CREW CENTRE OF EXPERTISE FOR WATERS

Guidance on Small Sewage Systems in Scotland

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Kaitlin Ramsay, Ania Escudero, Gabriele Frascaroli, Fiona Henderson, Emanuella Christensen and Karin Helwig.

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CENTRE OF EXPERTISE FOR WATERS

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Figures: Courtesy of GCU staff

Cover photographs courtesy of: clockwise –
Septic drain fields Hobrechtsfelde in LSG Buch Leonhard Lenz
Lid of a rural septic tank beside an intersection, Slammerhogen, Lysekil Municipality, Sweden
A septic tank being installed. Nonztp

Contents

Who this guidance is for?

This guide is aimed at developers and owners of a property who are starting to plan for the wastewater needs of a new small sewage system (SSS) serving less than 200 people (or equivalent). It may also be useful to people who are planning to replace or upgrade their wastewater treatment system.

It helps to provide:

- an overview of the permissions and registration steps required (Part A),
- clear criteria for selecting an appropriate system (Part B), and
- the types of systems available on the current market (Part C).

This guidance is advisory only. Developers and home owners are responsible for checking the relevant legislation.

N.B: Words shown in *italics* are described in more detail in the **Glossary**.

Introduction

Wastewater, if not properly treated, can cause a public health risk and cause environmental damage.
It can:

- contain harmful bacteria and chemicals;
- cause odours, be unsightly, and lead to complaints;
- contain *nutrients* (phosphorus and nitrogen), which, in excess can be detrimental to *ecosystems*.

It is illegal to discharge untreated or insufficiently treated wastewater from your site or property to the environment. If you are unable to connect to the public sewer system, you must have an appropriate SSS in place to transport and treat your wastewater. The system(s) used must abide by current regulations and you will need to obtain authorisation.

All sewage systems require regular maintenance, including desludging. Some of this will need to be done by a contractor. Different systems vary in their complexity, performance capacity, maintenance intensity, technical expertise and physical strength required to keep them in good working order. It is important to keep this in mind before you settle on a system.

For larger developments or systems that are shared between multiple properties, economies of scale can sometimes be achieved. It is strongly recommended that a factor is employed to ensure treatment systems are maintained and desludged regularly, for example through an ongoing contract with a maintenance company. Property title deeds should contain details of the owner's responsibilities, including providing access, contributing to funding for maintenance and clarifying liabilities should the system cause damage or health impacts. Clear and comprehensive planning for *wastewater* management at the development stage will avoid problems and complaints in the future, whilst also ensuring that arrangements remain in place when a property changes hands in the future.

Part A of this guidance document takes you through the main questions you need to ask yourself before choosing your system. These relate to permissions and requirements. Part B provides information on how the most common systems perform against key criteria. Part C gives more detailed information on specific systems.

PART A:
Permissions and registration steps required

The permissions required for SSS depends on whether it is a new or larger discharge (i.e. house extension or new housing development) or the replacement/ upgrade of an older system. **Figure 1** is an overview of the relevant SEPA authorisation steps for SSS. This is followed by information regarding each step.

Step 1.
Do you have an existing SSS?

This question may apply if you have recently moved into a home and/ or want to upgrade an older system. You can check whether the existing system is registered by submitting a registration check with SEPA (see reference 1 for more details). If you do not have an existing SSS, continue with **Step 2**.

Step 2.
Can you connect to the public foul sewer?

Properties must be connected to the main sewer where possible. Check with Scottish Water for details on connecting to the main sewer network (see reference 2).

If not, you will be asked to demonstrate that connection to the public sewer is not reasonably practicable before using a SSS. For up to 3 domestic properties, connection is normally considered 'reasonable' if a sewer is available within 50m, but this may vary due to site-specific conditions. You must comply with Section 3.8 of the Building Standards Technical Handbook (see reference 3 for more details).

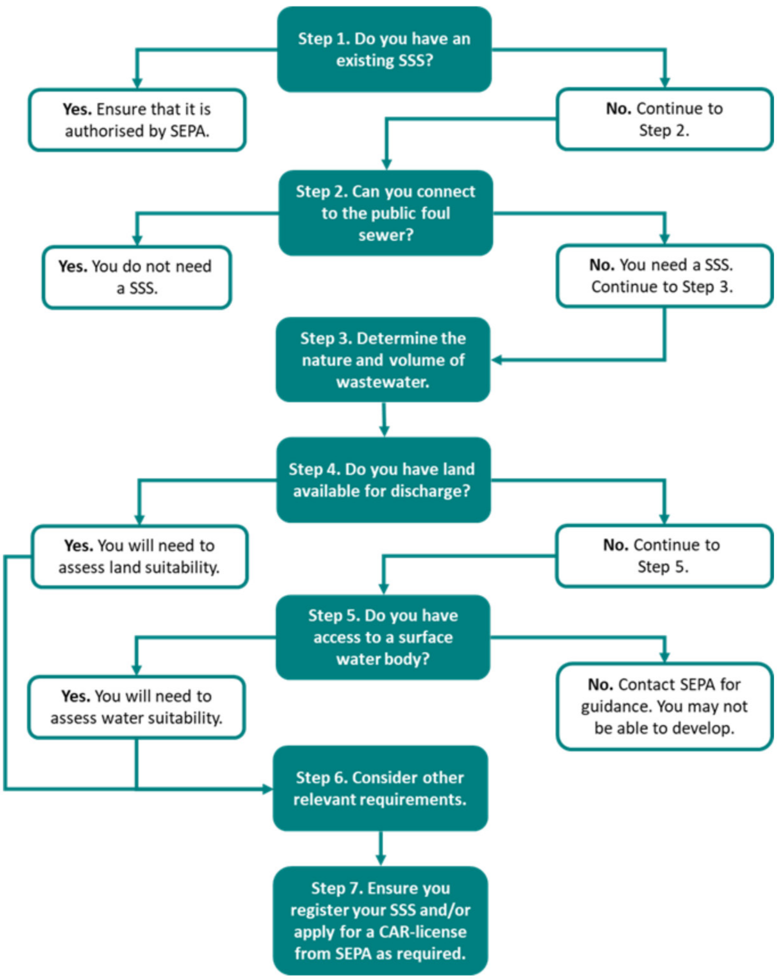


Figure 1. Step-by-step flowchart detailing the relevant SEPA authorisation processes for SSS

Step 3.
What is the nature and volume of your wastewater?

Determining the likely nature and volume of your wastewater is important when it comes to choosing your system. For that purpose, you need to calculate your expected flow and load where:

Flow: Refers to the volume of *wastewater* per day. Calculations should allow for a standard flow of 150L per person per day.

Load: Expressed as the *Biological Oxygen Demand (BOD)*, which is largely determined by the amount of solids in the wastewater. A standard residential home load of BOD is around 60g per person per day. Load is sometimes also referred to as *Population Equivalents (PE)* whereby 1PE = 60g BOD/day.

You will also need to assess the composition of the *wastewater* you need to treat and whether it will be a steady *flow* or variable *flow*. Please refer to British Water's Code of Practice on *Flows* and *Loads* for more details on how to determine nature and volume of your wastewater (see reference 4). For example, a wastewater system for a standard residential home of up to three bedrooms should be sized for at least five people. This would be referred to as 5 Population Equivalents (PE). This would allow for a steady *flow* of 750L/day and a minimum *load* of 300g BOD/day. However, groups of houses, other types of buildings or businesses may expect higher *flows* and *loads* with more variation.

N.B: Stormwater (rain water) **MUST** be excluded from the SSS and discharged separately.

Step 4.
Do you have access to suitable land where you can discharge your treated effluent?

Discharge to land, via an infiltration system, is normally preferred to discharge to water. You must ensure disposal of wastewater to land is safe, not a threat to the health of the people in or around the building and doesn't present an unacceptable risk to the water environment. You must check land suitability (i.e. not on a steep slope, not prone to waterlogging and acceptable soil percolation rates). Discharges to land must comply with Regulation WAT-RM-04 (see reference 5), meet the standards outlined in the Building Standards Technical Handbook (see reference 3) and be:

- at least 50m from any spring, well or borehole used as a drinking water supply
- at least 5m from any building
- at least 5m from the property boundary
- at least 10m horizontally from any watercourse (including any inland or coastal waters), permeable drain, road or railway.

Three tests are used to determine whether the soil is suitable for infiltration (see reference 6):

- a preliminary ground assessment, which may include a consultation with SEPA and the Environmental Health Officer;
- a trial hole, to determine whether the water table or bedrock level lies at least 1m below the bottom of the designed infiltration system; and
- a soil percolation (V_p) test, to provide information on the size of the area required for the infiltration system or whether a mound system will be required.

If the site fails the tests, then discharge to land may not be suitable.

N.B: The Local Authority's Building Control Department may wish to observe the tests being carried out.

Step 5.
If you cannot discharge to land, do you have access to a suitable surface water body?

To determine this, you must check that the surface water has a suitable flow in order to dilute the *effluent* that is discharged. An unsuitable level of dilution may result in an unacceptable impact on surface water quality. The Regulatory Method WAT-RM-03 details the steps which should be followed if the *effluent* cannot be discharged to land (see reference 7 for more details). The level of dilution by the surface water will give you an indication of the type of treatment required to treat your wastewater (although other factors, such as proximity to Bathing Waters, Shellfish Waters or drinking water supplies, may also need to be considered). For example:

High dilution: Your SSS may consist of a septic tank to treat the *wastewater* and a partial soakaway to minimise overflow in dry weather.

Moderate dilution: Your SSS may have to treat the wastewater to strict *effluent* standards regarding *BOD* and *nutrient* concentrations. This will require the use of more complex types of treatment (such as packaged treatment plants).

Little dilution: You may be refused permission to discharge to surface water. In most cases, ditches and streams with very low flow (low dilution) or those that are sometimes dry are not suitable for receiving treated *effluent*.

Step 6.
Other requirements you need to consider

You need to contact the Planning and Building Standards Department of your local authority (see reference 8 for contact details) to identify if there is any planning consent required. Apart from considerations about the discharge of treated effluent (as outlined in Steps 4 and 5), the type of SSS that you choose will itself have specific site requirements (more details can be found in Part C). However, there are general requirements that you must consider (see reference 3 for more details), which include:

- Any part of the SSS should be at least 5m away from houses.
- The site must have adequate vehicle access for carrying out installation, maintenance and repairs (i.e. tankers for *desludging*).
- Enclosed SSS must have an inspection chamber.
- SSS should be inspected monthly and desludged regularly, depending on the system.
- If the system is shared between multiple properties, a factoring arrangement should be set up and include a regular inspection and maintenance contract.
- Property title deeds should reflect the householders' responsibilities.
- A label should be put up in the property, near the gas or electricity meter, with the following statement: *'The drainage system from this property discharges to a wastewater treatment plant* (or septic tank, as appropriate). *The owner is legally responsible for routine maintenance and to ensure that the system complies with any discharge consent issued by SEPA and that it does not present a health hazard or a nuisance'.*

Step 7.
Registration and licenses required

All systems should be authorised (see reference 9) by SEPA but your *wastewater load* determines whether a this should be by Registration or licence.

New discharges (proposed or in use less than 2 years):

Systems serving up to 3 domestic properties or less than or equal to 15PE should be registered with SEPA

Existing discharges (in use more than 2 years):

Systems serving up to 9 domestic properties or less than or equal to 50PE should be registered with SEPA.

New systems larger than 15PE and existing systems larger than 50PE require a license from SEPA. Applications for SEPA authorisation can be done either online or by paper (see reference 10 for details).

PART B:
Selecting a small sewage system

Selecting an appropriate small sewage system (SSS) will depend on site-specific regulatory requirements; the end-user; the composition and volume of *wastewater* that will be produced and whether you are interested in added-value aspects such as energy recovery. Part B aims to provide clear criteria for selecting an appropriate system. In all cases, it is recommended that you seek advice from a suitably qualified contractor/designer, who can help you choose the type of system and its size.

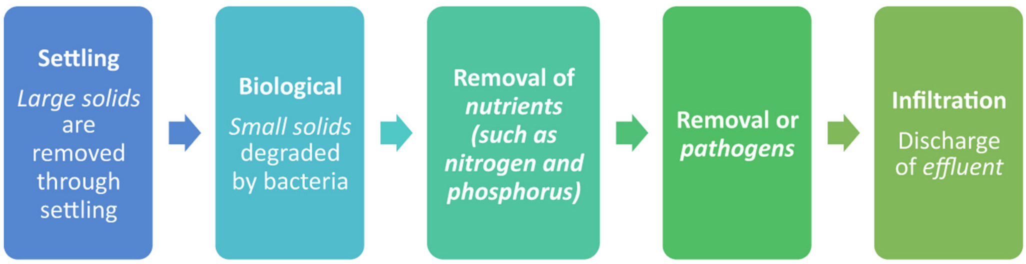
What are your criteria?

For new developments or replacing an existing SSS, the questions below may help you to identify general criteria that may narrow down your choice for potential systems:

- **Who will manage the system?** All systems require maintenance, which can take time or require specialist skills. You should consider whether you (or any future end-user of the building) is likely to have the necessary time and skills.
- **What outcomes are important to you or the end-user?** Some systems provide added value such as benefiting biodiversity, energy recovery, multiple dwelling treatment, etc. Consider the outcome that is important to you or the end-user.
- **What is the flow and load of the wastewater?** The *wastewater flow* and *load* will depend on the number of people that the system will serve and, where applicable, by the business type. Additionally, you will need to consider whether the *wastewater* is a steady or variable *flow* (see reference 4). This question is very important for ensuring your system will be able to treat your wastewater to the standard required.

Suitable systems based on effluent quality criteria

Wastewater may need to be treated to remove solids, pathogens and *nutrients* such as phosphate and ammonia. The quality of the effluent required depends on where in the environment the treated effluent is discharged to. For example, if discharging to a surface water near a Bathing Water or Shellfish Water, additional treatment steps are likely to be required. *Wastewater* treatment can be separated into key stages:



The steps in Part A will help to determine your circumstance. If in doubt, contact SEPA for guidance (see reference 10 for more details).

There are a variety of SSS available in Scotland but most are designed to treat one aspect of the wastewater (Table 1). Therefore, depending on the nature of your *wastewater* and *effluent* quality, you may need to consider more than one system.

The four main system types presented in this document are settlement systems, packaged treatment plants, infiltration systems and natural systems. For each system type, various options are available, each with their particular characteristics.

Table 1. Small sewage systems available and type of treatment						
	PE**	Removal efficiency*				
		Large solids	Small solids	Ammonia	Phosphate***	Pathogens
Settlement systems						
Septic tank	< 200	✓✓✓	N/A	N/A	N/A	N/A
Baffled reactor	< 200	✓✓✓	✓	N/A	N/A	N/A
Packaged Treatment Plants						
Activated sludge reactor	< 55	✓✓✓	✓✓	✓	N/A	✓
Submerged aerated filters	30 - 200	✓✓✓	✓✓✓	✓✓	N/A	✓
Rotating biological contactors	6 - 200	✓✓	✓✓✓	✓✓	N/A	✓
Sequencing batch reactors	3 -25	✓✓✓	✓✓✓	✓✓✓	N/A	✓
Biological filters	6 - 200	✓✓✓	✓✓	✓	N/A	✓
Infiltration systems** **						
Infiltration fields	< 200	N/A	✓✓	N/A	N/A	N/A
Mound filters	< 200	N/A	✓✓	N/A	N/A	N/A
Natural systems** **						
Constructed wetlands	< 200	N/A	✓✓	✓✓	✓✓	✓*****
Packaged filters	4 - 200	N/A	✓✓✓	✓✓✓	N/A	✓✓✓
Constructed reed beds	< 200	N/A	✓✓	✓✓	✓✓	N/A

* Removal efficiency is demonstrated using tick marks where 1 tick mark is low removal, 2 is medium and 3 ticks represent a high removal efficiency.

** Based on leading 3 manufacturers from the certified British Water list, where possible (see reference 11). ***Chemical dosing can be used in PTPs to aid phosphate removal if necessary. Packaged filters may remove phosphate but is dependent on filter material.

**** Only used after settlement or biological systems.

***** See references 12 and 13 for more details.

N/A for not applicable.

Suitable systems based on sustainability criteria

Before considering the sustainability of all SSS, you should have an idea of the type of system(s) suited to your circumstance. The sustainability criteria can then be used to further narrow your selection of suitable systems and is divided into two main categories:

- **Technical sustainability** which includes the land area required, operation complexity, maintenance intensity, energy demand and costs associated (Table 2).
- **Social and environmental sustainability** which focuses on how each SSS can be integrated into society. This includes the generation of odours and noise, landscape integration, expected lifespan, *effluent* quality and reliability (Table 3).

N.B. The listings are generalised and depend on system maintenance over its lifetime and materials used. More details on individual systems are provided in Part C.

Table 2. Technical sustainability criteria

	Land area required	Operation complexity	Maintenance intensity	Energy demand	Installation costs	Operational costs
Settlement systems						
Septic tank	●	●	● ●	N/A	£	£
Baffled reactor	●	●	● ● ●	N/A	££	£
Packaged Treatment Plants						
Activated sludge reactor	●	●	● ●	●	££	£
Submerged aerated filters	●	● ●	● ●	● ●	£££	£££
Rotating biological contactors	●	● ●	● ●	● ● ●	£££	£££
Sequencing batch reactors	●	● ● ●	● ● ●	● ●	£££	££
Biological filters	●	● ●	● ● ●	● ●	£££	££
Infiltration systems****						
Infiltration fields	●	●	●	N/A	£	£
Mound filters	● ●	●	●	N/A	££	£
Natural systems****						
Constructed wetlands	● ● ●	● ●	● ● ●	N/A	£££	££
Packaged filters	●	● ●	●	N/A	££	£
Reed beds	● ●	●	● ●	N/A	£	£

Land area required: Demonstrates the land area required for a particular system. Categories were low area (●), medium (● ●) and high area required (● ● ●). Note that the actual area will depend on the PE.

Operation complexity: Demonstrates the level of technical knowledge required to operate the system. Categories were little (●), adequate (● ●) and high (● ● ●).

Maintenance intensity: Includes an overview of the inspection difficulty and the frequency of cleaning (i.e. desludging or removing solids). Categories were low maintenance intensity (●), medium (● ●) and high (● ● ●).

Energy demand: Considers the systems that require an energy source to operate. Categories were low energy consumption (●), medium (● ●) and high (● ● ●).

Costs: Comparisons are based on systems within groups rather than across groups. For example, the cost of installing a septic tank (**£**) is less expensive than a baffled reactor (**££**). Similarly, the operational costs of a constructed wetland (**££**) are far higher than a infiltration field (**£**).

Table 3. Social and environmental sustainability criteria					
	Odours	**Noise**	**Landscape integration**	**Lifespan**	**Effluent quality**
Settlement systems					
Septic tank	● ●	●	+++	++	+
Baffled reactor	● ●	●	+++	++	+++
Packaged Treatment Plants					
Activated sludge reactor	● ●	● ●	+++	+	++
Submerged aerated filters	●	● ● ●	+++	++	++
Rotating biological contactors	● ●	● ●	+++	++	+++
Sequencing batch reactors	●	● ● ●	+++	++	+++
Biological filters	●	● ● ●	+++	+	++
Infiltration systems****					
Infiltration fields	●	●	+++	+	+
Mound filters	●	●	++	+	+
Natural systems****					
Constructed wetlands	●	●	+	++	++
Packaged filters	●	●	+++	+	+++
Reed beds	●	●	++	+	++

Odours and noise: Categories were low generation (●), medium (● ●) and high (● ● ●).

Landscape integration: Compares systems based on how well it makes use of the surrounding land. For example, biological systems (+++) are compact and will not impact the landscape. Compare this to mound filters (++) that require space and may impact the landscape.

Lifespan: Describes the lifetime of each system. Categories includes systems expected to have a lifetime of <10 years (+), 10-20 years (++) and >20 years (+++). Note that actual lifespan will depend on materials used and how well the systems are maintained.

Effluent quality: Demonstrates how well the system treats the wastewater. Categories were based on low effluent quality (+), adequate (++) and high (+++). Specific details for each system can be found in Part C.

PART C:
Small sewage systems currently available

In Part C, you will find an overview of the most common sewage systems available on the private market in Scotland, with, advantages and drawbacks for the developer, the end-user(s), and the environment.

As in Part B, four main types of systems are discussed, with various options for each.
These are **settlement systems** (p.10), **packaged treatment plans** (p.13), **infiltration systems** (p.19) and **natural systems** (p.22).

Overview of settlement systems

Settlement systems are watertight tanks. *Wastewater* enters a chamber through an inlet port and undergoes primary treatment by allowing *large solids* to settle. There are a variety of settlement tanks available on the UK market. Some provide basic treatment of *small solids* (septic tanks and baffled reactors) through limited biological processes. In most cases, the discharged *effluent* is not suitable for direct release into surface water and so additional forms of treatment (such as infiltration systems or a packaged treatment plant) is required. SEPA may permit direct release of effluent if the dilution in the water course is large. Settlement systems included in this guide are septic tanks and baffled reactors.

Is this type of system suitable for your circumstances?

Septic tanks may be installed subject to planning permission, building control and SEPA authorisation.
In general, there are treatment limitations and requirements that you should keep in mind.

- **Treatment limitations:** Settlement systems do not effectively treat wastewater and are only suitable for *blackwater* or a mixture with *greywater*. Systems can be damaged by paints, solvents, excess disinfectants and household hazardous substances. Rainwater should not go into small sewage systems.
- **Operational requirements:** Tanks must be securely sealed with a solid cover that is capable of being opened by one person using standard operating keys (see reference 3).
- **Maintenance requirements:** *Large solids* (forming sludge) will need periodic removal, known as *desludging*. Therefore, sites must be accessible for *desludging tanks*. The frequency will depend on the size of the tank, number of users and maintenance (see reference 14).

Septic tanks

In septic tanks, *wastewater* enters a chamber through an inlet port and undergoes basic treatment by allowing *large solids* to settle, forming *sludge* (Figure 1). The *wastewater* is then released through the outlet port as *effluent*.

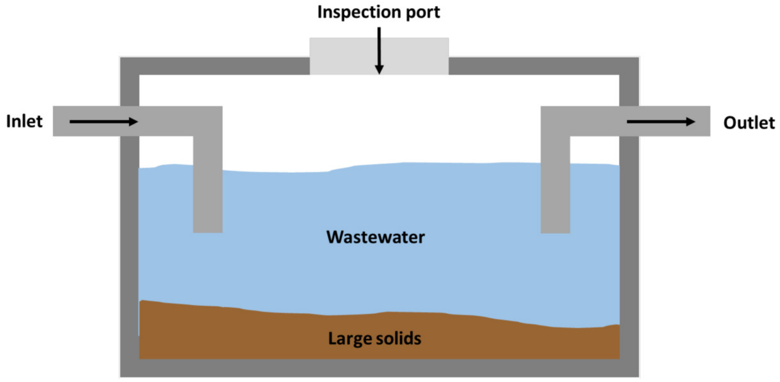


Figure 1. Example of a septic tank

Treatment efficiency	Good removal of solids (>50%) but low effluent quality. Not an effective treatment for the removal of BOD, ammonia or phosphate.
Regulations	Needs to comply with British Standard **EN 12566-1** for prefabricated tanks, and **EN 12566-4** for tanks assembled onsite (see references 15 and 16).
Cost considerations	Installation and maintenance costs are low. Extra costs include desludging and additional treatments (if required).
Site requirements	Sites must be accessible for desludging tanks. Height and depth of the tank should also be considered.
Operational complexity	Straightforward to operate and works well if designed, located and maintained properly. Paints, solvents, excess disinfectants and household hazardous substances must be avoided.
Maintenance required	Sludge will need to be periodically removed and specialist removal is required. Weekly inspections should be undertaken to check for leaking or blocked pipes. Water backing up into sinks, showers or toilets indicates a block.

Advantages	Disadvantages
• No power supply required • Works under steady and variable wastewater flows • High market availability	• Additional treatments may be required • Regular desludging required • Odours produced

Baffled reactor

The baffled reactor is a variation on a septic tank but has up to 8 compartments depending on your requirements (Figure 3). The separate compartments allow for a better separation between the *wastewater* and *large solids*. Increased contact time between natural bacteria in the tank and the *wastewater* encourages more effective treatment.

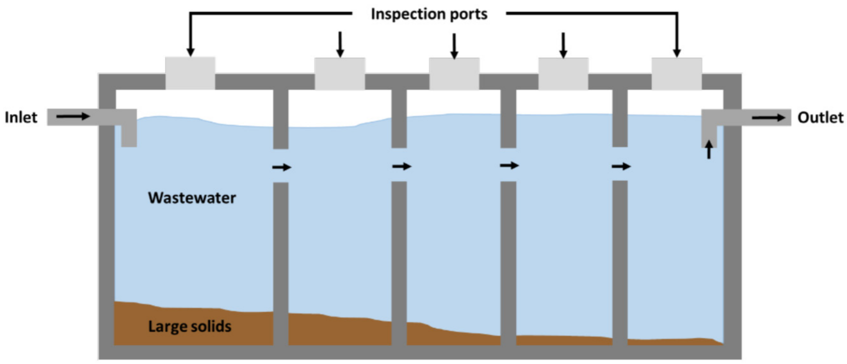


Figure 3. Example of a baffled reactor

Treatment efficiency	More effective removal of solids than septic tanks but low effluent quality. Not an effective treatment for the removal of ammonia, phosphate or pathogens.
Regulations	British Standard **EN 12566-1** for prefabricated tanks, and **EN 12566-4** for tanks assembled onsite (see references 15 and 16).
Cost considerations	Installation and maintenance costs are the highest of the settling systems. Bespoke designs may add to initial costs. Desludging should also be factored in.
Site requirements	Sites must be accessible for desludging tanks. Space available will dictate the number of chambers and may require bespoke design.
Operational complexity	More complex than traditional septic tanks but still easy to operate. Treatment of solids is dependent on bacteria which may take months to become effective.
Maintenance required	Sludge will need to be periodically removed by specialists. It is also important to check for leaking or blocked pipes. Adequate vent systems are also needed to prevent bad odours.

Advantages	Disadvantages
• No power supply required • Good removal of large solids • More effective than septic tanks	• Most expensive settling system • Performance is dependent on bacteria • Odour is produced

Overview of Package Treatment Plants

Packaged Treatment Plants (PTP) are made of prefabricated components that can be installed above or below ground, with minimal work, on your site. This type of system can be used after or instead of a traditional septic tank, providing that the system allows for *large solids* to settle. There are various designs of PTP such as activated sludge systems, submerged aerated filters, rotating biological contactors, sequencing batch reactors and biological filters.

Is this type of system suitable for your circumstances?

PTP do cost more to install and operate but there are a variety of designs, with some more cost effective than others. Most systems can be compact and can be applied at most sites. However, there are general requirements that should be considered.

- **Electricity requirements:** Most PTP require electricity due to pumps, motors and internal moving parts. Therefore, access to an electrical output may be required.
- **Operational requirements:** Tanks must be securely sealed with a solid cover that is capable of being opened by one person using standard operating keys (see reference 3). This is important as weekly or monthly inspections may be recommended. Good ventilation is also needed due to gases produced during treatment.
- **Positioning requirements:** Systems must be positioned at least 7m away from buildings. You should also consider the potential impact of noise and odour pollution before deciding on the location of the system. If the system requires electricity, then seek advice from a qualified contractor regarding the installation and protection of electrical cables from the outside elements.

Activated sludge processes

Activated sludge systems are designed with one or two chambers that facilitate biological and *settling* processes (Figure 4). *Aeration* supplies oxygen to bacteria that feed on the *small solids*. *Large solid* are separated through gravity. In tanks with two chambers, the settled solids are recirculated back to the biological chamber for further treatment.

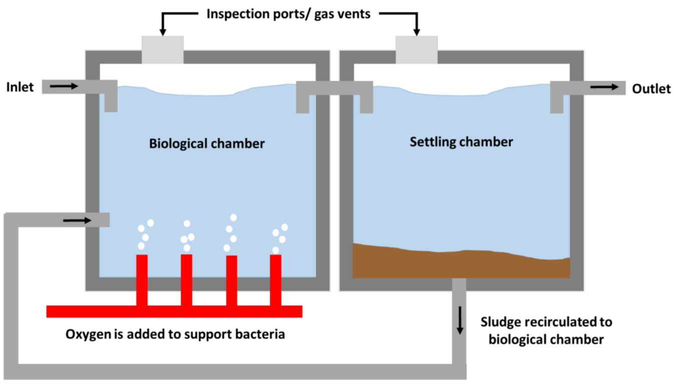


Figure 4. Example of an activated sludge system

Treatment efficiency	Good removal of solids with effluent quality better than 20mg/L BOD and 20mg/L ammonia. Not an effective treatment for the removal of nitrates or phosphate.
Regulations	British Standard **EN 12255-3** for PTP over 50-person size and **EN 12566-3** for under 50-person size (see references 17 and 18).
Cost considerations	Installation costs are less expensive than most PTP but operating costs will need to include the use of electricity for the oxygen supply and recirculation of sludge.
Site requirements	Requires site access for desludging tanks and access to an electrical power supply.
Operational complexity	Simple to operate but requires adequate technical knowledge for optimum operation. A constant flow of oxygen and electricity is needed.
Maintenance required	Low maintenance as there are no internal mechanical or electrical parts moving in the tank. Weekly inspections should check for signs of adequate aeration and clear effluent. Desludging will be required periodically and adequate vents to prevent gas build-up.

Advantages	**Disadvantages**
• Better effluent quality than traditional septic tanks • Compact system • Low sludge production	• Irregular flow may impact efficiency • High operating costs • Sensitive to certain types of wastewater

Submerged aerated filters

Submerged aerated filters (SAF) systems work on the principle of *aeration* and treat *wastewater* using bacteria fixed on floating biofilm. Oxygen is added to support bacteria which in turn feed on solids, cleaning the *wastewater.* The wastewater then enters a *settling* chamber post treatment. This prevents bacteria from leaving the tank and promotes a cleaner *effluent* (Figure 5).

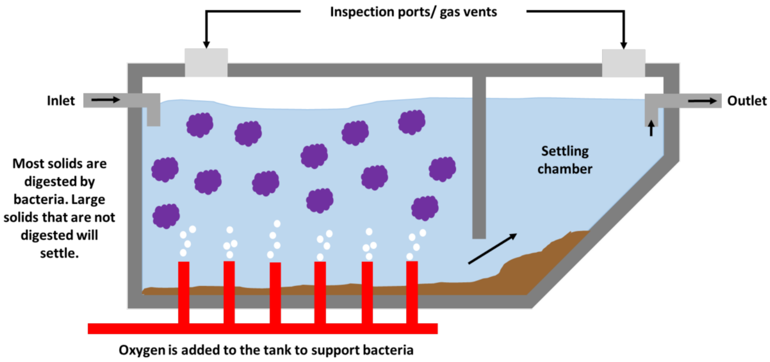


Figure 5. Example of a submerged aerated filter

Treatment efficiency	High removal of solids with effluent quality to be as low as 10-20mg /L BOD. Not an effective treatment for the removal of nitrate or phosphate.
Regulations	British Standard **EN 12255-3** for PTP over 50-person size and **EN 12566-3** for under 50-person size (see references 17 and 18).
Cost considerations	High installation costs which varies based on type of media used. Operating costs are high due to the use of electricity.
Site requirements	Only suited to sites where the PE is greater than 30. Sites must allow access for desludging tanks and have access to an electrical power supply.
Operational complexity	Simple to operate but requires technical knowledge for optimum operation. A constant flow of oxygen and electricity is needed.
Maintenance required	Low maintenance as there are no internal mechanical or electrical parts moving in the tank. However, weekly inspections should be anticipated to check for aeration within the tank. Desludging will be required periodically and adequate vents to prevent gas build-up.

Advantages	**Disadvantages**
• Good effluent quality • Simple to operate • No moving parts	• High investment costs • Low removal of nitrate and phosphate • Not suitable for single homes

Rotating biological contactors

Rotating Biological Contactor (RBC) systems are designed to remove solids, pathogens, ammonia and phosphate (Figure 6). A slow rotating disc, lined with bacteria, is partially submerged in *wastewater.* Bacteria access oxygen on rotation before digesting solids and *pathogens*. The movement also agitates gases (carbon dioxide, nitrogen, etc.) to escape the system easily.

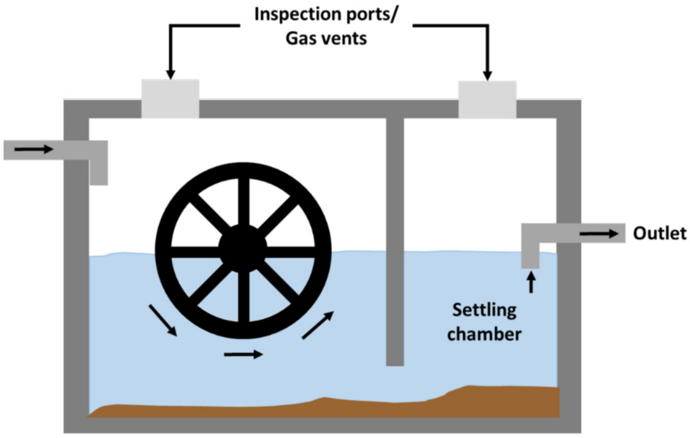


Figure 6. Example of a rotating biological contactor

Treatment efficiency	High removal of solids with effluent qualities of 8mg/l BOD, 4mg/l ammonia and 2mg/l phosphate.
Regulations	British Standard **EN 12255-3** for PTP over 50-person size and **EN 12566-3** for under 50-person size (see references 17 and 18).
Cost considerations	Installation costs vary but are on the higher end. Some systems do not have a settling chamber. This may be installed as an add–on.
Site requirements	Requires site access for desludging tanks and access to an electrical power supply.
Operational complexity	Requires technical knowledge for optimum operation. A constant supply of electricity is needed.
Maintenance required	High maintenance due to internal mechanical parts moving in the tank. Desludging will be required periodically and adequate vents to prevent gas build-up.

Advantages	Disadvantages
• High effluent quality • Low space required • Low sludge production	• High investment costs • Odour may cause problems • High maintenance requirements

Sequencing batch reactors

Sequencing Batch Reactors (SBR) is an advanced activated sludge system that facilitates biological and settling treatment in a series of stages within the one tank (Figure 7). The stages start with filling the reactor with wastewater which is followed by mixing/*aeration* with bacteria to break down *small solids*. *Large solids* are separated from the wastewater in stage 3 during settling before the wastewater and *sludge* is removed. The timings of each stage can be easily adjusted to meet specific effluent requirements.

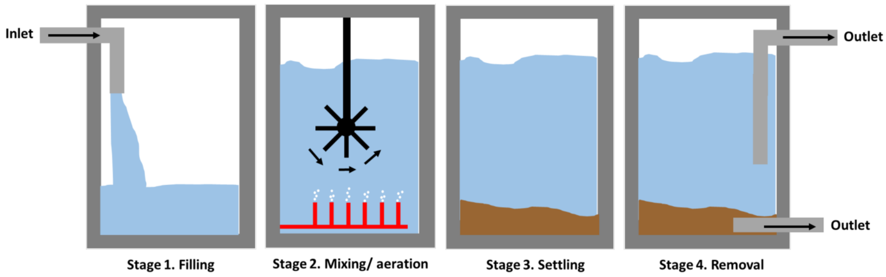


Figure 7. Example of a sequence batch reactor

Treatment efficiency	High removal of solids with effluent quality to be as low as 5mg/L BOD, 0.7mg/L ammonia and 2.3mg/L phosphate.
Regulations	British Standard **EN 12255-3** for PTP over 50-person size and **EN 12566-3** for under 50-person size (see references 17 and 18).
Cost considerations	High Installation and operating costs due to automating stages. Maintenance costs may need to consider a cleaning method between stages.
Site requirements	Requires site access for desludging tanks and access to an electrical power supply.
Operational complexity	Requires high technical knowledge for optimum operation as treatment may be dependent on timing.
Maintenance required	High maintenance due to monitoring requirements and integral moving parts within the reactor. Visual checks should be completed monthly for signs of damage or leaks. Desludging will be required periodically and adequate vents to prevent gas build-up.

Advantages	Disadvantages
• High effluent quality • Flexible operating conditions • Process is contained in one tank	• High installation costs • Dependant on power supply • Requires skilled knowledge

Biological filters

Biological filters are similar to activated sludge systems, but filter the *wastewater* before it leaves as *effluent*. Solids are kept within the tank and may be digested further by the bacteria within the tank (Figure 8). The filter can be submerged within the tank or kept outside.

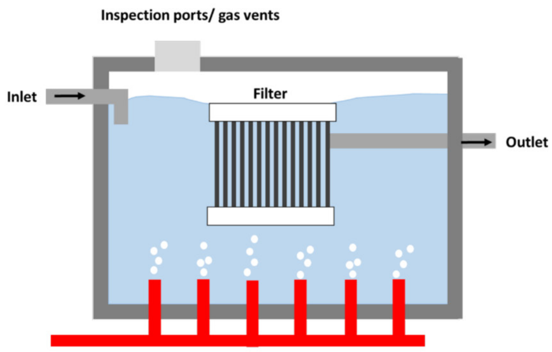


Figure 8. Example of a biological filter

Treatment efficiency	Good removal of solids with effluent quality better than 20mg/L BOD and 20mg/L ammonia. Not an effective treatment for the removal of nitrate or phosphate.
Regulations	British Standard **EN 12255-3** for PTP over 50-person size and **EN 12566-3** for under 50-person size (see references 17 and 18).
Cost considerations	High Installation, operating costs and maintenance costs due to continued monitoring and cleaning regimes required.
Site requirements	Requires site access for desludging tanks and access for cleaning. It may also need to be in reach of a power supply.
Operational complexity	Requires technical knowledge for optimum operation as *wastewater* type, flow and reactor pressure will impact performance.
Maintenance required	High maintenance due to monitoring requirements and internal components (i.e. filter). Filters may require a strict cleaning regime which could impact treatment.

Advantages	Disadvantages
• Good effluent quality • Low space requirements • Easily automated	• Not effective for the removal of nitrate or phosphate • Electricity may be required • Filters will need to be maintained

Overview of infiltration systems

Infiltration systems are used post-treatment, allowing effluent to be released into the ground safely. It is important to note that the systems do not treat the wastewater; therefore, should only be used to control the flow of already treated effluent e.g. from settlement or PTP. Adding an infiltration process to the end of your system will prevent the direct release of effluent to surface water.

There are various types available on the market, included here are infiltration fields and mound filters, both of which consist of buried plastic components such.

Is this type of system suitable for your circumstances?

Sites must be suitable to use an infiltration systems (see reference 6); see Part A, Step 4.

Each of the three tests required could individually cost up to £1,500 during the site investigation. Therefore, this should be considered in your overall budget. If the site fails the test, then an infiltration system cannot be selected.

Infiltration fields

Infiltration fields, often known as soakaways in Scotland, can take the form of total soakaways or partial soakaways (also known as a seasonal soakaway). Partial soakaways allow infiltration during dry weather but discharge to surface water during wet weather. Soakaways have buried perforated pipes that control the flow of the *effluent* (Figure 8). In addition to controlling the discharge, any naturally occurring bacteria in the soil may help to breakdown pollutants.

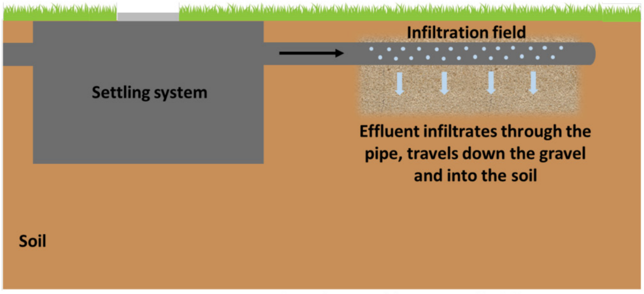


Figure 8. Example of an infiltration field

Treatment efficiency	Infiltration systems control the flow rather than treat the wastewater. However, natural processes within the soil will help to reduce BOD and ammonia.
Regulations	British Standards **EN 752:2008** and **BS 6297:2007** for the code of practice (see reference 19 and 20).
Cost considerations	Installation is not expensive but depends on size, labour and materials.
Site requirements	Buried pipes do not impact landscape, but strict land and soil percolation requirements apply. The size of a partial soakaway area for registration level sewage should be at least $25m^2$ for a septic tank or $10m^2$ for a PTP (see reference 3). For licence level i.e. >3 domestic properties or 15pe, partial soakaways should normally only be used if they are within 10m of a watercourse.
Operational complexity	Straightforward to operate and works well if designed, located and maintained appropriately.
Maintenance required	Moderate maintenance includes removal of solids and litter/debris from the inlet and outlet sources, as needed, by the property owner or specialists. Permissions or licenses for transport and disposal of solids may be required.
Advantages	**Disadvantages**
• Controlled effluent flow • Easy to construct and operate • Can be retrofitted	• Soil percolation requirements • Risk of groundwater pollution • Moderate maintenance required

Mound filters

If your site fails the requirements for an underground drainage field, then you may be able to install a mound filter. It works on the same principles of controlling the flow of treated effluent but the infiltration pipes are placed under an artificial mound filled with sand, gravel and rubble (Figure 9).

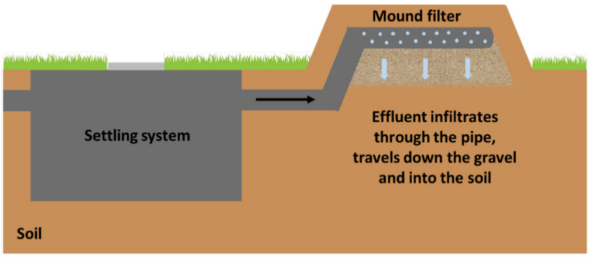


Figure 9. Example of a mound filter

Treatment efficiency	No treatment added. However, natural processes within the soil will help to reduce BOD and ammonia.
Regulations	British regulations **REP BR 478** for treatment of domestic wastewater (see reference 21).
Cost considerations	Installation is not expensive but depends on size of mound, labour and materials.
Site requirements	Depending on the size of the mound, buried pipes may impact the landscape. Therefore, the natural gradient of the land should be considered and there must be at least 0.25m of natural soil before the bedrock.
Operational complexity	Straightforward to operate and works well if designed, located and maintained appropriately.
Maintenance required	Moderate maintenance includes removal of solids and litter/debris from the inlet and outlet sources, as needed, by the property owner or specialists. Permissions or licenses for transport and disposal of solids may be required.

Advantages	Disadvantages
• Can be built if soil is unsuitable for a drainage field • Easy to construct and operate • Control effluent flow	• Construction costs may be high • May limit land use • May not be aesthetically pleasing

Overview of natural systems

Similar to infiltration, natural systems can be used as a post-treatment to control the flow of effluent, but can potentially improve the quality of the *effluent* further. The systems are a good alternative if your site does not meet the criteria for an infiltration system or you require a higher quality of *effluent*. The types of systems described in this guidance document are constructed wetlands, reed beds and packaged filters.

Constructed wetlands and reed beds

Constructed wetlands are lined artificial ponds that utilise natural material (such as gravel and sand) and processes (Figure 10). Reed beds may be used as an alternative, especially for households and small communities. The systems control the flow of effluent and can add an additional element of treatment due to bacteria naturally occurring in the environment.

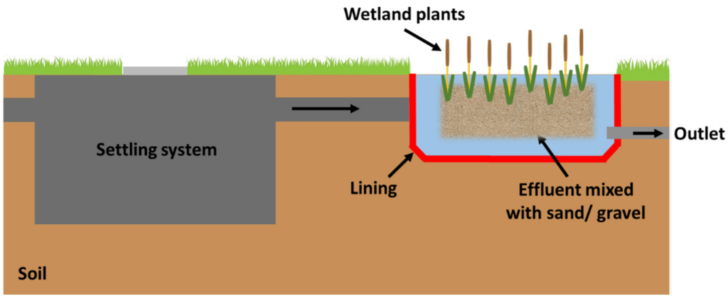


Figure 10. Example of a constructed wetland

Treatment efficiency	Bacteria, fungi and insects naturally occurring in the wetland of reed beds will help to reduce BOD and nutrients such as ammonia and phosphate. However, colder temperatures during winter may affect this.
Regulations	The **Good Building Guide (GBG 42) part 2** provides details on design, construction and maintenance (see reference 22).
Cost considerations	Installation cost is high and depends on the materials used. Discharge of the effluent needs to be considered. If there is no watercourse nearby then a drainage field may be required.
Site requirements	Constructed wetlands demand a lot of site space whereas reed beds can be more compact. You may need to consider a drainage field before the effluent reaches the environment, installation of appropriate signage and a lifebuoy, depending on the size and width of the wetland.
Operational complexity	The operation is not complex but it has a limited lifespan.
Maintenance required	Regular maintenance required which includes weeding and removal of solids/ debris. Users must be aware of the dangers of coming into contact with harmful bacteria.

Advantages	Disadvantages
• Environmentally friendly • Low operation and maintenance costs • Control effluent flow	• Can be space demanding • Affected by weather • Vaccinations should be up-to-date

Packaged filters

Packaged filters can be used as an advanced form of treatment for *effluent* leaving a settlement or biological tank. *Effluent* is passed through a filter medium (examples include peat, coir or sand) that acts as a barrier to the movement of *small solids, nutrients* and *pathogens* remaining that was not removed during prior treatment (Figure 11). The final *effluent* that leaves the packaged filter is of a higher quality.

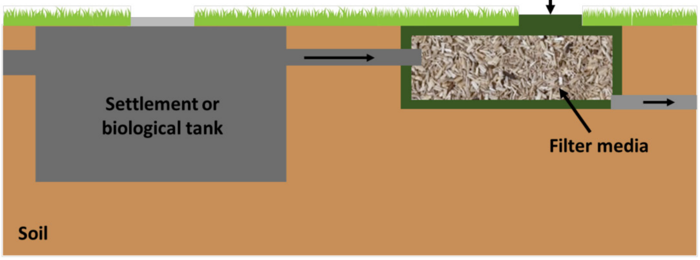


Figure 11. Example of a packaged filter

Treatment efficiency	Efficiency depends on the SSS used prior to filtration. If used after a septic system, then you can expect a high effluent quality of 6mg/l BOD, 0.6mg/l ammonia and a reduction of pathogens. The quality will increase if used after biological treatment.
Regulations	British Standard **EN 12566-3** for filters used after septic treatment and **EN 12566-7** if used after biological treatment (see references 23 and 24).
Cost considerations	Initial installation costs can be high depending on the filter media used but maintenance costs are low. You will need to consider replacing the filter media after 10-15 years but the full-system will not need to be replaced.
Site requirements	Compact systems that can be designed to be above or below ground depending on the site. You should be able to access the system to allow for cleaning, servicing or replacement of the filter media.
Operational complexity	The operation is not complex but the filter medium has a limited lifespan.
Maintenance required	Low maintenance required. Visual inspections should be conducted weekly to ensure the effluent is clear and the systems should be serviced annually.

Advantages	Disadvantages
• Environmentally friendly • Low operation and maintenance costs • Very high effluent quality	• Limited lifespan • Filter media will need to be replaced • Previous systems can impact performance

Glossary

Aeration: The introduction of air, rich in oxygen, into a sewage system to support chemical and biological removal processes for treatment.

Biogas: A mixture of carbon dioxide and methane that can be used as renewable energy. Costs do apply.

Blackwater: The wastewater from toilets that contains faeces, urines and pathogens.

BOD: Biological oxygen demand (BOD) is the amount of oxygen needed by bacteria to break down solids. It is used to indicate pollution.

Desludging: The process of removing sludge from a sewage system.

Ecosystem: The complex of interacting organisms, their physical environment and their interrelationships.

Effluent: The treated wastewater discharged by a sewage system into an infiltration system or directly to land, river, lake or sea.

Flow: Refers to the volume of *wastewater* per day. Calculations should allow for a standard flow of 150L per person per day.

Greywater: The wastewater from bathtubs, showers, sinks, washing machines.

Large solids: Heavy solid material such as sand, gravel, eggshells, bones, seeds, coffee grounds, and other large particles typically found in wastewater.

Load: Expressed as the Biological Oxygen Demand (BOD), which is largely determined by the amount of solids in the wastewater.

Nutrients: Inorganic and organic substances, such as nitrogen and phosphorus, which can be present in wastewater and could be recovered for other uses (e.g. fertilisers).

Pathogens: Bacteria, viruses, fungi and other microorganisms that can cause disease mainly spread by the faecal-oral route through blackwater.

Settling: The process of separating large solids from wastewater for removal.

Small solids: The organic and inorganic particles that remain in wastewater and do not settle.

Sludge: The formation of large solids.

Wastewater: The polluted form of water generated from rainwater runoff and domestic, industrial, commercial or agricultural activities. It includes both blackwater and greywater.

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