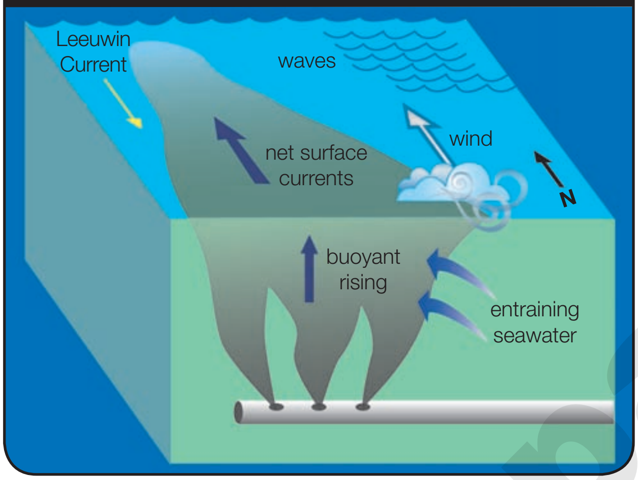


FIG 2.7 Pipe encouraging marine growth

SUSTAINABLE SEWAGE PRACTICES

Population growth has brought with it a substantial increase in sewage waste, along with the potential hazard to human health through the contamination of surface and groundwater. New, more effective and environmentally sound systems for sewage waste management programs have been developed and are constantly improved to allow for the handling and treatment of increased amounts of sanitary sewage in an eco-friendly and sustainable manner. These solutions include sustainable methods that incorporate biological processes to deal with disposal and processing of human excrement into organic compost material. Examples are composting toilets that do not require the use of water and the extraction of wastewater from sewage systems that can be treated and purified for reuse in irrigation systems, rather than discharged into a body of water. A description of some examples of these technologies follows.

Biosolids

Biosolids are the dried, stabilised matter that remains after the sewage treatment has finished. They contain methane gas that is captured and combusted to produce electricity, and nitrogen and phosphorus that can be used for:

- forestry and farming
- landscaping
- site rehabilitation
- blended organic products.

Sewer mining

Sewer mining is the process of extracting wastewater from the sewerage system itself, treating it locally then using it for 'fit-for-purpose' uses. It has many benefits for large cities with complex sewer systems. For instance, catching and reusing water as it flows towards coastal sewage treatment plants reduces the volume of water that reaches the ocean outfall plants.

Dissolved air filtration flotation

Some treatment plants use large ponds in which sunlight and other microorganisms reduce the pathogens. However, additional treatment may be required if the wastewater is to be reused for purposes such as irrigation of food crops (Figure 2.8) or where close human contact may occur. The tertiary treatment provided at Bolivar Waste Water Treatment Plant in South Australia (Adelaide's largest sewage treatment plant) uses dissolved air filtration

SUSTAINABLE PLUMBING: BLACKWATER RE-USE

Sydney's first building to incorporate the re-use of 'blackwater' (the term used to describe untreated effluent)—'1 Bligh'—is located in Bligh Street, Sydney and recycles 100 per cent of its effluent for re-use in its toilets and for irrigation. Check out the website for more details: www.1bligh.com.au flotation (DAFF) to produce a much higher standard of treated wastewater suitable for these purposes.

DAFF is a water treatment process that involves injecting the effluent with billions of fine air bubbles which carry small particles and suspended matter to the surface for skimming off. Further filtering and chlorination is undertaken so the water can be reused. This allows the water from Bolivar to be used for direct irrigation of crops through the Virginia pipeline, where more than 100 km of pipes bring treated 'class A' wastewater to the region and provide an alternative source of water to local irrigators (Figure 2.9).

FIG 2.8 Treated wastewater being used for irrigation

Other benefits of DAFF at Bolivar include:

- a reduction in pressure on undergroundwater supplies
- a reduction in the discharge of nutrients into the marine environment
- a demonstration of the effectiveness of reusing treated water on a large scale for commercial horticultural production.

FIG 2.9 The Virginia pipeline in South Australia

SUSTAINABLE PLUMBING: RETICULATED RECYCLED WATER

Reticulated recycled water systems are now being installed in urban areas. These systems treat raw sewage to a standard high enough that it can be safely resupplied through the reticulation network to entire communities. The treated water can then be used in washing machines (except laundry tubs) for flushing toilets, watering gardens, washing cars and filling ornamental ponds, as well as for fire-fighting and industrial purposes.

Sydney Water currently operates 12 water recycling plants. The Quakers Hill plant, for example, produces 31.1 mL of water a day and supplies a population of 144 700 people. You can read more about Sydney Waters' recycled water plants on their website: www.sydneywater.com.au

FIG 2.10 The Quakers Hill Sewage Treatment Plant

FOR STUDENT RESEARCH

Find out the location of your local sewage treatment works and the type of system used.

ONSITE STORIES 2.1

VENTURE INTO THE UNKNOWN

Bruce Paulsen, *Plumbing and Sustainability Teacher, North Sydney TAFE, co-author of McGraw-Hill* Plumbing Services Series: Basic Skills

You know, as a plumbing and drainage contractor you really do get some interesting calls.

I remember getting a call from the local sewerage treatment plant. I'd never done a job at a treatment plant before but they wanted me to come along and cut a thread for them on a pipe on the top of their 'digester' tank.

'What's a digester tank?' I asked myself. Sounds like a huge stomach! It turned out it was a great big steel tank where the partially treated sewage sat and fermented while the anaerobic bacteria did its job—choice!

Anyhow, I ended up on the top of this 6-metre-high tank with my thread cutting dies, cutting a thread on a 50 mm pipe that was sticking out of the top of the tank. The smell wasn't that bad, I guess, considering I was working on the top of who knows how many thousand litres of effluent!

The job went well, the thread was cut and they were able to fit their new valve, so all good. And they even paid on time!