CREW CENTRE OF EXPERTISE FOR WATERS

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

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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

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Glossary

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
CAR	The Water Environment (Controlled Activities) (Scotland) Regulations
CE	European Conformity
CEDEX	Center for Experimentation of Public Works
DWWTS	Domestic Waste Water Treatment Systems (Republic of Ireland)
EPA	Environmental Protection Agency (Republic of Ireland)
FARYS	Flemish water board (Flanders)
GBR	General Binding Rules
GIS	Geographic Information System
GRP	Municipal Sewerage Plan (Netherlands)
GUP	Area Implementation Plan
HaV	Swedish Agency for Marine and Water Management
HHNK	Hoogheemraadschap Noorderkwartier [a water board in the Netherlands]
HRT	Hydraulic Retention Time
HSFCW	Horizontal Subsurface Flow Constructed Wetlands
IBA	Individual wastewater treatment system (Flanders and Netherlands)
RBMP	River Basin Management Planning
NGO	Non-Governmental Organisation
NIP	National Inspection Plan (Republic of Ireland)
NRW	Natural Resources Wales
PE	Population Equivalent
PSC	Plumbing Sub-Council (Alberta, Canada)
PSDS	Private Sewage Disposal Systems (Alberta, Canada)
PSTP	Package Sewage Treatment Plant
SCC	Safety Codes Council (Alberta, Canada)
SEPA	Scottish Environment Protection Agency
SEWEB	Scotland's Environment Web (https://www.environment.gov.scot/)
SOC	Safety Code Officers (Alberta, Canada)
SPZ	Source Protection Zones (England, UK)
SS	Suspended Solids
SSS	Small Sewage Systems
STOWA	Foundation for Applied Water Management (Netherlands)
TSS	Total Suspended Solids
Vp	Percolation Value
WFD	Water Framework Directive

Executive summary

Aim of the project

This project sought to answer the following questions:

- What is the policy baseline on small sewage systems (SSS) in Scotland?
- How are small sewage systems (SSS) and discharges in other countries controlled?
- Are there examples of approaches that encourage circular use of water, energy or nutrients?

Findings

Common issues

All countries for which policy was examined allowed SSS in some circumstances. Environmental and public health issues associated with poorly-maintained or inadequate systems were reported elsewhere too and were similar to those in Scotland.

Strategic consideration of roles and responsibilities

During this project, one of the most interesting emerging topics was that of roles and responsibilities of the public and the private sectors in relation to wastewater management provision in remote areas. In Scotland, in areas where sewerage is not available, the developer is responsible for putting in place a suitable decentralised wastewater treatment system. When the property is sold, responsibility for its maintenance and repair transfers to the home owner. In such cases, it is not within Scottish Water's remit to enter into a vesting agreement. In these areas, wastewater infrastructure construction and management is privately owned, yet resolving environmental and public health consequences requires significant public sector involvement.

Planning and authorisation of new systems

Two main approaches were evident. In some countries SSS are privately owned, with the private owner responsible for maintenance and repair. In most countries, planning and building regulation controls need to be satisfied before systems can be installed. New systems are then registered and, in principle, subject to regular inspection with varying frequency (although in some countries it was unclear whether regular inspections took place). In other countries, householders may have the option to request that the municipality or water board takes ownership and responsibility for the installation, management and maintenance of small decentralised systems. Householders pay a charge similar to the sewerage charge. The involvement of trained municipality or water board staff in the management of systems is likely to lead to better environmental outcomes and is more convenient for home owners.

Registering existing tanks and prioritising older systems for upgrading

In one country, a register was in place detailing the wastewater arrangements for all properties. In other countries, accurate registration of systems remained a challenge, similar to in Scotland. We encountered incentives for registration such as an exemption from permitting or eligibility for grants. We were unable to ascertain what type of information was recorded in the registers (e.g. whether system type is recorded). Several countries required that owners retained and made available for inspection any records relating to maintenance and repair.

We found several plan-based approaches to prioritisation and improvement. These included Geographical-Information-System (GIS) based assessments including proximity to water, sensitivity of the receiving environment, Water Framework Directive quality assessments, proximity to bathing waters and drinking water resources, sometimes combined with numerical targets for the number of systems that local authorities must ensure are upgraded.

Partnership working

In several countries, stakeholders are represented in permanent platforms that facilitate knowledge exchange, collaborate on research, publish information and guidance, and organise training events. A joint body can help ensure that language and definitions are used consistently throughout the partner organisations and that all aspects of SSS – planning, construction, operation and monitoring – are considered holistically, which may be more challenging if different authorities control different aspects.

Support for householders

Gaps in knowledge and understanding of wastewater systems among householders were evident both in countries with large numbers of 'historic' systems and in newly developed properties. Some well-designed sources of information on decentralised systems were available, in one case via an extensive online decision-support tool and in another via a very comprehensive catalogue of systems and brands on the market. Nevertheless, the provision of information alone was no 'silver bullet' for the installation of suitable systems.

Concern over cost is a barrier for householders to carry out the necessary maintenance to their systems. In different countries, grant support was in place for systems where improvement had been mandated following inspection; was

available where the property was in a prioritised area; was tied to the use of accredited installers; was dependent on system performance; required the system to be registered; or was dependent on household income.

British Water have a list of accredited service engineers, but Scotland is underserved with only two providers. No similar scheme is in place for installers. Elsewhere, we found that accreditation provided confidence for homeowners; in one country, installers were required to demonstrate to homeowners that the system would meet environmental regulations. Accreditation schemes also offer training opportunities for businesses.

System types

While innovative SSS may offer more effective treatment and offer potential for water, energy or nutrient circularity, they can also be more complex to maintain and more difficult to inspect. Householders and municipal staff do not necessarily have the necessary expertise to do so.

Background

Private small sewage systems, such as septic tanks, are prevalent in many of Scotland's remote, rural and island locations. If not properly managed, they can lead to a number of issues including pollution of the water environment, nuisance issues such as ponding and odour, and public health risks. These issues can have significant negative impacts on local communities and are difficult for these communities to address.

Research undertaken

Through grey literature review, the research team initially gathered information on approaches to planning, authorisation, performance requirements, post-commissioning responsibilities, compliance monitoring, enforcement, upgrading programmes, and associated grant support of SSS in thirteen countries. The Scottish policy baseline was also established. Approaches that appeared interesting or had potential to be suitable for Scotland were investigated in more detail. Relevant academic literature was also reviewed, although very little is available on the topic.

Recommendations

1. The direction of travel in terms of wastewater management in rural areas should be carefully considered, in terms of fairness, climate resilience and environmental protection. Leaving decisions to private individuals and businesses may not provide these. This study has encountered alternative models as outlined above that make better use of expertise held at water boards and provide more equitable provision.
2. Bringing together the relevant datasets that indicate sensitive environment would be useful to Local Authorities and property developers alike. This could be coupled to setting and communicating performance criteria and / or used for developing prioritisations for upgrade and enforcement efforts. It is furthermore recommended that efforts for improved data gathering on SSS are continued, with carefully consideration what data can and needs to be included (e.g. size, technology, site-specific conditions) to allow future risk assessments or plan support for enhancement.
3. The introduction for a requirement of record-keeping as part of the CAR-authorisation, to include an appropriate set of system performance checks as well as maintenance records.
4. The establishment of a permanent discussion and knowledge exchange platform for water stakeholders, including property developers and the general public, in Scotland, with the purpose of knowledge sharing and improving wastewater management.
5. Further develop the new guidance for householders and property developers, including an online guide. The awareness needs of property developers and householders should be further explored, on an ongoing basis, via a partnership organisation as proposed.
6. To put in place financial support for householders, particularly where an improvement notice has been served. When doing so, bear in mind that ownership, property use and occupation may change over time; therefore, resilient systems should be encouraged. It may be appropriate to tie the provision of grants to the use of accredited installers, although only if these are available in the remote areas where systems are likely to be located.
7. To consider introducing an installer accreditation system, including how its use could be encouraged or mandated. Such a system should be developed to attract wide membership across Scotland, in particular in remote, rural and island areas.
8. To provide incentives for the significant expansion of the number of accredited servicing technicians in Scotland, ensuring wide geographical coverage in particular in remote, rural and island areas.
9. With current levels of capacity in communities, it is recommended to focus on simple systems that are easy to maintain. More complex and circular systems may seem attractive but are only effective (or even safe) if maintained by capable individuals. Climate resilience (both in terms of emissions and in terms of resilience under flood or drought conditions) should be included in decision-making.

1 Introduction

1.1 Background and rationale

Private small sewage systems, such as septic tanks, if not properly managed, can lead to a number of issues including pollution of the water environment and nuisance issues such as ponding and odour. These issues can have significant negative impacts on local communities and are difficult for these communities to address. Through an international review of approaches to small sewage systems, this project sought to understand how small private sewage systems are managed in other countries (with similar socio-economic profiles to Scotland) and the benefits and disbenefits associated with different approaches, with a view to informing approaches in Scotland.

The review focused in particular on policies relating to the authorisation of new and existing small sewage systems and to the ongoing regulation both 'historic' and newly-installed systems.

1.2 Approach

1.2.1 Literature review

Whilst the primary focus of the project was on the 'grey' literature, a targeted literature approach was used to identify relevant peer-reviewed articles, whereby the focus was on material from geographical areas that were considered broadly comparable to Scotland, in particular Europe, USA, Canada, Australia and New Zealand. Material that focused mainly on the performance of various SSS systems was not considered here. Only a limited number of publications that were both relevant and recent was encountered. Findings from the peer-reviewed literature are integrated into Chapters 2 and 3.

1.2.2 Country review

Through web search and information from our network, the research team gathered initial information on the management of small sewage systems in the following countries: Canada (Alberta and British Columbia), England, Wales, Denmark, Sweden, Norway, Finland, Estonia, Netherlands (drawing on policies from several water boards), Belgium, Republic of Ireland, Spain, New Zealand, USA (Nevada). This initial selection was based on language skills within the research team, availability of documents in the available languages, and accessibility of available information more generally. Information for Scotland was also gathered.

An initial scan of this information was conducted and high-level answers to the following questions were gathered:

- In what circumstances are new SSS allowed?
- What types of systems are encouraged/required?
- Who authorises new systems?
- What are the performance criteria?
- Who is responsible for management post-commissioning?
- How is compliance monitored for existing systems?
- Who monitors and/or enforces compliance for older systems?
- Is there a programme for upgrading older systems?
- Are there any grant or subsidy systems?
- How is circularity (energy, water or nutrient recovery) encouraged?

It should be noted that this screening phase was primarily intended to identify interesting approaches; the type and level of detail of the information provided in answer to these questions is therefore not necessarily consistent for all countries.

1.2.3 Recommendations for Scotland

The status quo in Scotland, i.e. the policy baseline, was obtained primarily from *GPP 4: Treatment and disposal of wastewater where there is no connection to the public foul sewer* (NIEA and SEPA, 2017) with supplementary information from NetRegs (NetRegs, n.d.), the Water Environment (Controlled Activities) (Scotland) Regulations (2011) or CAR Regulations, the SEPA website (SEPA, n.d.) and the Building Standards Technical Handbook (Scottish Government, 2020). Recommendations for Scotland are based on the extent to which international approaches address the issues identified in Scotland and on whether they would fit with stakeholder roles and responsibilities in Scotland.

1.3 Structure of the report

This report is organised thematically, answering each of the above questions in turn in Chapter 2. Each section includes:

- A short summary of the current approach in Scotland
- A brief overview of the approaches encountered internationally (grouped as appropriate)
- A table with country details in brief for all selected countries, highlighting in blue the approach that has been selected for more detailed investigation
- More extensive coverage of selected case studies with approaches were particularly interesting.

Findings relating to the organisational infrastructure in other countries were also considered relevant and are covered in Section 2.6.

Chapter 3 then discusses which of the approaches may be most appropriate for Scotland.

2 Results of the policy review

2.1 In what circumstances are SSS allowed?

2.1.1 Scotland

In principle, allowing SSS will be considered when connection to the public sewer is not *'feasible and reasonably practical, for example if it is too costly or there are land access issues'* (NetRegs, 2017). GPP4 makes reference to the need to provide evidence that this is the case. NetRegs advises that *'Your local council will check this first when deciding the acceptability of your plan'* (NetRegs, no date).

The applicant will need to ensure that the site is suitable, by checking that there is nothing that would prevent the use of a septic tank (e.g. a well or borehole supplying drinking water); that there is enough space to construct a soakaway or drainage field; that the ground conditions and slope are suitable for a soakaway and that the soakaway is not prone to flooding. If a soakaway is not possible, discharge to surface water may be allowed subject to conditions.

2.1.2 Internationally

All countries allow the use of SSS in certain circumstances (Table 1). The main approaches to authorisation are:

- Spatial: either via a 'Distance from main sewer' criterion or via a zone-based plan (which can also take into account the nature of the receiving environment)
- Case-by-case initial approval via the planning system
- License or permit requirements (which may be subject to regular renewal)
- Minimum treatment standards, either as technology requirements or effluent requirements (these may depend on the size of the effluent, the nature of the effluent, or the nature of the receiving environment)
- Reference to other standards e.g. Building Regulations stipulations on water efficiency
- Requirement of engineers' reports about various aspects of the site
- Areas where the regular authority is exempt from providing services, based on e.g. settlement size (varying from around 60-2000 Population Equivalents (PE)) or population density (Iceland; not covered).

2.1.3 Case study

Flanders

In Flanders, the main organisations involved are the municipality , the province and FARYS (the Flemish water board). An Area Implementation Plan (GUP) specifies the area where the municipality is responsible and at what point the province takes over. A Zonation Plan details the approach to wastewater treatment for each property (Vlaamse Milieumaatschappij, 2017). Both GUPs and Zonation plans are part of River Basin Management Planning (RBMP), which appears to be the main driver for optimising treatment. For every property in Flanders, the approach to wastewater treatment is recorded in the Zonation plan, which distinguishes four zones:

- **Central area**: Properties must be connected to the main sewer. FARYS will do this at the request of the householder.
- **Rural Area already Collectively Optimised**: Properties must be connected to the main sewer. FARYS will do this at the request of the householder.
- **Rural Area yet to be Collectively Optimised**: In this area, sewerage is planned, but not yet available. Properties must treat wastewater via a septic tank. After treatment, there are three options for discharging the effluent: into a sewer that is not yet connected to a WWTP; discharge into a canal; or indirect discharge into the ground (via a perforated settlement tank or 'sterfput').
- **Rural Area to be Optimised Individually**: In this area, collective treatment is not economical and individual properties need to be connected to an individual wastewater treatment system (IBA). Whether the householder needs to do this themselves, or whether FARYS will do it, depends on the location of the property; householders can check on the Farys website. The decision on where collective treatment is offered via Farys is taken by the municipality.

Of the rural area, 10% are in the collectively optimised area, 78% of properties are in the area yet to be collectively optimised, and 12% is in the area to be individually optimised. Of the latter, 1% is already optimised via an IBA and 11% is yet to be optimised (2016 figures; Vlaamse Milieumaatschappij, 2018).

Where the local authority has decided that individual treatment is approached collectively (i.e. via FARYS), the householder can choose to ask FARYS to buy, install and maintain their IBA. To be clear, these IBAs serve

Table 1 In what circumstances are SSS allowed?	
COUNTRY	**IN WHAT CIRCUMSTANCES ARE SSS ALLOWED?**
ENGLAND	SSS allowed when the Environment Agency decides you cannot 'reasonably' connect to the mains sewer (based on distance, cost, access (e.g. if a main road prevents connection to the mains sewer) or if the SSS would have environmental benefits, such as reuse of treated effluent (UK Government, no date). SSS are subject to Planning Permission and Building Regulations. Source Protection Zones (SPZ) have been defined to protect drinking water sources. Different types of permits apply depending on SPZ, whether discharge is to surface water or soil, volume per day, and age of the system. Discharges into tidal waters must be below the mean spring low water mark.
WALES	Allowed via free registration where the sewer is more than 30m away. For larger development, the 30m is multiplied by the number of homes. An environmental permit is required if the SSS is < 500m from a designated area (Site of Special Scientific Interest or Source Protection Zone); has more than 13 residents and is a septic tank discharging to a soakaway; has more than 33 residents and is a Package Sewage Treatment Plan (PSTP) discharging to a water course; or is <50m from a borehole or well.
REPUBLIC OF IRELAND	Allowed but subject to permissions. A suitably qualified person must be engaged to check requirements (including slope < 1:8; 3<Vp<120 (Vp=percolation value); minimum soil depth and separation distances) (Environmental Protection Agency, 2021).
NETHERLANDS	Municipalities[1] are responsible for providing sewers; they can provide package plant or similar as long as the degree of protection of the environment is the same as it would be for centralised plant (in agreement with the local water board, which are generally catchment-based). Private SSS allowed if the main sewer is more than 40m from the property (rising to > 3km for 100-200 PE; systems >200 PE must always be connected to a public sewer). Private SSS are also allowed in built-up areas if provision is made in the municipal sewage plan.
BELGIUM	Area-based, as specified in municipal zonation plan or by the province.
SPAIN	Only in very small and dispersed communities (authorised by municipalities).
SWEDEN	Allowed, SSS mainly used for holiday cabins (1/3) and rural homes (2/3); about 1M properties in total.
NORWAY	Allowed. SSS used for 16% of households. Total 350,000 systems, to serve 800,000 people.
DENMARK	Allowed, licensed by municipality.
NEW ZEALAND	It is legally required to use mains sewer connection if available on the property but local authority can provide a waiver allowing on-site wastewater treatment to be installed. Even if connected to the mains sewer, property owners are allowed to install a greywater system (Smarter Homes, no date (a).
NEVADA, USA	Allowed only if no public sewer is available within 400ft of the property. Permit required; owner is required to provide range of documentation, depending on system (e.g. soil analysis, leach line calculation, etc).
ALBERTA, CANADA	SSS allowed but must meet certain standards, depending on the size of the effluent.
BRITISH COLUMBIA, CANADA	It is the responsibility of the homeowner to ensure sewage is discharged to a sewerage system that is constructed and maintained in accordance with the regulation that sewage from the structure does not cause a health hazard.

[1]We use the term municipality in countries where local government is at the scale of a village, town or city. These can vary in population size from 100 to 1000,000, but are distinct from UK Local Authorities in that they tend to cover only one settlement (or sometimes small neighbouring settlements). In some countries, a regional government level is also in place; we have referred to that as the 'province' regardless of the local term used (e.g. 'provincie' in the Netherlands or 'gewest' in Belgium).

individual properties and are NOT managed collectively by householders; they are maintained by FARYS. If the householder makes such a request, someone from FARYS visits to discuss the best system and the best location. The householder may request a different system, if that is technically possible, but if this is more expensive then that householder needs to pay the difference. FARYS then sends an offer/quotation and the householder needs to sign and return this. The householder is responsible to install a power supply, make arrangements for an overflow and ensure their rainwater is separate from their wastewater. FARYS regularly maintain and check the IBAs they have placed. Where the householder is responsible to place an IBA themselves, this will be indicated in the planning or development consent.

2.2 Who authorises new systems?

2.2.1 Scotland

New developments must have planning permission and both SEPA and Scottish Water are statutory consultees in the planning process. Neither would normally get involved for a single house application unless there was a specific

concern e.g. a sensitive area (Akoumianaki, 2022). An objection from either institution does not necessarily lead to planning refusal. If planning permission is granted, the applicant needs to obtain a CAR-authorisation from SEPA if they intend to discharge effluent to the environment. This will be a Registration for smaller discharges or a Licence for larger discharges; both are subject to conditions, including system maintenance. The technical detail of the proposed system needs to be submitted to the Local Authority by the developer, before a Building Warrant is granted (at least some Local Authorities require a CAR license to be in place). The system must be in accordance with the Building Standards Technical Handbook (Scottish Government, 2020b). In other words, the planning decision indicates *whether* the development can go ahead, whereas the Building Consent details the conditions for *how* it should go ahead.

GPP4 further advises that permission from the owners of the lands that the system's connections will cross or where the system will be installed may also be required, and that permission is needed from the relevant roads authority if excavations are required in the public road, under the Roads (Scotland) Act 1984 or the New Roads and Street Works Act (1991).

2.2.2 Internationally

Those involved directly in authorisations include municipalities, provincial government, water boards, public-health related groups and environment agencies, whilst national government organisations also play a role, in particular for determining zone plans or by providing guidance documents (Table 2).

2.2.3 Case Studies

The Netherlands[2]

Municipality duties

The municipality has a duty of care to provide sewerage services. This can include decentralised provision as

Table 2 Who authorises new systems?

COUNTRY	WHO AUTHORISES NEW SYSTEMS?
ENGLAND	The Environment Agency decides whether it is 'reasonable' to connect to public sewer. If a permit for an SSS is granted, Local Authorities authorise the system via Building Regulations and sometimes also via planning permission. Retrospective permission is possible.
WALES	Natural Resources Wales, via a registration and permitting system. Planning requirements and building regulations also apply.
REPUBLIC OF IRELAND	Local authorities issue discharge licenses. An exemption is in place for domestic sewage not exceeding 5 cubic meters per day.
NETHERLANDS	The municipality pays for installation and maintenance from sewerage charges (unless an exemption applies; see below).
BELGIUM	The Province or Municipality, depending on location (rural areas are covered by the Province).
SPAIN	Municipality.
SWEDEN	Municipalities are responsible for licensing and inspection. The supervisory guidance authority is the Swedish Agency for Marine and Water Management. Municipalities have a duty to supply water and sewage for villages with 20-30 households if necessary for environmental or public health reasons.
NORWAY	Municipalities are responsible for licensing and inspection. Ministry for Climate and Environment authorises sewage zones.
DENMARK	Municipalities are responsible for licensing and inspection. Ministry of Environment provides guidance.
NEW ZEALAND	Building consent is required. The system must meet regional council requirements.
NEVADA, USA	Division of Public and Behavioural Health.
ALBERTA, CANADA	Safety Codes Council, via permits and inspections. SCCs are regulated by Alberta Municipal Affairs. A Plumbing Sub-Council (small working group of contractors, suppliers, engineers, public etc) advises.
BRITISH COLUMBIA, CANADA	Similar to Alberta.

[2] New Environment Law from July 2022
A new law is due to come into force in the Netherlands on 1 July 2022: the Environment Act (Omgevingswet). When this takes effect, the province will be removed from the decision-making; the Local Authority itself can determine what sanitation provision (main sewer, alternative system, or leaving treatment to the householder or business) is in place outside of settlements. The formal requirement to produce a GRP will also be scrapped, although it is expected that most municipalities will continue to do so. The biggest change under the new Environment Act is that the municipality and water boards will be able to set rules themselves; under the current legislation they do not have these powers (although under certain conditions they are able to require site-specific measures).

long as it meets the same environmental standards as centralised provision. The decisions on where to provide sewers, where to provide alternative systems and where to apply for an exemption are detailed in the Municipal Sewerage Plan (GRP). This is prepared by the municipality, in consultation with the water board and the province. In areas where an alternative system is in place, and provided that the system is managed by the municipality, the municipality is allowed to charge a sewage charge for residents connected to this system. The municipality may also use income from sewerage charges for the installation, management and maintenance of alternative systems. The municipality is not responsible for collecting commercial wastewater, although this service is often provided anyway (with conditions).

Role of the province

The municipality can apply to the province for an exemption to its duty to provide services for areas outside of a settlement or settlements smaller than 2000 PE. Where such an exemption has been approved by the province, the householder or business is responsible for their wastewater. They must then comply with regulations around discharges.

Duties of the water board

All of the general rules as detailed above apply when the protection of the environment is not at risk; this is determined by the local water board. If there is a risk to the environment, discharge is prohibited unless an exemption is granted. For discharge to soil, effluent limit values apply. The water board is also responsible for treating the wastewater (collected via the main sewer).

Alberta, Canada: Independent Regulatory Body

Safety Codes Council (SCC)

The SCC is an independent regulatory body, established via the *Province of Alberta Safety Codes Act* (2000) with a goal to provide an effective and sustainable safety codes system for structures, facilities and equipment. The SCC provides training and certifying Safety Code Officers (SOC) to oversee permits and inspections, accreditation to municipalities for compliance monitoring, and compliance monitoring for unaccredited areas (this includes private sewage systems). The **Plumbing Sub-Council (PSC)** is a sub-group of the SCC and focus primarily on issues relating to wastewater. As all sub-councils, the group is volunteer-based and includes the members of the public, manufacturers & suppliers, professional engineers, contractors, inspectors and employees from the urban municipalities division and the rural division. Members meet four times each year and have been operating since 2017. Written records of all meetings are retained and are available publicly. The primary role of the PSC is to provide technical guidance and recommendations to the plumbing industry and to make sure that the environment is safe to inhabit; their remit includes private sewage systems. Key topics that have been discussed by the group include:

- Definitions and terminology.
- Roles and responsibilities of homeowners, designers and installers and described
- Types of wastes that are prohibited
- Training and management of different strengths of wastewater
- Clarifying minimum capacity of holding tanks (recreational, seasonal and commercial)
- Tank access considerations
- Soil and material requirements for infiltration systems
- Training for designers, installers and SOCs on the new Standard of Practice (public guide for private sewage treatment published in 2015).
- Water reuse solutions guide and fact sheet updates.

Private Sewage Disposal Systems (PSDS) working group

The PSDS working group was formed in 2017 with a mandate to provide technical guidance and recommendations in matters related to the Alberta Private Sewage Systems Standard of Practice. It also provided an opportunity for stakeholders to input in the development and maintenance of private sewage systems, codes and standards of practice. The working group members were appointed to their roles by the PSC. Representation consisted of SOCs, council members, individuals from the rural municipalities division, designers & installers, academics, industry reps and plumbing council members.

Issues that the PSDS working group has identified and amended include changes to existing Standard of Practice (types of filters acceptable, design worksheets, fixed units, etc.) and the certification of new technologies. New systems require recognition by the Standard of Practice. Documentation needs to be submitted in order to demonstrate the technologies comply.

2.3 What types of systems are encouraged or required and what are the performance criteria?

2.3.1 Scotland

No specific system is recommended but discharge to land is usually preferred over discharge to water. The guidance

emphasises the need to contact the regulator and the local authority. Systems must meet the Building Standards Technical Handbook 2020, which determine that various system quality standards apply. Septic tanks have to comply with Standard EN12566-1 for prefabricated septic tanks, and EN 12566-4 applies for septic tanks assembled at on-site from prefabricated kits. BS 6297: 1983 applies to drainage fields and infiltration systems. Furthermore, the Building Regulations prescribe that covers are sealed and secure; that an inspection and sampling chamber must be present; and that the system provides access for desludging. Other construction requirements, such as minimum distance from a property or water body, also apply. According to the Handbook, the disposal of greywater (from baths, showers, washbasins, sinks and washing machines) may be accomplished by an infiltration field (area calculations are described in the Handbook).

A CAR License, issued by SEPA for larger systems, may specify performance criteria specific to the application, e.g. in the form of effluent limit values. Enhanced treatment may be required, e.g. if the SSS is near a bathing water or discharges into a smaller water course. It is not clear whether Local Authorities ever apply additional site-specific performance criteria but it seems that they mainly check for compliance with the Building Standards.

2.3.2 Internationally

Most countries allow a range of different systems (Table 3). Industry standards (e.g. BS) are used in various countries. Requirements are set in terms of Biological Oxygen Demand, Chemical Oxygen Demand, Suspended Solids, Phosphorus content, Nitrogen content, and

Table 3 What types of systems are encouraged and what are the performance criteria?

COUNTRY	WHAT TYPES OF SYSTEMS ARE ENCOURAGED AND WHAT ARE THE PERFORMANCE CRITERIA?
ENGLAND	Four categories of systems are permissible. 1) A septic tank; 2) A small sewage treatment plant; 3) A cesspool; 4) a non-standard system such as a reed bed or trench arch system. Relevant British Standards must be met (BS EN 12566 for small sewage treatment plant; BS 6297:2007 for drainage fields; or CE-certified plant). For plants older than 1983, no certificate is required but plants must meet General Binding Rules (GBR). GBR also apply to newer systems.
WALES	Septic tanks, package sewage treatment plant, a cesspool (sealed tank and sewage removed by contractor) or non-standard systems (e.g. a reed bed or a trench arch system) are allowed. Non-standard systems need permits from the Natural Resources Wales (NRW).
FLANDERS, BELGIUM	Rainwater must be separated. 'Compact' and 'extensive' systems are distinguished. Three-stage treatment required as standard: solids settlement and water buffering; aeration; solids removal and effluent discharge.
REPUBLIC OF IRELAND	Standard Recommendation SR66: 2015 provides the guidance to designers, manufacturers and installers when selecting a Domestic Waste Water Treatment System (DWWTS) guidance on selection, minimum performance and scaling parameters and minimum sludge storage capacity. If a site is not suitable for a standard percolation area, there may be other options. A filtering system can be added to the septic tank (e.g. soil and sand filters, constructed wetlands, media filters, willow bed evapotranspiration systems) or a mechanical treatment plant can be used.
NETHERLANDS	For systems < 6 PE, most common are septic tanks, but other options are biorotor, helophyte or oxidation bed (alternative systems are allowed as long as they are similarly effective as a septic tank). Septic tanks have to adhere to NEN-EN 12566-1:2018 Ontw. En. (likely the same as BS EN 12566). Needs to be at least 6m^3 and have a hydraulic efficiency of 10gr. Systems installed before 2009 do not meet these requirements but are allowed under a transition arrangement (i.e. the right to abide by rules that were in place at the time of installation). For systems > 6 PE, dischargers are free to choose any system as long as it meets the standards prescribed in CIW (1999). Four classes of system are distinguished, depending on the level of treatment; a requirement for a specific class rather than a specific system is be imposed.
SPAIN	Appropriate systems are selected in each specific case. If the systems are managed by the local authority, the limitations of technical requirements and operating costs will be much more severe than in the case of a regional or autonomous management entity. There is no specific regulation for discharges from facilities <2000 PE (only that "adequate treatment" is required), and there are different criteria in each basin organization. The discharge limit values are defined in the discharge authorization. Generally, the limits after a secondary treatment established by the Directive 91/271 / CEE are required (Suspended Solids (SS) <35mg/L; BOD5.25mg / l; Chemical Oxygen Demand (COD), 125mg / l).
SWEDEN	Sludge separator required, three-chamber well model for toilets required, unless they have bio thermic digesters (but often this requirement is not met). Soil infiltration, sand beds and drainage field systems are most common, small site-assembled wastewater treatment systems and enhanced biological phosphorus reduction are few but increasing. Liquid/solid separation toilets also on the increase. Requirements depend on property proximity to water bodies: In 'Normal level' risk areas, which are areas far from water bodies, the requirement is to a) limit the use of water in treatment; b) use phosphate free chemicals; c) 90% reduction organic matter; d) 70% reduction phosphorus; e) recovery of nutrients. In 'High level' risk areas, i.e. near water bodies, all the above apply and f) 90% reduction of phosphorus[3]; g) 50% reduction of nitrogen

Table 3 What types of systems are encouraged and what are the performance criteria?	
COUNTRY	**WHAT TYPES OF SYSTEMS ARE ENCOURAGED AND WHAT ARE THE PERFORMANCE CRITERIA?**
NORWAY	New builds prefabricated one chamber septic, soil infiltration, mini treatment plants, and Horizontal Subsurface Flow Constructed Wetlands (HSFCWs) are the most common treatment systems. Where not feasible in high mountain regions, a new innovative system promoted since 2009 is source-separating sanitation, mini-treatment plants which use mechanical filters and above ground biofiltration systems in a weather protected encasement. Performance criteria depends on sewage zone, seven sets of purification levels for Phosphorus, SS or BOD. Sensitive and less sensitive areas are distinguished.
DENMARK	Septic, soil infiltration, mini-treatment plants, and vertical subsurface flow constructed wetlands. Horizontal subsurface flow constructed wetlands popular from 1980-2000's but now not approved. Highest percentage of small waste systems with tertiary treatment after Germany. Four categories with different levels for each parameter of pollution control. Four categories are O: Organic matter reduction BI5 (mod.) of 30. OP: Organic matter and phosphorus SO: Organic matter and nitrification. SOP: Organic matter, phosphorus and nitrification
NEW ZEALAND	Septic tanks are the most commonly used. There are various other systems in use as well, including single waterless toilets, or aerobic or 'secondary' treatment systems. Many councils require new systems to have at least two chambers. Some councils will require additional treatment of wastewater with ozone, ultraviolet, filtration or chlorine to make the soakage treatment area safe.
NEVADA, USA	Most documentation refers to septic tanks. Requirements include but are not limited to the following: cesspools are prohibited; septic systems are prohibited in areas subjected to vehicular traffic, areas to be paved or in shaded areas; only 1 single-family dwelling is permitted per individual sewage disposal system; disposal fields must be located in unshaded, unobstructed areas, etc. There are many requirements. Quality may be decided on a case-by-case basis. For water reuse, the Biological Oxygen Demand (BOD) needs to be less than 30mg/L and the TSS under 30mg/L. Faecal coliform and Total coliform are based on the method of reuse.
ALBERTA, CANADA	Systems must comply with the Alberta Standard of Practice 2009. This also provides certification to installers. No specific type of treatment is required, but decentralised, communal, distributed or cluster systems seem to be encouraged. Holding tanks are also used, whereby the collected effluent is transported to a centralised plant.
BRITISH COLUMBIA, CANADA	Three types are recognised: Type 1 is septic tank and dispersal field. Type 2 is treatment that produces an effluent containing less than 45mg/L TSS and a BOD of less than 45mg/L. Type 1 and 2 are used in instances where the estimated minimum daily domestic sewage flow is no more than 9,100L. These can be performed onsite by registered practitioners. Type 3 requires professional engineers to design and construct. As in Alberta, there is a Standard Practice Manual.

[3] Phosphorus removal appears to be via an alkaline filter as a tertiary step

hydraulic performance, but can also cover the need for regular maintenance or the need to act on problems such as scum or smells. Site-specific requirements may be imposed (see also e.g. LeGro, Vowels and Vondra, 2017; soil depth is a requirement in Wisconsin) and requirements also depend on the size of the effluent or property. Limits on the volume discharged can apply. In New Zealand, tertiary treatments are sometimes required.

2.3.3 Case studies

Flanders

An IBA must involve the following steps:

1. During the pre-treatment, solids settle and the water is buffered;
2. During the biological treatment, bacteria degrade the waste material using oxygen. In an extensive system, the transport of oxygen to the waste material occurs via plants or natural materials;
3. During the post-treatment, the solids are removed and the treated effluent can then be discharged into canals or surface water. The effluent quality must conform the norms of the environmental regulation: pH between 9 en 6.5; BOD 25 mg/l; suspended solids 60 mg/l (Vlario, 2022).

Information is given on IBAs lists 'compact' IBAs and 'extensive' IBAs. A compact IBA is an underground system, made of synthetic material or concrete, takes up little space, and only one or more lids and the control unit are visible. An extensive IBA can be e.g. a reed bed or coconut bed, is above ground, can be integrated into the garden, is able to cope with flow variation, and uses less electricity than a compact one. New IBAs (yet to be installed) need to have a CE mark, which will be integrated for Belgium into BENOR certification.

The Flemish environmental law (*Vlarem II*) obliges householders to separate sewage and rainwater when installing an individual wastewater treatment system (IBA). It may be caught for re-use, infiltrated into own ground, buffered with delayed discharge to surface water or artificial rainwater discharge system, or discharged to

the rainwater in the street. The wastewater connection and correct separation of wastewater and rain water is inspected.

The Netherlands: treatment classes, maximum limit values and site-specific consideration

In the Netherlands, three classes of IBA are distinguished, with one subdivided into two:

- IBA class 1 is a septic tank that conforms to the maximum limit values specified below;
- IBA class 2 is an aerated system, mainly useful for removing suspended solids;
- IBA class 3A additionally removes nitrogen compounds; and
- IBA class 3B also removes phosphorus.

The IBA class installed may have implications for charges to the householder.

For discharge to soil, the following limit values apply to new installations (De Graaf and Swart, 2015):

The Dutch authorities acknowledge that for new installations, careful consideration is sometimes required to determine what is best for the environment and what is legally allowed. This results in site-specific recommendations. For example, in some areas, vacuum toilets were considered but rejected due to the risk of noise pollutions; elsewhere they are allowed. Another example is that, normally, food waste macerators are not allowed in the Netherlands unless the discharge is to a closed system. In one project (marina + residential), a vacuum system was installed to recover biogas; to increase biomass, residents were instructed to install a food waste macerator. In this case the use of macerators was approved, because the project discharges to a collection tank. The purchase of the macerator was initially compulsory for residents, but the installers were charging significantly more than had been initially agreed. After a legal challenge by a resident, the policy was changed after which residents are encouraged (rather than required) to install one (STOWA, 2014).

Denmark: circularity and environmental protection

Since the 1980's, Danish national wastewater strategies, legislation and government investments have put a strong emphasis on increasing the circularity of wastewater and designing small sewage systems for environmental protection. As a result, Denmark has become a global market leader in green technologies and ecological innovations for tertiary wastewater treatment, both small and large scale (Miljøstyrelsen 2021a) and research collaborations between universities and private companies have produced innovative sewage solutions for households that are not connected to the municipal sewage systems, including constructed wetlands (Nordic Innovation Center 2005; Brix et 2007; Adrados et al 2018) and mini-treatment sewage systems with tertiary treatment options which can be either biological or chemical or a combination of both (Miljøstyrelsen 2021b).

Where low-cost and low-technology septic tanks are installed instead of mini-treatment plants or constructed wetlands, then sludge separation is a minimum requirement and the sludge is collected by the municipality, at a cost to the household. At the municipal wastewater treatment plants, phosphorus is extracted from sewage sludge and reused in struvite fertilizer products (Danish Water Forum 2016), which is deemed

Table 4 Maximum Limit Values for discharge of domestic wastewater (mg/L) in the Netherlands. Translated from De Graaf and Swart, 2015)

Maximum limit values for discharge of domestic wastewater (mg/L)				
	Discharge to soil or to 'indicated'* ('aangewezen') surface water body		Discharge to non-indicated ('niet-aangewezen') surface water body	
Parameter	Representative 24-hr sample	Grab sample	Representative 24-hr sample	Grab sample
Biochemical Oxygen Demand	30	60	20	40
Chemical Oxygen Demand	150	300	100	200
Total Nitrogen	-	-	30	60
Ammoniacal Nitrogen	-	-	2	4
Undissolved solids**	30	60	30	60
Total Phosphorus	-	-	3	6

*'indicated' water bodies are those that do not require special protection as far as discharges are concerned. These are the larger surface water bodies. A definition of the term is provided in Activiteitenbesluit Milieubeheer (2021).
**Not applicable to discharges of < 6 PE, provided that the water has passed through a treatment installation.

preferable to direct application of sanitised sludge due to concerns over (heavy metal) contaminants.

2.4 Who is responsible for management post commissioning and how is compliance monitored and enforced?

2.4.1 Scotland

The owner is responsible for management: it is a legal requirement to maintain the system appropriately so that it is operating according to the conditions of the authorisation at all times. Failure to do this could be a criminal offence (GPP4). In tenanted properties, the landlord is responsible for "keep[ing] in repair and in proper working order the installations in the Let Property for the supply of water, gas, electricity, sanitation, space heating and water heating" (Scottish Government, 2021). Under the same agreement, the tenant should "not put any damaging oil, grease or other harmful or corrosive substance into the washing or sanitary appliances or drains". For larger (e.g. communal) systems, the Water Resources (Scotland) Act 2013 also applies. This stipulates that in case of jointly owned systems, each owner is liable according to the proportion of ownership and enables any of the systems owners to recover costs for maintenance from another owner. SEPA can 'serve notice' on an owner if the conditions of the Registration under CAR have been breached (in particular the stipulation that 'the effluent treatment system shall be maintained in accordance with the manufacturer's or designer's recommendations, and in any event, in good working order') or if the system is causing or likely to cause 'significant adverse harm' to the water environment.

Neighbours can complain to the Local Authority's Environmental Health team if an SSS causes a (statutory) nuisance under the Environmental Protection Act 1990. The Local Authority is required to investigate any complaints and can then require the owner to address the issue. If owners do not make the necessary improvements, they could be committing a criminal offence. However, the Environmental Health team only tend to take action if the situation poses a risk to public health.

Neighbours can also apply directly to the Sherriff Court under Section 82 of the Environmental Protection Act 1990.

2.4.2 Internationally

In most cases, owners are responsible (Table 5); in the Netherlands and Flanders, systems may also be owned and operated by the municipality or the water board.

Tenants may have duties if stipulated in their rental agreement. Inspection programmes range from non-existent to once every 10 years to annually. Fines and other penalties are in place in case of failure. In addition, authorities are usually able to act on suspected failures e.g. following complaints.

2.4.3 Case studies

Experience with community systems in Sweden

Community or shared Small Sewage Systems (SSS) are either co-owned or administered by an association. Co-owned systems are usually smaller, often no more than 2-5 households, and association administered SSS are usually a larger number of households. It can take up to five years to get a community set up from idea inception to final installation (JTI 2015). It is however quite common that communities initially decide to make a community SSS, but due to the challenges of high upfront costs, high maintenance costs and time demands, and collaborative decision making between neighbours, the community SSS often gets turned over to the municipalities to manage in the long run (Christensen and Helwig, 2021). The municipality has, under certain circumstances regulated in the Public Water Supply and Wastewater Systems Act, a duty to take over the maintenance if there is a request.

Republic of Ireland: Rural Water Programme and EPA National Inspection Plan

The Republic of Ireland has nearly half a million septic tanks. The Environmental Protection Agency is required to Water Services Act (2007) (as amended) to make a National Inspection Plan (NIP) for wastewater treatment installations; the most recent NIP covers the period 2022-2026 (EPA, 2021). The plan has two strands: inspections of domestic wastewater treatment systems to check these are operating correctly and adequately maintained, and engagement with homeowners, ensuring they know how to operate their system and are aware of the risks of not doing so.

The EPA's *Domestic Waste Water Treatment System Inspections 2020* report states that over 1000 systems are inspected annually, in accordance with the plan's target. The annual target will increase to 1200 from 2023. In 2020, over half failed and nearly a quarter (23%) posed a risk to the environment or human health. Local Authorities carry out additional inspections in response to complaints. Failing systems identified through either process receive an advisory notice from the local authority to fix the system. The report notes however that this does not always result in action by the householder, as significant numbers of older cases remain unresolved, and that some local authorities have entered legal proceedings against

Table 5 Responsibilities post-commissioning, monitoring and enforcement	
COUNTRY	**RESPONSIBILITIES POST-COMMISSIONING, MONITORING AND ENFORCEMENT**
ENGLAND	Operators must ensure their septic tank or treatment plant is emptied at least once a year, by a registered waste carrier. In 2015 new legislation came into force setting out general binding rules in respect of septic tanks. The legislation granted a grace period of five years before sanctions apply. The sanctions became live on 1 January 2020. NB. Despite the five years' grace period many homeowners and prospective buyers are still not aware of this legislation (Chidlow, 2019). Records must be kept of work done to empty, maintain or repair the septic tank or sewage treatment plant, e.g. invoices, bills or receipts. In addition, a written record must be kept of a) any accidents or incidents that could have led to an accident; b) problems with equipment, including how resolved and preventive action going forward to reduce recurrence; c) Complaints against equipment by others and how these were resolved.
WALES	For septic tanks, inspection is recommended by NRW to be carried out every month and tank emptied by registered contractor every 12-24 months. PSTP require professional servicing every 12 months with a detail check every 6 months. Regular maintenance of the system must follow manufacturer's instructions. SSS must meet the relevant British Standard (BS EN 12566) in force at the time of installation. Maintenance records must be kept for 5 years and NRW may request that records are made available for inspection. SSS in England and Wales are both subject to the Environmental Permitting (England and Wales) regulations 2016 and violation of the registration or the binding rules can result in a £50,000 fine (NRW, 2019). However, enforcement appears to be 'light touch' (B.J. Cesspool, n.d.). Environmental Permitting Regulations (2010) state that all discharges from septic tanks and small sewage treatment plants in Wales needed to be registered. NRW are responsible for enforcement and can issue a warning, statutory enforcement notices, injunctions, civil sanctions, require remedial work is carried out, issue a formal caution, prosecute or suspend/revoke environmental permits. Local authorities may also take appropriate action if needed.
REPUBLIC OF IRELAND	Inspections of septic tanks and other domestic wastewater treatment systems are carried out by City and County Council staff who complete a specific training course and are appointed by the EPA. They carry a certificate of appointment and identification which they will show to the homeowner if requested. Records of emptying and maintenance records must be kept for inspection.
NETHERLANDS	Bearing in mind that in most cases municipalities own and operate the systems, most municipalities appear to have opted for annual monitoring in combination with a sensor system for early detection of faults. The owner /user is asked to contact the municipality or water board 'when the red light comes on'. The water board regulates the municipalities. In at least one case, the municipality pays the water board to manage the system on its behalf; as the water board is responsible for surface water quality it is in its interest to manage the systems to a good standard.
SPAIN	If the system discharges to a local sewer, then the municipality; if it discharges into the environment, then the regional authorities. The responsible body has an annual discharge inspection plan, water quality control networks and personnel assigned to take samples.
SWEDEN	Compliance is not enforced effectively. There appears to be a lack of knowledge at the municipalities of environmental compliance. Standard tests are being developed to resolve this. Requirements to inspect systems vary across municipalities and they are required to inspect illegal or malfunctioning systems.
NORWAY	The municipality.
DENMARK	The municipality. If a plant does not function in an environmentally sound manner, it must be improved or replaced.
NEW ZEALAND	This varies regionally. In Auckland and Hawkes Bay, consent holders pay for routine compliance inspections only if their system is not on a list of accredited manufacturers. If it is, owners are exempt from these inspections. Regardless of the accreditation status of the system, the frequency of maintenance must be as specified in the consent.
NEVADA, USA	In the event any owner of improved property fails or refuses to make such a connection upon being requested by the city, the city may take such lawful action as necessary to effect such connection (30-day period of notice). If deemed unlawful, the owner could face a fine of up to $1,000 or imprisonment for a term not exceeding 6 months. If it is deemed to be an offence, fines can increase to a max of $150,000. Each day constitutes a separate offence. It is not clear who monitors or enforces but the fines are paid to Clark County, Nevada.
ALBERTA, CANADA	The owner has responsibility of ensuring that the system is maintained, operated within the design parameters of the system and effectively treats the wastewater. However, the designer/installer is responsible for ensuring that the site has been investigated and that the system operates safely as intended by the design and meets the objectives of the standard. Failure to abide by the rules, which are laid out in a number of documents, can result in daily charges of up to $10,000 with a maximum penalty of $100,000.
BRITISH COLUMBIA, CANADA	The owner is responsible and must keep records of maintenance. Environmental Health Officers are in control of compliance and tend to act mainly on complaints. EHO may order owners to alter or repair systems or to connect to a different system or to the main sewer. Failure to comply is an offence.

householders for failures to fix systems.

The Water Services Authorities are tasked with identifying and prioritising systems for inspections. The EPA has produced a risk-based methodology, using the Source-Pathway-Receptor model, to assist with this; full details in the EPA publication 'A risk-based methodology to assist in the regulation of domestic waste water treatment systems' (EPA, 2013). The methodology aligns with RBMP. The focus is specifically on systems that pose a risk to private water supplies (wells) and to systems in areas where private sewage systems have been identified as a risk to surface water quality in RBMP.

NIP 2022-2026 also includes detailed guidance for water services authorities' inspectors, as Appendix A to the document. This details the process from advisory notice, through reminders and warnings, and legal proceedings if necessary. Failure to comply with an advisory notice is a prosecutable offence with a potential fine of up to €5,000.

Enforcement powers in England

A range of civil sanctions are available to the Environment Agency for the offences they are responsible for enforcing, which were introduced by the Regulatory Enforcement and Sanctions Act 2008 (RES Act), the Environmental Civil Sanctions (England) Order 2010, the Environmental Civil Sanctions (Miscellaneous Amendments) Regulations 2010 and the Control of Mercury (Enforcement) Regulations 2017. The range of penalties include Fixed Monetary Penalty (£300 for businesses or £1000 for individuals); Variable Monetary Penalties for more serious cases; Compliance Notices that require the offender to take action to come back into compliance, for example, where an individual or business has regularly submitted data returns as required but stops doing so; Restoration Notices which requires the offender to put right any damage caused by an offence. They can also issue Stop Notices that immediately requires an activity to stop. There are also Enforcement Undertakings; Enforcement Cost Recovery Notices; Non-Compliance Penalty Notices, and of course Criminal proceedings. The EA can also issue a penalty under a climate change scheme: European Union Emissions Trading Scheme (EU ETS), CRC Energy Efficiency Scheme (CRC), Energy Savings Opportunity Scheme (ESOS), Fluorinated Greenhouse Gas regime (F-Gas) and Climate Change Agreements (CCA). It can also recover costs.

Delegated maintenance responsibility in The Netherlands

In the Netherlands, the 21 water boards are responsible for ensuring surface waters meet quality standards. In several areas, Local Authorities, who are responsible for providing sewerage, have entered into agreements with the local water board that these install and/or maintain IBAs on their behalf. In some areas, it appears that all IBAs are under control of the water board; in others some are but others are maintained by the householder.

When maintained by the water board, typically small systems (< 10 PE) are maintained once a year, larger systems two to three times a year (e.g. (Waterschap Rivierenland, no date). Reference added in Section 4). The water board makes an appointment with the householder to carry out the maintenance. In between times, householders may be asked to keep an eye on the system; some have e.g. a red warning light that indicates a system failure. Householders can also contact the water board at any time if they have concerns or questions and are provided information on the use of the system, what not to flush away, etc..

In one water board, Hoogheemraadschap Noorderkwartier (HHNK), some IBAs are maintained by householders and others by the HHNK (Hoogheemraadschap Noorderkwartier, no date). People who maintain their own IBA pay a pollution charge and people whose IBA is maintained by HHNK pay a treatment charge. The amount is the same. Single households pay a tariff based on 1 PE, larger households (>1) pay a tariff based on 3 PE. However, if a larger household has a IBA class 2 or 3 (indicating aeration and sometimes nutrient removal), it pays the same tariff as that for a single household. In that case, proof is needed that the IBA meets the criteria, proof of purchase, and proof that the IBA is maintained annually. Where HHNK is responsible for maintenance, this is outsourced to a private company that reports to the water board. Householders receive a reimbursement of the energy cost of the IBA. Some IBAs that did not function well have been replaced with improved septic tanks; these IBAs were donated to an NGO for deployment in regions without sanitation.

A third water board, Hunze and AAs, reports in some detail on the management of IBAs that are owned by the Local Authority but maintained by the water board, 1727 installations in total (Hunze en Aas, 2017). It aims to maintain these effectively for the lowest cost possible, whilst maintaining a good relationship with the users. In recent years, the cost per IBA per year has fluctuated from €150 to €200, with a total maintenance cost of just over €300,000 in 2017. Where the cost of a repair is up to €400, the water board bears the cost of the repair; whilst not explicitly stated it appears any repairs that exceed this cost need to be covered by the Local Authority. The most common issue by far was a broken aeration pump; the water board reported having started a programme of preventive replacements of these aeration pumps.

Oosterwold: an experiment in self-organisation

An experimental approach was recently adopted in the newly developed area of Oosterwold, where home owners are fully responsible for their own wastewater and evaluated in Van Karnenbeek, Salet and Majoor (2020). This radical urban experiment involved a wider set of aspects of living in which "self-organised citizens" (Van Karnenbeek, Salet and Majoor, 2020, p. 1459) to take responsibility for house building, food growing, energy generation, both individually and collectively, in a context of reduced legitimacy of the government and greater empowerment of citizens. Residents signed documents agreeing their responsibility towards wastewater treatment as a condition of being able to purchase property in Oosterwold. Against the municipality's expectation, residents mostly chose individual rather than collective wastewater treatment (all using Class 3 treatments; see section 2.3.3 under The Netherlands).

Sweden

Before 2011, the Swedish Environmental Protection Agency was the supervisory guidance body for all sewage systems. After 2011, supervision of larger sewage systems (>200 PE) remained with them, while smaller sewage systems (<200 PE) were delegated to the Swedish Agency for Marine and Water Management (hereafter called HaV). All legislation, guidance documents and external party links found on their website. Municipality environmental offices, (290 municipalities in Sweden, but sometimes they have a joint environmental office) are responsible for inspections, licenses, and fines. Inspections are done mainly by on-site inspection (HaV 2021a). The time interval for on-site inspections is varying. Some local authorities have well developed strategies, others may not. Municipalities can use injunctions to encourage upgrades of systems that fall short of regulatory requirements, but it is reported that there is a slow pace of change (Christensen and Helwig, 2021). For example, sludge separation and a following treatment step is required according to the environmental code, but about 20% of properties with small sewage systems with WC do not have that minimum requirement and another 10% of properties have a system which the local authorities have no information about. Only 2-3% of the total amount of systems are renovated per year (HaV 2021a). An additional challenge for enforcement is that there is an increase of new phosphorus-removal mini-treatment plants and SSS technologies available on the market (HaV 2019), in some rural areas these are promoted by retailers instead of simpler efficient solutions, which in some cases could be accepted by the local authorities. This has not only limited the market choice for some homeowners, but in addition it has been reported that the municipality's inspectors do not always have the know-how to deal with monitoring the range and variety of more complex SSS systems and at the same time these systems require more intense supervision (Christensen and Helwig, 2021).

Legislation to improve SSS regulation has been a work in progress during the last decade. In 2013, the Swedish Agency for Marine and Water Management (HaV) reported that SSS guidelines were fragmented and not legally binding leading to inefficiencies and legal uncertainty in municipal monitoring efforts and for homeowners (HaV 2016a). In 2016 HaV issued a proposal to the Swedish government that included: a clarification of the constitutional rules, changes of phosphorus treatment requirements (stricter requirements in eutrophication risk areas and less strict in non-risk areas), performance certification requirements for SSS developers with additional requirements for continuous monitoring mechanisms, and the establishment of a digital register of all SSS in the country. HaV expected the proposal would increase the demand for simpler SSS systems as fewer homeowners would actually need phosphorus-removal mini-treatment plants and could opt for source-sorting sewage and simpler soil-based treatments (HaV 2016b). However, as of 2021 the majority of the HaV proposal had not been accepted and many of the inefficiencies remain, although a new legislative bill, the National Strategy for Supervision According to the Environmental Code (Naturvårdsverket 2022), will address the question of updated municipal register of all SSS. Hopefully this will lead to better ability to differentiate and to direct the supervision to areas and SSS where the risks for environmental and health are (Christensen and Helwig, 2021). Additionally, HaV has since 2013 financed more than 40 research and knowledge exchange projects including the establishment of a digital SSS register and shared e-service platform to improve municipality supervision (HaV 2021b; HaV 2022).

2.5 Is there a programme for upgrading older systems; is there any grant or subsidy system, and how is circularity encouraged?

2.5.1 Scotland

Whilst at present, no programmes for upgrading older systems are in place, owners do need to take action when SEPA serves them with a notice because they no longer meet the terms of the CAR authorisation. Local Authorities

may also require that systems are better maintained or improved. In these cases, no specific interventions are suggested and it is up to the system's owner to decide how best to bring the system back to compliance. Although all systems should be CAR-registered, this is not actually the case, which limits SEPA's opportunity to serve this kind of notice. Where existing systems are not already registered, this should happen at the point of house sale.

2.5.2 Internationally

Whilst we encountered some support for upgrades, little evidence of policies that encourage circularity was found (Table 5), other than in Denmark as described in Section 2.3.2 on p10). In some cases, circularity or innovation may actually be discouraged through list of 'approved systems' and through warnings about constraints on grey water reuse. Sludge reuse appears to be encouraged in the Nordic countries.

2.5.3 Case studies

2.5.3.1 Improvement programmes

Flanders: prioritising sewerage projects

A 'master plan methodology'[4] was developed to prioritise sewerage projects as part of River Basin Management Planning, which feeds into the preparation of GUPs (municipal implementation plan) The prioritisation of [sewerage] projects is based on a cost-benefit analysis whereby environmental impact was compared to financial cost (investment cost of each project is determined on the basis of unit prices for sewers and road maintenance). The environmental impact of the wastewater treatment plant is also considered. Ecological criteria are evaluated using an environmental impact evaluation map ('milieu-impacttoetskaart'), which combines various five environmental aspects that can affect the environmental impact of wastewater into one global score: flood zones; priority surface water bed; ecologically valuable areas or water courses; drinking water and bathing water; upper reaches and advice from catchment management organisations. The application of the master plan methodology resulted in an area-covering implementation plan in which GUP projects were classified according to priority. The GUP-projects are divided in priority classes 1-12, 1 being the highest priority. Projects with priority 1 and 2 are projects relating to decisions that already have been taken, and related GUP-projects. Other GUP-projects are prioritised using an algorithm based on the methodology. Every project is also linked to the relevant RBMP programme of interventions.

An actor is identified for each sewerage project: province, municipality (or sewer maintenance company) or private individual. For each project, an investment cost and the number of inhabitants to be connected. For every municipality, a GUP-Project list is available, indicating actor, cost, environmental impact and project priority.

The GUP then determines by when properties will be required to place an IBA; at this time, FARYS or the municipality contacts householders to communicate that they are required to install an IBA. Until that is the case, it may still suffice to discharge wastewater via a septic pit, which should in that case treat both grey and black wastewater.

Existing IBAs that conform to VLAREM can stay. If a householder already has an IBA and the property is in an area where IBAs are maintained collectively by FARYS, they can ask to join this collective system. They can submit the invoice for their system and FARYS will offer to buy it off them, based on the price and age of the system. If the householder agrees, FARYS buys the system and the householder starts paying a maintenance contribution to FARYS.

Republic of Ireland: Rural Water Programme

The Irish Ministry for Housing, Local Government and Heritage has established a Rural Water Programme, which includes grant funding for septic tank improvements in selected areas (see below). In its Water Services Policy Statement 2018-2025, the Irish Government acknowledged that … "in order to upgrade deficient wastewater treatment systems, improve water quality and avoid financial penalties, remedial action will require significant capital investment, together with improvements, in the operation and management of wastewater systems to optimise performance". Until relatively recently, water and wastewater services in the Republic of Ireland were provided by Local Authorities. The Water Act (2013) established the publicly owned organisation Irish Water as the single national responsible authority for delivering water and wastewater services.

Public investment in small sewage systems in The Duero Basin, Spain

In Spain, the Duero Basin was selected for an experimental solution to rural wastewater treatment. The issue was especially relevant in the Duero basin, as 96% of urban wastewater discharges are from municipalities with less than 2,000 equivalent inhabitants, and more than half did not have an adequate treatment system. Wastewater treatment in these rural areas was conditioned by a set of common circumstances, such as the variability of flow

[4] One document (Vlaamse Milieumaatschappij, 2020, T*oelichtingsdocument zoneringsplannen en gebiedsdekkende uitvoeringsplannen)* refers to LINGO models. LINGO appears to be prioritisation modelling software.

Table 6 Upgrading older systems, grants, and circularity	
COUNTRY	**UPGRADING OLDER SYSTEMS, GRANTS, AND CIRCULARITY.**
ENGLAND	In 2015, new legislation came into force setting out general binding rules in respect of septic tanks. The legislation prohibits discharging directly from a septic tank into any water source. The legislation granted a grace period of five years before sanctions apply. The sanctions became live on 1 January 2020. Despite the five years' grace period it seems that many homeowners and prospective buyers are still not aware of this legislation. Re. circularity, SSS are sometimes allowed when they would be environmentally preferable to a mains connection; see Table 1.
WALES	Upgrades may be required as part of the permit application. If buying a house with SSS, the NRW recommend that the new owners negotiate with the previous owners on responsibility for the upgrade of existing systems. Systems that are working well, comply with permits and not causing pollution do require to be upgraded. Upgrades are only required if the system leaks or releases pollution to the land. In which case, the owner is liable to prosecution and enforcement action. Wales also align to the general binding rules (2015) that are followed by England. The legislation prohibits discharging directly from a septic tank into any water course. We have not found evidence of any encouragement of circularity.
REPUBLIC OF IRELAND	The EPA has published guidance on the remediation and replacement of domestic wastewater treatment systems. Grants of up to 85% up to a maximum of €5000 are in place via a number of different grant schemes. The building regulations generally stipulate that water conservation measures should be adopted to reduce water consumption and the quantity of wastewater generated in a household.
NETHERLANDS	Resource recovery is discussed in some detail in the 'Saniwijzer': a guidance document for developers or anyone seeking to install or upgrade a wastewater system. Specific guidance is available for e.g. for farmers or commercial properties. The option of resource recovery is discussed rather than strongly encouraged; for example, for urine recovery, an explanation is given on the need for storage, the constraints on reuse in agriculture, but also the potential for reuse in private gardens, and information on relevant pilot projects is provided. For heat recovery, a statement is included that baths and showers with heat exchangers are already commercially available.
BELGIUM	In Flanders, a zone-based prioritisation is in place to upgrade systems. Some evidence that water circularity is encouraged.
SPAIN	Plan Nacional de Calidad de las Aguas: Saneamiento y Depuración (2007-2015). One of the most important challenges of this plan was to be able to extend the treatment systems to small towns. For that purpose, a collaboration mechanism was defined between the different Public Administrations for the execution of all pending investments. In the Duero Basin, these have been already formalised between Junta de Castilla y Leon and Xunta de Galicia. The Duero Hydrographic Confederation is developing a pilot project with a budget of almost €3M for the construction of 14 small treatment plants (low cost technologies) in different small towns in the basin, considering different characteristics in each.
SWEDEN	The encouragement of circularity depends on municipality where septic is emptied. Treated sludge sometimes reused for composting, land applications, bio-gas processing or incinerated. Limited grant support.
NORWAY	The encouragement of circularity depends on municipality where septic is emptied. Treated sludge sometimes reused for composting, land applications, bio-gas processing or incinerated.
DENMARK	Systems are required to be upgraded in some cases. A support scheme is in place to provide a helping hand to the most financially needy landowners who are ordered as a result of the state water plans. The scheme is mainly regulated by the Payment Act, which falls under the Danish Energy Agency.
NEW ZEALAND	Some examples of regional councils offering support for upgrades, e.g. Hawkes Bay. A loan programme is also in place in Hawkes Bay. Some caution is issued to householders about grey water reuse, e.g. about restrictions and run-off (Smarter Homes, n.d. (b)).
NEVADA, USA	No evidence of a programme for upgrades. Costs are to be met by the owner. Where connection to a main sewer is required, owners are sometimes reimbursed by the government. Grey water can be used for underground irrigation only and installation of a grey water system requires a permit.
ALBERTA, CANADA	The 'Water for Life' programme is a regional funding initiative, which can be used for new water systems or for upgrading old ones. Eligibility is directed towards cities (<45,000 people), villages and settlements. Federal funding also appears to be available. Federal funding for Green Infrastructure is available; further investigation is needed to determine whether this can be used for small sewage systems.
BRITISH COLUMBIA, CANADA	Less information was available for BC; it appears that an initiative may have been in place several years ago so this could be something that happens periodically.

and pollutant load in the discharges and limitations to the economic, human and technical resources for operation and maintenance. Therefore, the solution to the poor water quality in the Duero basin involved the research and development of flexible treatment systems that could be adapted to the characteristics of each discharge point.

The Duero Hydrographic Confederation developed a pilot project with the collaboration of the Center for Hydrographic Studies of CEDEX (Center for Experimentation of Public Works) called *Experimental singular treatments for discharges from small towns in the Duero basin* (Confederacion hidrografica del Duero; 2013), with the purpose of establishing the (technical and economical) suitability of technologies for the small municipalities of the basin. This project, with a budget of € 2,844,580.96, consisted of the construction of 14 small treatment plants based on low-cost technologies in several municipalities of less than 2000 PE and considering each of the plants' singularities.

The main objective of this project was to establish suitable low-cost technology for each SSS. The basic design in each case consisted of:

1. Roughing/grinding
2. Imhoff tank with floating macrophytes (recommended Hydraulic Retention Time (HRT) > 5 days). Oversizing this stage is key to guarantee the absorption of any type of effluent. This stage is the key to the performance of the next stages.
3. Horizontal artificial wetland with subsurface flow (reed). The artificial wetlands were selected with different configurations depending on the location.

Once the 14 different systems were built, the Duero Hydrographic Confederation handed them over to the different municipalities for them to manage, operate and maintain.

Based on this experience, it was concluded that for small municipalities this type of low-cost technology is appropriate for several reasons:

- Lower investment costs than conventional technologies based on active sludge treatment.
- Much lower maintenance costs too.
- Simplicity in its management and maintenance.
- Very robust, since they allow treating highly variable flows and loads, very common in these small municipalities with unitary networks and a large seasonal population.
- Integration in the environment.
- Very good purification performance (BOD5 values <10 and Suspended matter <10 mg/l).

2.5.3.2 Financial Support

Hawkes Bay, New Zealand: loans from the Council

Hawkes Bay, New Zealand, has a similar population density to Argyll & Bute in Scotland (around 13 pop./km^2).

The Hawkes Bay Regional Council support scheme is presented as a discussion of rainwater storage installations and septic tank upgrades. Cheap financial support is available to householders who wish to either upgrade their tank or install water storage. The latter is for the collection of rainwater, or for establishing a reserve from bore or reticulated supply. It is not designed as a potable supply due to public health requirements. The Building Act G12/A5 2 NZ requires a consent if the tank is connected to the potable water; it should have back flow prevention to protect the network supply; and the work must comply with the Building Code as consented by TLA's.

The scheme allows householders to borrow up to NZ$20,000 at a rate of 4% from the Council, to be repaid over 10 years at a Voluntary Targeted Rate (VTR). It is not a loan, and more akin to an additional payment to the Council tax to cover the borrowing. A ready calculator on the website allows homeowners to instantly calculate both the amount they would have to repay each month and the interest that must be paid. For the maximum of NZ$20,000, that is a total repayment of NZ$24,290, costing NZ$202.42 per month for 10 years. The amount is instantly repayable if the household misses three consecutive payments. If there is any outstanding amount when the house is sold; the full amount must be paid on selling.

The Council states it may refuse an application where there are concerns that the repayments may force the householder into financial hardship.

The region offers householders a list of approved suppliers and installers (i.e. those who have the appropriate 'wastewater accreditation training') on the same page as the application details. There is no mention of how the Council ensures these suppliers do not overcharge for labour or inflate purchase costs.

Republic of Ireland: partial grant support

In the Republic of Ireland, grant support is available to repair, replace or upgrade a domestic wastewater treatment system. Eligible owners can apply for funding for 85% of the cost of the repairs to their system or a new system, up to a maximum of €5,000 (Citizens Information, 2021).

There are three different schemes (Government of Ireland, 2021):

Firstly, if the Irish Environmental Protection Agency (EPA) has identified that the system is not meeting the

expected standard under its National Inspection Plan and an advisory notice has been issued by the Local Authority under the Water Services (Amendment) Act 2012.

Secondly, if the property served by the system is in a Prioritised Area for Action identified in the River Basin Management Plan 2018-2021. The Local Authority Waters Programme Office would issue a letter confirming eligibility to apply. The relevant Regulations are Housing (Domestic Waste Water Treatment Systems Financial Assistance for Prioritised Areas for Action) Regulations 2020 (SI No. 185 of 2020).

Thirdly, if the property served by the system is in a High Status Objective Catchment Area identified in the River Basin Management Plan 2018-2021. The relevant Regulations in this case are Housing (Domestic Waste Water Treatment Systems Financial Assistance for High Status Objective Catchment Areas) Regulations 2020 (SI No. 186 of 2020).

Grant eligibility is tied to the need to register systems: to be eligible, systems must have been registered by 2013 or, in the case of newer systems, within 90 days of connection.

Grants are administered by the local authority and cannot be used for normal operational or maintenance costs, such as desludging or servicing.

Alberta: funding for municipalities

The 'Water for Life' programme, started in 2006, provides funding to municipalities wishing to install new wastewater services or to upgrade existing wastewater services to more environmentally sustainable provision. The rationale for providing funding in this way is that, according to the Alberta authorities, regional wastewater treatment is more environmentally sustainable and more cost-effective than independent systems. The level of funding provided depends on the number of properties that will benefit. Full details with worked examples of available funding are available on the website. Funding is available for a range of settlements, from cities up to 45,000 people to 'eligible hamlets', and for municipal partnerships, public-private partnerships (only the public part is eligible) or contracted services. It can cover feasibility studies, pipelines and treatment works. Materials, services and equipment must be provided by the private sector and the use of Alberta companies is encouraged. Additional eligibility criteria may include environmental requirements and cost-effectiveness compared to alternative solutions must be evidenced.

2.6 Partnership organisations involved in policy on SSS

In several countries, partnership or umbrella organisations were encountered that have a key role in informing or developing policy on SSS. Other than the Alberta Safety Codes Council already mentioned (which has a formal regulatory role), this was the case in the Netherlands and Belgium.

Flanders: Vlario and Vlakwa

Vlario is a Flemish membership organisation that aims to be a central knowledge centre and meeting space that brings together, encourages and supports all actors involved in managing (municipal wastewater) and precipitation. Its 440 members include municipalities, cities, policy makers, sewer managers, architects, accreditors, research centres, and developers.

Vlario has working groups on topics including financing sewerage; design and calculation of sewerage systems; sewerage and water treatment in rural areas; quality control and materials choice; sewer management; municipalities as the voice of local government; think tanks; safety; and project management. It emphasises the need for sustainable investment in all water matters. The organisation meets regularly with the government and offers policy support and advice on national and local levels. Its members are offered discounts study days, training, conferences; can contribute to Vlario publications; and can call on a network of experts. Training activities include sewerage systems (design, renovation, connections, de-coupling of rainwater), climate impacts, and regulatory guidance; they also include accreditation courses for inspectors of decentralised systems.

Vlakwa (Vlaams Kenniscentrum Water or Flemish Knowledge Centre Water) is also a knowledge centre, financially supported by national and provincial governments. Its main activities are around innovation projects and communication activities. Its members include governments, universities / research centres, developers and businesses and organisations in the water sector. Vlakwa helps developers, researchers and governments with innovation and implementation of water solutions; the focus is on a systematic perspective on water challenges, water innovation projects, and scaling up successful innovations.

The Netherlands: STOWA and RIONED

STOWA (Stichting Toegepast Waterbeheer or Foundation for Applied Water Management) is the knowledge centre of dutch water boards and provinces. It collates and shares knowledge to benefit water managers, spanning technical, environmental, social, legal and policy aspects.

On decentralised treatment, STOWA organises knowledge exchange events, publishes research, has developed the Saniwijzer and the Sanimonitor (a database for monitoring results from decentralised systems in the Netherlands and Belgium).

RIONED is a foundation and umbrella organisation of a more diverse range of partners; members of RIONED's executive committee represent municipalities, water boards, construction firms, utility companies, and the ministry. Its purpose of providing knowledge for policy makers, businesses and the public; it collaborated with STOWA on the development of the Saniwijzer. RIONED is funded by 'benefactors' (e.g. municipalities, provinces, water boards, advice bureaus, ministries, businesses, and educational institutions) who have free or discounted access to the services provided by the organisation. These services include research publications, training days, webinars, an image bank, etc.

3 Discussion and recommendations

This study investigated the use, management and governance of decentralised wastewater treatment systems, or 'small sewage systems' (SSS), in selected countries, with a view to informing Scottish policy development and practice.

In Scotland, SSS are typically located in rural areas where mains sewers are not available and can pose challenges for public health and environmental quality (NetRegs, n.d.) Many systems have been in place for a long time and are not necessarily known to the regulator, which hinders enforcement. Moreover, single small systems are unlikely to cause environmental damage to the extent that SEPA, the Regulator, would deem it necessary to take enforcement action. Multiple such systems nevertheless may cumulatively pose a threat to environmental quality. The Local Authority also play a regulatory role, acting predominantly on complaints from the public, for example when odours or ponding becomes an issue. Any action is likely to be driven by Public Health concerns. SSS can also pose a threat to private water supplies, which tend to draw on local water resources that can become contaminated as a result of poorly functioning SSS (see e.g. LeGro, Vowels and Vondra, 2017, for groundwater contamination by SSS). For new systems, the current approach is that private developers who proposed properties that cannot reasonably be connected to the mains need to include a decentralised wastewater solution. Increasingly, as we understand it, Scottish Water normally would not take on wastewater management for such properties and this therefore remains private, with the property owner(s) retaining responsibility in the long term. The Scottish Government has expressed a desire to see remote and island areas repopulated (Scottish Government, 2020a, p.168), yet its Rural Planning Policy to 2050 (Scottish Government, 2020c) makes no explicit mention of water or wastewater infrastructure (unlike, say, digital infrastructure or renewable electricity generation), suggesting a 'blind spot' in the planning process. As speculative rural housing development continues apace, the expectation can therefore be that, over time, an increased number of properties will be served by decentralised, privately owned wastewater systems. At the same time, (lack of) water and wastewater infrastructure act as constraints on rural property development (Savills, 2020), Also worth mentioning is that SSS are often vulnerable to climate change, as increasingly erratic precipitation patterns lead to flooding during intense rainfall events and droughts may lead to reduced water consumption where properties rely on decentralised supply, causing irregular flows that can be challenging for some systems.

3.1 Planning and authorisation of new systems

The questions on planning and authorisation of new SSS and the management of older SSS are tied to the question of the provision of services by authorities. Most countries recognise that in some cases the cost of providing sewerage to a property would be disproportionate. In those cases, private developers can be authorised to install decentralised systems, subject to conditions. Internationally, approaches to sewage treatment in new rural developments encountered in this study fell into one of two broad categories. In the first, new systems are registered and subsequently subject to regular inspections backed up by enforcement, whereby often older systems are not compliant and need to be upgraded by owners. This approach poses common challenges in several countries: incomplete registers of SSS; large numbers of SSS and therefore significant resource requirements to complete inspections; difficulties in enforcement of the regulations; low levels of compliance; and challenges for householders poorly equipped to deal with and/or unable to pay for replacement of failing systems. The cost of achieving compliance is borne by the householder and where enforcement is unlikely there is little to encourage householders to comply. In a contrasting approach, systems are increasingly brought under the management of a (public or private) water management organisation. This can involve the installation of local sewer networks and small to medium-scale collective treatment systems; or the adoption (or purchase), management and maintenance of individual treatment systems. This is done by either the water board or the municipality, depending on the division of responsibilities between the two. The water board's expertise on treatment systems and sometimes their responsibility for surface water quality mean that these organisations are well-placed and motivated to manage decentralised systems successfully. Where the municipality is the responsible authority for

providing sewer services, it may pay the water board to deliver the service on its behalf (via a service level agreement). This kind of provision is (partially) paid for by a charge levied from the householder; as far as we are aware the charge is comparable to that levied of householders connected to mains sewerage. In some regions (Alberta and the Spain), central government support has been made available for the development of services in specific areas. Environmental quality benefits and reduced enforcement costs may partially offset the cost of service provision. Bringing systems under municipal or water authority management provides an opportunity to harmonise sewerage charges regardless of whether properties were connected to the mains or to a decentral system. A potential advantage to householders is that this would replace the highly irregular cost of repair or replacement with a more predictable household bill.

Empowering individuals and communities to enhance the sustainability of their wastewater systems can be attractive but, as experience in the Netherlands shows, may not lead to optimised environmental outcomes and require expert involvement. If property developers install systems, householders' responsibility to run systems effectively would need to be recorded in title deeds, but they are also likely to need support to do so that SSS are climate-resilient, fit-for-purpose and can be maintained, with a reasonable time and financial cost, householders and communities in rural areas may be disadvantaged in terms of wastewater management compared to those connected to main sewers and environmental standards may be at risk. Planning officers often make decisions on unsewered housing development with incomplete knowledge of potential environmental impacts and "… both the monetary and non-monetary cost of unsewered housing may be underestimated" (LeGro et al., 2017 p. 69).

International policy indicates that regional provision is often preferable (Alberta), that municipalities cannot always effectively control complex systems (Sweden) but also that simple but effective systems are suitable for management by municipalities (Duero basin). Vesting of older systems by water authorities appears to be delivering environmental benefits as well as equity for householders in the Netherlands and Belgium.

RECOMMENDATION:
The direction of travel in terms of wastewater management in rural areas should be carefully considered, in terms of fairness, climate resilience and environmental protection. Leaving decisions to private individuals and businesses may not provide these. This study has encountered alternative models as outlines above that make better use of expertise held at water boards and provide more equitable provision.

3.2 Registering existing tanks and prioritisation for upgrading older systems

The study found several plan-based approaches to prioritisation and improvements over time. These include environmental criteria (proximity to water, sensitivity of the receiving environment, Water Framework Directive quality assessments, proximity to bathing waters and drinking water resources) as well as numerical targets (such as Republic of Ireland's 1000 inspections per year). Data for environmental criteria is readily available in Scotland's Environment Web (SEWEB) resource and it would be possible to combine relevant layers to identify priority areas. A greater challenge lies in the integration of local-authority complaints data, which could otherwise also inform prioritisation, and in the fact that many systems remain unregistered.

We came across various incentives to register tanks. In Wales, systems that comply with GBR do not require a permit, but they must register in order to be able to apply for an exemption. Similarly, in the Republic of Ireland, owners need to have registered their tank within three months of installation in order to be eligible for a grant for future repairs or replacement. Clearly, such systems would only lead to registration if there was awareness of the provision. Devitt et al. (2016) found that the NIP, in particular the perceived 'risk' of inspection and fear of fines, made householders more aware of their system and led them to carry out their own inspections.

In Flanders, the sewerage provision for every household is recorded in the municipal zonation plan, a spatial database. Scottish Local Authorities also use spatial property data bases; it has been suggested that these could be combined with data on sewerage billing; data from (e.g. odour) complaints; and current SSS registrations. Whilst such data integration is not without challenges due to data protection laws, we understand that the Government's Improvement Service is working on a database. A spatial database would also allow integration with data on environmental sensitivity as recommended in 3.3.

We did not find out what data exactly are recorded in the various systems. Inclusion of treatment type etc. would aid environmental risk assessment and prioritisation and provide additional control if different treatment types are required due to site-specific criteria (e.g. advanced treatment systems where soil depth is limited; LeGro, Vowels and Vondra, 2017). The Dutch Sanimonitor.nl database allows registered SSS users to enter system performance data, to provide a shared, real-life evaluation of SSS. Whilst the utilisation of such data in risk assessment seems a long way off in Scotland, it is useful to consider what data will be useful in the long term to support upgrade requirements, grant systems,

enforcement, and other aspects of SSS management.

RECOMMENDATION:
Bringing together the relevant datasets that indicate sensitive environments would be useful to Local Authorities and property developers alike and could be coupled to setting and communicating performance criteria and could be used for developing prioritisations for upgrade and enforcement efforts. It is furthermore recommended that efforts for improved data gathering on SSS are continued, with careful consideration what data can and needs to be included (e.g. size, technology, site-specific conditions plan) to allow future risk assessments or support for enhancement.

3.3 Requirement to keep records

In Alberta, Republic of Ireland, England and Wales, householders must retain records of desludging, maintenance, and repair and make these available for inspection on request. Although we do not have information on whether inspections actually took place, the requirement in itself may emphasise to householders the need for maintenance and the possibility of inspection may lead to higher levels of self-inspection (Devitt et al., 2016) and possibly maintenance. Inspecting records can be done remotely, which may enable greater inspection capacity. It would also give the householder the opportunity to demonstrate that they have made efforts to comply, even if these have been unsuccessful.

Records can include system checks, such as sludge and scum levels, pumping activity, condition of the soil; invoices or receipts for work carried out, including desludging; accidents, incidents and near-misses; and any details of system problems and how these were resolved. It may be helpful to provide householders with a logbook to encourage accurate and appropriate record keeping. Contractors should be encouraged to complete the logbook when carrying out works; this could be part of training and accreditation (see section 3.5.3)

RECOMMENDATION:
Introduce a requirement of record-keeping as part of the CAR-authorisation, to include an appropriate set of system performance checks as well as maintenance records.

3.4 Partnership working

In several countries, stakeholders are represented in permanent platforms that facilitate knowledge exchange, collaborate on research, publish information and guidance, and organise training events. In Alberta, the Safety Standards Council has a regulatory role, in Belgium and the Netherlands the organisations have an advisory role. In the Netherlands, one organisation (STOWA) is a joint body for government and water boards, the other has broader representation including from developers.

A joint body can help ensure that language and definitions are used consistently throughout the partner organisations and that all aspects of SSS – planning, construction, operation and monitoring – are considered holistically, which may be more challenging if different authorities control different aspects.

In Scotland, to our knowledge no permanent umbrella body with a specific focus on (waste)water management exists. Members could include SEPA, the Scottish Government, Local Authorities, Scottish Water, Citizen's Advice Scotland, property developers associations, installers, plumbers and the general public. This may also be a good platform to discuss rural infrastructure planning issues.

RECOMMENDATION:
To establish a permanent discussion and knowledge exchange platform for water stakeholders, including property developers and the general public, in Scotland, with the purpose of knowledge sharing and improving wastewater management.

3.5 Support for householders

3.5.1 Information on systems

Information needs exist in two main areas: for existing tanks, on how to effectively manage and maintain a septic system; and for new systems or upgrades, on the suitability of the alternatives.

Devitt et al. (2016) found that most participating Irish SSS owners in their study had gaps in their understanding of the need for system maintenance. These knowledge gaps were a major barrier to effective management, and suggests there was a lack of successful engagement under NIP. Participants did not know what should or shouldn't go into a septic system, were unaware of the need for desludging, emptying, or maintenance of the systems, and felt unqualified to judge the seriousness of any problem. As tanks are 'out of sight, out of mind' (Devitt et al., 2016 p. 542), people's risk awareness was also seriously lacking. This situation can be expected to be similar in Scotland and an effective awareness campaign may help compliance, especially when combined with financial support (see 3.4.2).

For new systems or upgrades, comprehensive guidance and information on systems available was provided in Sweden and the Netherlands. In the Netherlands, this is in the form of the Saniwijzer.nl website, which covers not only technologies but also gives an overview of government guidance. In Sweden, a 180-page product overview is available (HAV 2019).

It is not always appropriate for authorities to advise on the

most appropriate system, as this might incur liability if the system is not effective. This can leave people reliant on consultants and commercial retailers of treatment systems. Whilst sometimes these give clear and appropriate information, there are also examples where the information provided by these businesses is not necessarily appropriate. Therefore, a comprehensive, independent source of general system information could empower people to make better choices.

RECOMMENDATION:
Further develop the new guidance for householders and property developers, including an online guide. The awareness needs of property developers and householders can be further explored on an ongoing basis via a partnership organisation as proposed in Section 3.4.

3.5.2 Grant support

Concern over cost is a barrier for householders to carry out the necessary maintenance to their septic systems (Devitt et al., 2016). Whilst financial support on its own may not be sufficient to ensure householders improve their systems – Devitt et al. (2016) also uncover a lack of understanding both of environmental and health risks and of the need for maintenance, as outlined above - it can reasonably be assumed that financial support could address this barrier.

In approaches identified by this study, financial support was provided as grants or loans, with the level provided determined by system cost, eligibility and subject to a set maximum. Support was tied to various conditions in different countries, including household income, installation by an accredited supplier, system performance, the property being subject to an authority's improvement notice, the property being in a priority area, and with the system being registered.

Tying financial support to the use of an accredited supplier would give the authority some control over the types of systems that would be funded (see also Section 3.5.3 below). However, care should be taken that this requirement does not render inhabitants of remote or island communities ineligible for support, if no accredited supplier is available locally.

When a system upgrade is mandated by the regulator, the availability of a grant may help ensure compliance with the improvement notice (possibly saving costs of further enforcement). Tying grant support to an improvement notice has the advantage that funding is directed to the most pressing environmental or public health needs. System upgrades do not necessarily provide lasting improvements, as circumstances may change (e.g. properties may see new business development; may be extended; or may change hands); tying the funding to the improvement notice (as opposed to e.g. a one-off grant per household) would mean that in such cases multiple grants could be made available to the same property. Indeed, the requirement to upgrade 'inherited' sub-obtimal systems was perceived as unfair by some Irish householders (Devitt et al., 2016).

Upgrades to systems can be expensive and it is understandable that householders do not choose to spend thousands of pounds if they do not have to. Financial support that would be available more widely may also encourage non-mandated upgrades and encourage system registration.

We did not encounter any systems where householders could apply for support with general maintenance of their systems, e.g. desludging, although Devitt et al (2016) in their research with householders in the Republic of Ireland found that concern (and sometimes overestimation) of cost was a barrier to maintenance.

RECOMMENDATION:
To put in place financial support for householders, particularly where an improvement notice has been served. When doing so, bear in mind ownership, property use and occupation may change over time; therefore, resilient systems should be encouraged. It may be appropriate to tie the provision of grants to the use of accredited installers, although only if these are available in the remote areas where systems are likely to be located.

3.5.3 Accredited installers and service engineers

British Water already have a scheme in place for service technicians (List of Accredited Service Technicians; (British Water, n.d.) but it currently only lists two Scottish companies, one in Callander and one in Dumfries. To our knowledge, there is no equivalent scheme for installers. Accreditation of installers and service technicians provides home owners with confidence that they have engaged someone with the appropriate knowledge and skill. Accreditation also opens up avenues for enhancement of environmental performance. For example, in Denmark, installers are required to demonstrate to the home owner how they will meet the environmental regulations. This would reduce risks to public health and environmental quality and to some extent shift liabilities from the general public to the installer.

Training requirements and associated accreditation for installers also enables the authority some control over the types of systems that are encouraged, to provide education to householders via installers, and, if appropriate feedback loops are in place, enables the authority to better understand the issues faced by installers and residents. It also provides opportunities for monitoring new technologies with a view of evaluating their effectiveness.

The content of any training could be developed by a partnership organisation as recommended in Section 3.4. As site-specific knowledge is required for decision-making on SSS, it would be useful to include a local knowledge element in training. This may also support the local economy in communities reliant on SSS.

A decision would also need to be made on how the use of accredited installers would be encouraged, e.g. via a regulatory requirement or, as in Hawkes Bay, New Zealand, as a requirement for financial support. Accreditation costs should therefore not be set so high that it is not attractive for smaller businesses to become accredited. Including the need for local knowledge to qualify for accreditation may support local businesses.

RECOMMENDATION:
To consider introducing an installer accreditation system, including how its use could be encouraged or mandated. Such a system should be developed to attract wide membership across Scotland, in particular in remote, rural and island areas.

RECOMMENDATION:
To provide incentives for the significant expansion of the number of accredited servicing technicians in Scotland, ensuring wide geographical coverage in particular in remote, rural and island areas.

3.6 System types

A Polish study found that domestic wastewater treatment tanks (assumed to be the same as package treatment plant) is a good investment compared to a septic tank, as while investment costs are higher, operating costs are lower (Witkowska, 2017). Some authors (e.g. Cipoletta, 2021) highlight the potential of new technologies for SSS to enhance circularity and resource recovery, which they say may also help reduce abstraction pressure on local water resources. Based on our findings, whether this can be realised depends on the capacity for managing complex systems: the experience in Sweden is that most municipalities have limited knowledge and capacity to regularly supervise new systems, whilst private owners may not be able to maintain them appropriately. In the Netherlands and Belgium, by contrast, the decentralised systems are increasingly managed by organisations that have considerable expertise and capacity for innovation. The Dutch Oosterwold experiement, where self-organised citizens were responsible for wastewater treatment, led to a reduction in water quality despite significant support. The Spanish case study demonstrates that sometimes modest public investment in suitable, simple but innovative technologies for decentralised systems can be very effective. Therefore, decisions on the future management of decentral system should take into account whether innovation and circularity can be supported.

Nevertheless, resource recovery and circularity are clearly important considerations in the current climate crisis. Scotland's Update to the Climate Change Plan 2018-2032 identifies the Circular Economy as an opportunity, whilst also seeking to deliver improved water quality; it states an expectation for Scottish Water to invest heavily in modernising the wastewater treatment capability across Scotland and to recover more heat from sewers (p.164). Scottish Water itself has announced a new Net Zero strategy in 2020 (Scottish Water, 2020), with a target of zero emissions by 2040.

Where new properties are at risk of flooding, an evaluation of the resilience of the decentralised system under flood conditions is paramount.

RECOMMENDATION:
With current levels of capacity in communities, it is recommended that to focus on simple systems that are easy to maintain. More complex and circular systems may seem attractive but are only effective (or even safe) if maintained by capable individuals. Climate resilience (both in terms of emissions and in terms of resilience under flood or drought conditions) should be included in decision-making.

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