Natural England's research on Small Sewage Discharges (SSDs) and their risk to protected sites.

[redacted] – Principal Officer - Water

A few caveats….

- Research undertaken around 2011-2015 so approaching 10 years old
- Based on a limited number of systems and on the system used in England (e.g building regs, general binding rules)
- But… first of its kind research
- Does not relate to NN advice on mitigation options, this was all pre NN
- I understand NE research well on SSDs, not an SSD expert…

Small Sewage Discharges introduction

- Small Sewage Discharges (SSDs) are defined as discharges of domestic waste of 2 cubic meters or less per day to ground or 5 cubic meters or less per day to surface water.

- Found typically in rural areas where no connection to the sewer was or is possible (400,000 in England alone).

- SSDs can include Septic Tanks (STs), Package Treatment Plants (PTPs) and Cesspits (CPs).

Septic Tanks (STs)

- Usually a 2 or 3 chamber system that holds sewerage for a short period of time allowing solids to settle as sludge at the bottom, and the oil and grease to float as scum at the top.

- Inside the tank, waste is broken down by anaerobic bacterial decomposition to produce a relatively clear liquid effluent that leaves the tank through an outlet pipe.

- Because the tank is sealed, the level of waste inside of the tank remains constant and the outflow volume equates to, and varies with, the influent volume over time.

Septic Tanks (STs)

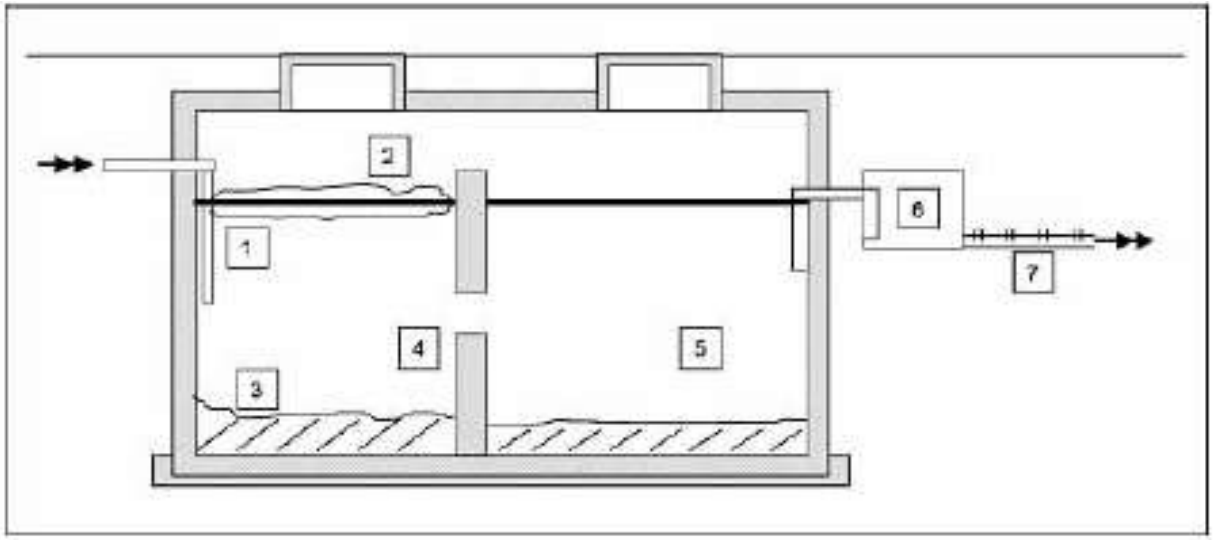


Figure 1 A standard septic tank design

1 - inflow; 2 - floating scum; 3 - settled sludge; 4 - connection between chambers; 5 - secondary chamber; 6 - outflow and effluent inspection chamber; 7 - soakaway or drainage system (reproduced from Hilton et al., unpublished).

Septic Tanks (STs)

- Effluent from a ST is not of a suitable quality to discharge directly to a watercourse, because it contains suspended solids, dissolved nitrogen (N) and phosphorous (P), and a range of potentially pathogenic bacteria and viruses.

- It must have additional treatment before it enters a waterbody. Most commonly, the effluent is spread across a soil soakaway or drainage field through a series of perforated distribution pipes; sometimes ST effluent is passed through a package treatment plant, reed bed or gravel filter for further treatment before it is discharged to the environment.

- In properly functioning systems, these secondary treatments reduce the level of pollutants in the effluent, especially in terms of nutrients and pathogens.

Septic Tanks (STs) Regulations

- The Building Regulations (2002) require all STs to be sited
  - At least 10m from a watercourse or permeable drain.
  - More than 50m from a water supply abstraction point and not within a Zone 1 groundwater protection zone.
  - At least 15m from any building and sufficiently far from other systems that the soil soakage capacity is not exceeded.
- The Building Regulations (2002) also stipulate the size and design features that a septic tank must have for use in a domestic situation:
  - At least 2,700 litres capacity for up to four users, plus 180 litres for each additional user.
  - Water tight.
  - Inlet and outlet pipes with access for sampling and inspection.
  - Access covers for emptying and cleaning.

Septic Tanks (STs)

- As many older STs were not installed under the regulations outlined above, they fail to meet current building standards. In particular, many are too small, inappropriately sited and badly maintained

- The quality of the effluent discharged from a ST is not regulated unless it discharges to an environmentally sensitive area or causes a nuisance to neighbours.

Package Treatment Plants (PTPs)

- Package treatment plants (PTPs), also known as biodisc systems or aerobic treatment units, are similar to septic tanks but contain a rotating biological filter or aeration system that encourages aerobic breakdown of wastes by bacteria.

- They are often installed as an alternative to STs for on-site treatment of domestic waste. Although PTPs are usually installed as self contained units, they are sometimes installed to provide secondary treatment of ST effluent where an improvement in effluent quality is required.

Package Treatment Plants (PTPs)

- Only PTPs that have an effluent quality compliant with the European Standard EN 12566-3 (2005) are acceptable to the Environment Agency in England for new installations. This standard requires the system to significantly reduce biochemical oxygen demand (BOD), suspended solids and ammoniacal nitrogen concentrations in the effluent in comparison to the influent waste water before it is discharged from the tank.

Package Treatment Plants (PTPs) Regulations

- In general, the effluent from PTPs is perceived to be of much higher quality than that from traditional STs. For this reason, they are often considered suitable for direct discharge to a watercourse if the effluent volume is ≤ 5 m3 per day. However, it should be noted that, although the quality of the effluent from these systems is higher than that from a standard ST, the mandatory tests for certification do not include P content. This raises questions about the P content of the discharge and its suitability for direct discharge to water. This has changed after NN

- Where package treatment plants discharge to a soil soakaway, the Building Regulations (2002) require PTPs to be located at least 10m from a watercourse or building.

Cess Pits

- Cess pits are covered, completely watertight tanks that have no outlet and are used for storing domestic wastewater. They need to be emptied regularly and are only practical as a temporary measure until a more permanent solution can be found. Use of cess pits is discouraged in England and Wales, and not permitted at all in Scotland.

- The Building regulations (2002) require that cess pits are sited at least 7m from, and preferably downslope of, any habitable parts of buildings. In addition, they should have the following design features:
  - 18,000 litres capacity for up to two users plus 6,800 litres for each additional user.
  - No openings except for the inlet and for ventilation.
  - Lockable access covers.
  - Access for inspection of the inlet.

Cess Pits

- As cess pits need to be emptied regularly, they also require good and safe vehicular access. An 18,000 litre tank serving two domestic users is likely to fill every 6-7 weeks under normal usage. However, as the capacity of a typical emptying tanker is only 9,000 litres, it may need to be emptied more frequently than that.

Why do we care about SSDs?

- The main reason for our interest in SSDs is the impact they cause on phosphorous concentrations in water bodies.
- STs can cause an impact either through being directly connected to water (older systems) or through seepage through the soil soakaway and being hydrologically connected.
- PTPs more recently are thought to have caused problems because many are connected through a pipe straight to a watercourse.
- Cesspits are less of an issue, because they are sealed. Therefore problems only occur when they leak.

Environment Agency SSD reform 2014

- On 30 April 2014, the Government issued a consultation on proposals to reform the regulatory system to control SSDs in England.
- The aims of the proposals were, firstly to simplify existing regulation within less sensitive areas (which cover most of the country) by removing registration and record keeping requirements whilst keeping key requirements for preventing pollution, and secondly, to provide a more risk-based approach to permitting so that permits are only required in the most sensitive areas where a higher level of protection is needed.

Environment Agency SSD reform

- Proposals of the reform to
  - Remove the registration process for most SSD owners
  - Remove the requirement to keep maintenance records (for 5 years)
  - Improve the General Binding Rules (GBRs)
  - Introduce a permit for new discharges that sit in ***environmentally sensitive areas***
  - Introduce permits to all discharges (*existing and new*) in groundwater source protection zone 1s.

Natural England's Research into SSDs

- NE interest in SSDs where we have protected sites that are failing their P targets and are likely to have SSDs located nearby.
- The contribution that P from SSDs might be making was little understood, but the risks were highlighted on a large number of sites through Diffuse Water Pollution Plans (DWPPs).
- NE therefore undertook 4 phases of work, looking to gather evidence on the likelihood of SSD pollution to protected sites.
- These 4 phases of work including the objectives and outcomes are explained through the remainder of this training.

NE small discharges reports - overview

- **Phase 0 –** The impact of phosphorus inputs from small discharges on designated freshwater sites (NECR170)
- **Phase 1 -** Development of a risk assessment tool to assess the significance of septic tanks around freshwater SSSIs: Phase 1 – Understanding better the retention of phosphorus in the drainage field (NECR171)
- **Phase 2 -** Development of a risk assessment tool to assess the significance of septic tanks around freshwater SSSIs - Phase 2 risk screening of 20 potentially vulnerable SSSIs (NECR222)
- **Phase 3 -** A review of the effectiveness of different on-site wastewater treatment systems and their management to reduce phosphorous pollution (NECR179)
- **Phase 4 –** Phosphorus in Package Treatment Plant (PTP) effluents (NECR221)

Phase 0 – Aims and Scope

- **Aim** – understand scale and nature of problem of small discharges of phosphorus(P) for designated sites + start to identify management solutions.

- **Literature review**
  - On site options for waste water treatment
  - review of the impacts of septic tank (ST) discharges on receiving waters - WQ & Ecology
  - Estimating losses of P from septic tanks to water at the catchment scale
  - First time sewerage schemes
- **Case studies**
  - Avon (Wylye & Nadder) and Broads (Ant & Bure)
- **Developing risk assessment framework** (Appendix 1)

Phase 0 - Key conclusions

- Many septic tank systems not functioning properly – incorrectly sited or improperly maintained (based on limited data)
- Cases identified where STs have significant impact locally on downstream P concentration e.g. up to 700% increase
- Can have considerable ecological damage at local scale
- STs have potential to increase P concentration all year round
- At catchment scale impact less but could still affect likelihood of meeting water quality targets
- Case studies also showed that for these 4 sites that ST contributions may not be negligible at the catchment scale - Based on worst case assumption

Phase 0 – Risk assessment framework

- Review of existing risk assessment frameworks
- Likelihood of ST causing and issue - related to location and way managed
- Initial screening using location factors (national datasets), then further assess based on design and way managed

Location factors	Design factors	Management factors
Soil hydrological characteristics	Age of tank	Frequency of drainage field maintenance
Topography	Condition	Frequency of de-sludging
ST density	Receives run off	Use of appropriate household cleaning products
Proximity to watercourse	Size for household	

Phase 1 – Aims and Scope

Aims

- Examine the relationship between ST management and maintenance and the discharge of P to the environment.
- Investigate how far P discharged from these systems travels through the upper, aerated zone of the soil soakaway.

Scope

- Monitoring of 11 tanks discharging to ground (10 STs and 1 Package Treatment Plant (PTP)) in four locations:
  - River Clun, Shropshire
  - River Wylye, Hampshire
  - River Thames, Oxfordshire
  - Broads, Norfolk

Phase 1 – sites monitored

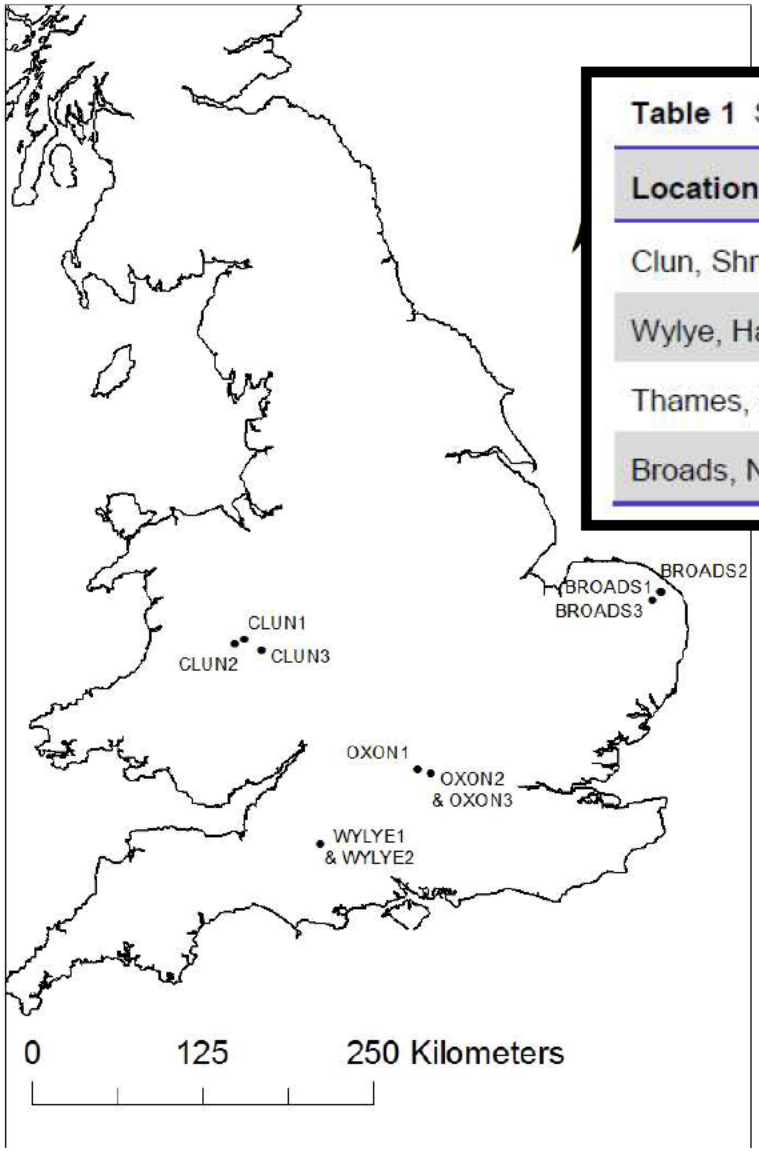


Table 1 Summary information on location, major soil types and average rainfall in each study area

Location	Major soil type	Average rainfall (mm/y)
Clun, Shropshire	Heavy soils; some lighter loams	1293
Wylye, Hampshire	Shallow chalk; greensand; river alluvium	950
Thames, Oxfordshire	Loam over chalk	707
Broads, Norfolk	Muddy sand sediments over shelly crag	667

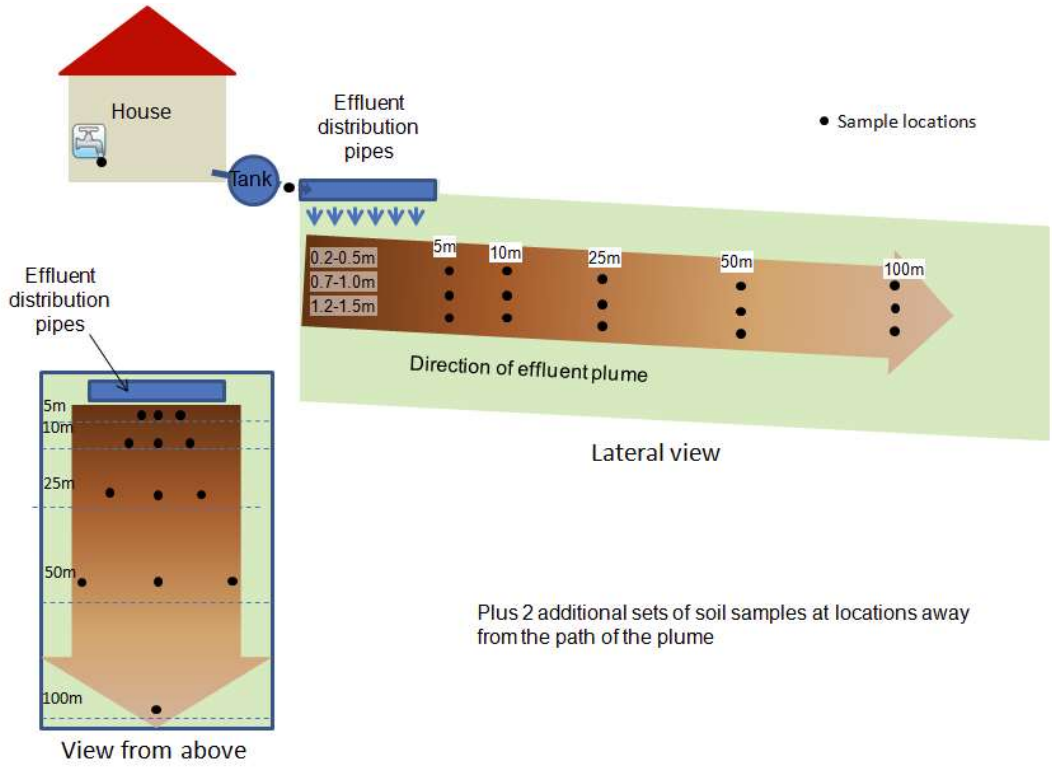
Previous studies focused on known problematic sites – not looked at aerated zone

Had to be more than 100m from natural or constructed drainage network and more than 2m above water table

Phase 1 - Methodology

At each tank the following collected:

- Tap water – to assess the amount of effluent P that was likely to have entered the STS through the domestic water supply.
- STS effluent – to assess the P concentration within the discharge.
- Soil and soil porewater – to investigate the path of P transport through the aerated zone of the soil soakway.
- Questionnaire completed by householder on ST design, management and household lifestyle



Phase 1 – Key findings

- P concentrations in the effluents were remarkably similar across all types of system, including the PTP.
- P found up to 1.5m depth in aerated soil - much of the P in the effluent that moves vertically through the aerated part of the soil profile is retained by those soils
- Soils can provide an important function in terms of P retention within these systems but this can be compromised by enhanced hydrological connectivity
- Suggests very important that soil soakaways are situated in areas that provide a significant depth of aerated soil below the effluent distribution pipes
- Positive relationship between concentration of P in tap water and concentration of P in tank effluent (based on limited data).

Phase 1 – Key findings continued

- Some evidence of older tanks discharging higher levels of P to the environment than more recently installed tanks but inconclusive as hard to pull out from other factors with small sample size.
- P moved laterally through the soil profile for a distance of 20-30m in most of the soil types included in this study.
- Septic tank systems may need to be located at setback distances of greater than 10 m (Building Regulations, 2000) to protect sensitive waterbodies.
- In general the soakaway system (within 30m) does remove P from STS effluent effectively unless it is compromised by enhanced hydrological connectivity such as that caused by direct discharge to a waterbody, local drainage channels or a high water table.
- If soils become waterlogged for any reason, they will fail to provide this function effectively.

Phase 2 – Aim and methodology

Aim

- To identifying areas where Small Domestic Discharges (SDDs) are at high risk of causing P pollution within the catchment of 20 SSSIs

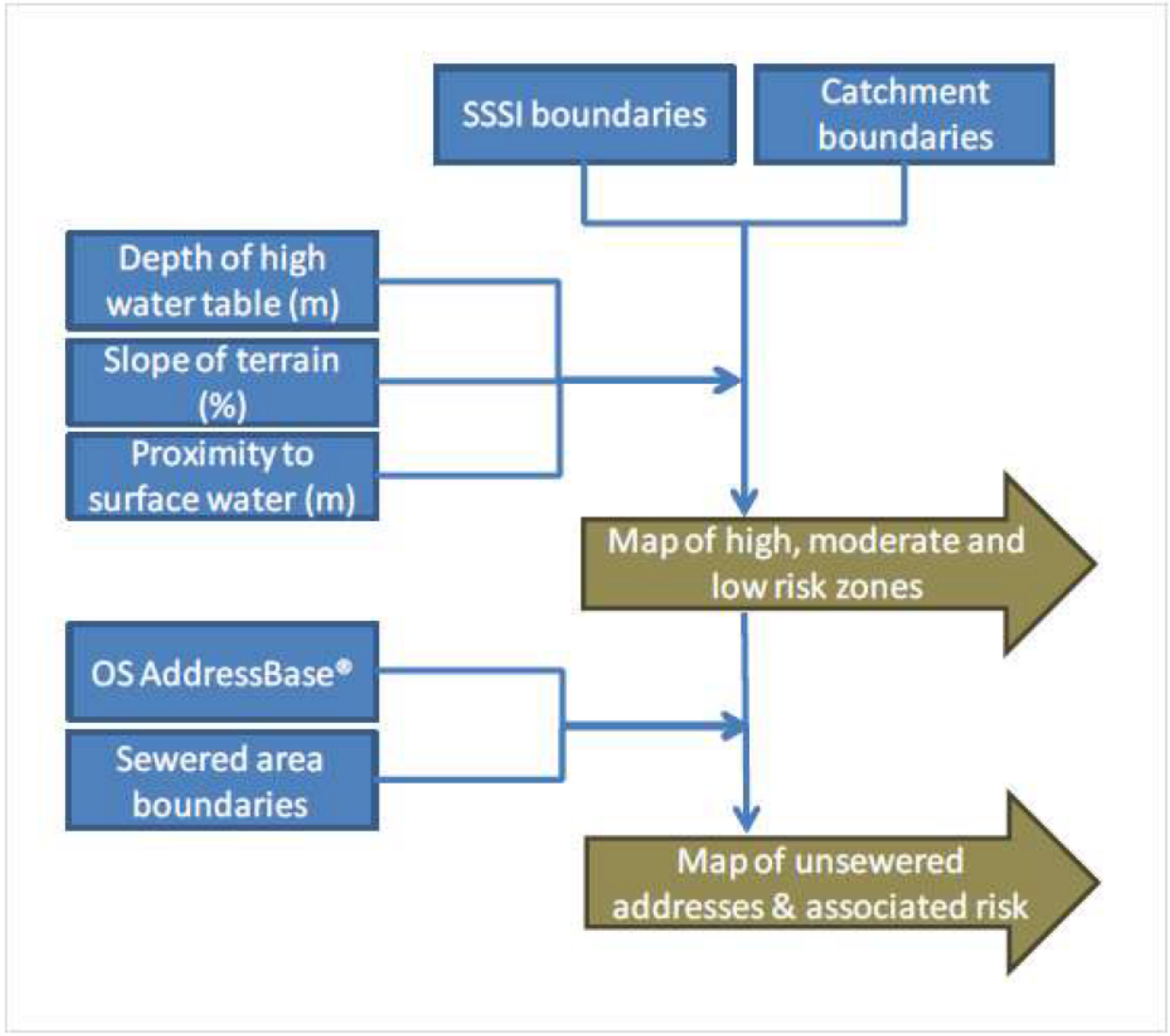
Methodology

- Used series of pre-defined risk factors: slope, proximity to the nearest waterbody that forms part of the catchment drainage network, and depth to the high water table.
- Used national scale datasets for each risk factor
- Risk categories were assigned for each risk factor. These were combined to generate an overall level of risk and this was mapped for each catchment.
- Likely locations of existing SDDs (using national scale datasets) were then mapped on these areas of high, moderate and low risk to assess the level of risk that existing systems may pose to the downstream SSSI .
- Assumed all properties in sewered areas are connected to mains and all SDDs discharged to ground

Phase 2 – risk descriptions

RISK CATEGORY	DESCRIPTION OF RISK CATEGORY
Low	Unlikely to cause P pollution problems
Moderate	May cause P pollution problems
High	Very likely to cause P pollution problems

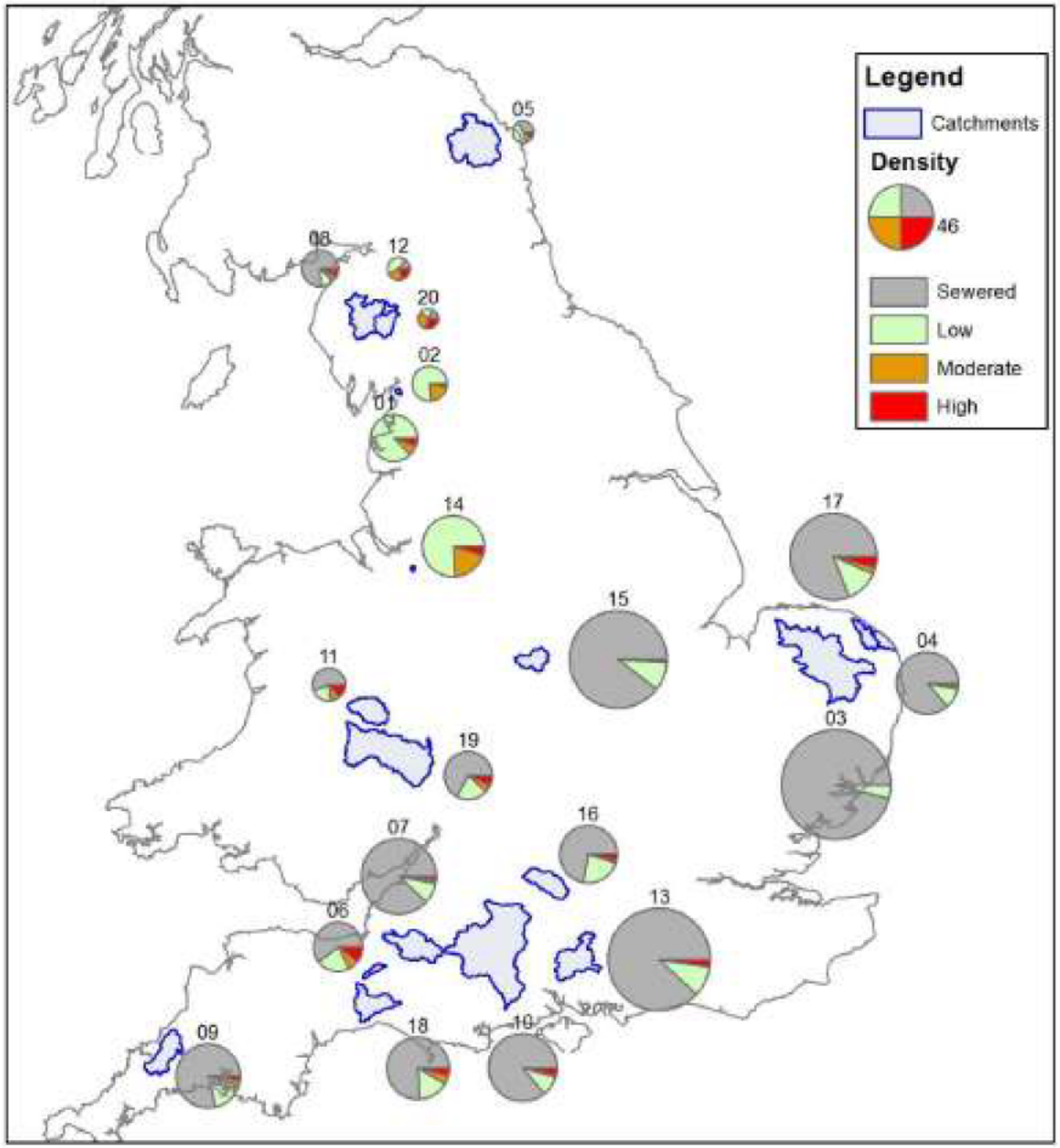
Phase 2 – Overview of the catchment mapping and risk assessment process



Phase 2 – Catchment summary

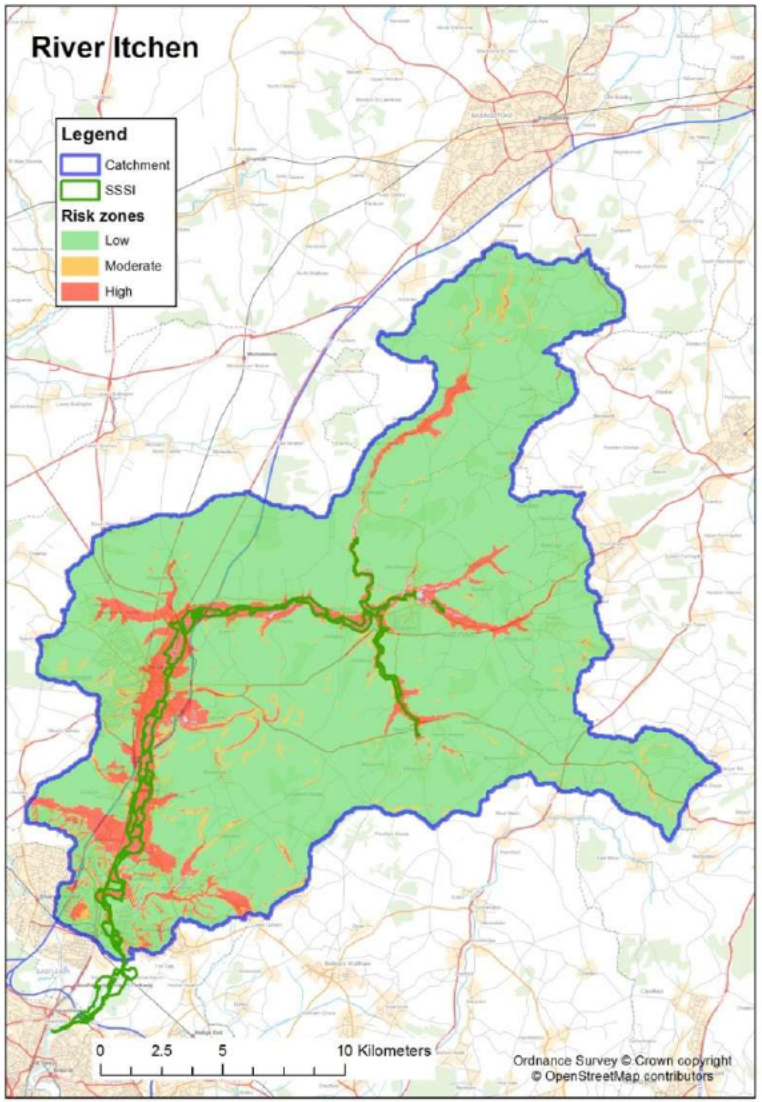
SSSI	NAME	CATCHMENT AREA (km^2)	PROPERTIES						
			TOTAL NUMBER	UNSEWERED DENSITY (km^{-2})	SEWERED	UNSEWERED	HIGH RISK ZONE	MODERATE RISK ZONE	LOW RISK ZONE
01	Leighton Moss	9.7	230	23.8	0	230	13	17	200
02	Hawes Water	2.5	33	13.4	0	33	1	7	25
03	Yare Broads & Marshes	1228.8	162,348	7.5	153,090	9,258	1,511	1,045	6,702
04	Upper Thurne Broads & Marshes	79.2	3,359	5.9	2,894	465	44	67	354
05	River Till	670.1	3,373	3.3	1,138	2,235	331	376	1,528
06	West Sedgemoor	41.1	1,102	9.9	695	407	124	34	249
07	Tealham & Tadham Moors	390.9	24,290	7.5	21,358	2,932	390	403	2,139
08	Bassenthwaite Lake	364.6	5,304	3.6	4,009	1,295	409	295	591
09	River Camel Valley & Tributaries	290.8	13,037	9.7	10,225	2,812	293	383	2,136
10	River Avon System	1668.8	85,450	7.2	73,510	11,940	2,930	1,133	7,877
11	River Clun	270.8	3,272	5.3	1,839	1,433	441	334	658
12	Dacre Beck	38.4	216	4.8	31	185	43	47	95
13	River Itchen	393.5	45,537	14.5	39,836	5,701	1,124	170	4,407
14	Oak Mere	5.6	233	41.5	0	233	12	44	177
15	River Mease	167.6	17,572	11.8	15,602	1,970	184	117	1,669
16	River Lambourn	264.4	9,584	10.1	6,916	2,668	355	140	2,173
17	Ant Broads & Marshes	124.5	10,327	16.0	8,340	1,987	419	233	1,335
18	River Axe	296.8	12,648	10.3	9,582	3,066	494	596	1,976
19	River Lugg	1079.7	27,738	8.4	18,618	9,120	1,899	1,404	5,817
20	Ullswater	147.5	665	3.7	112	553	201	205	147

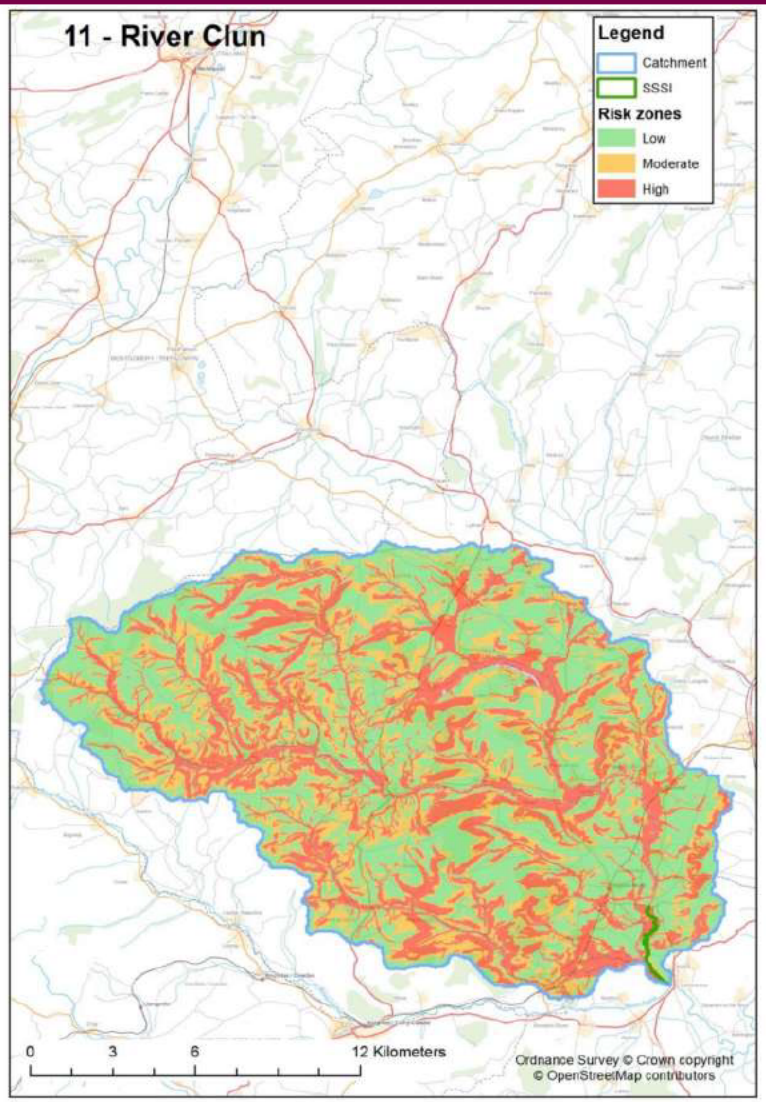
Phase 2 – Overall findings



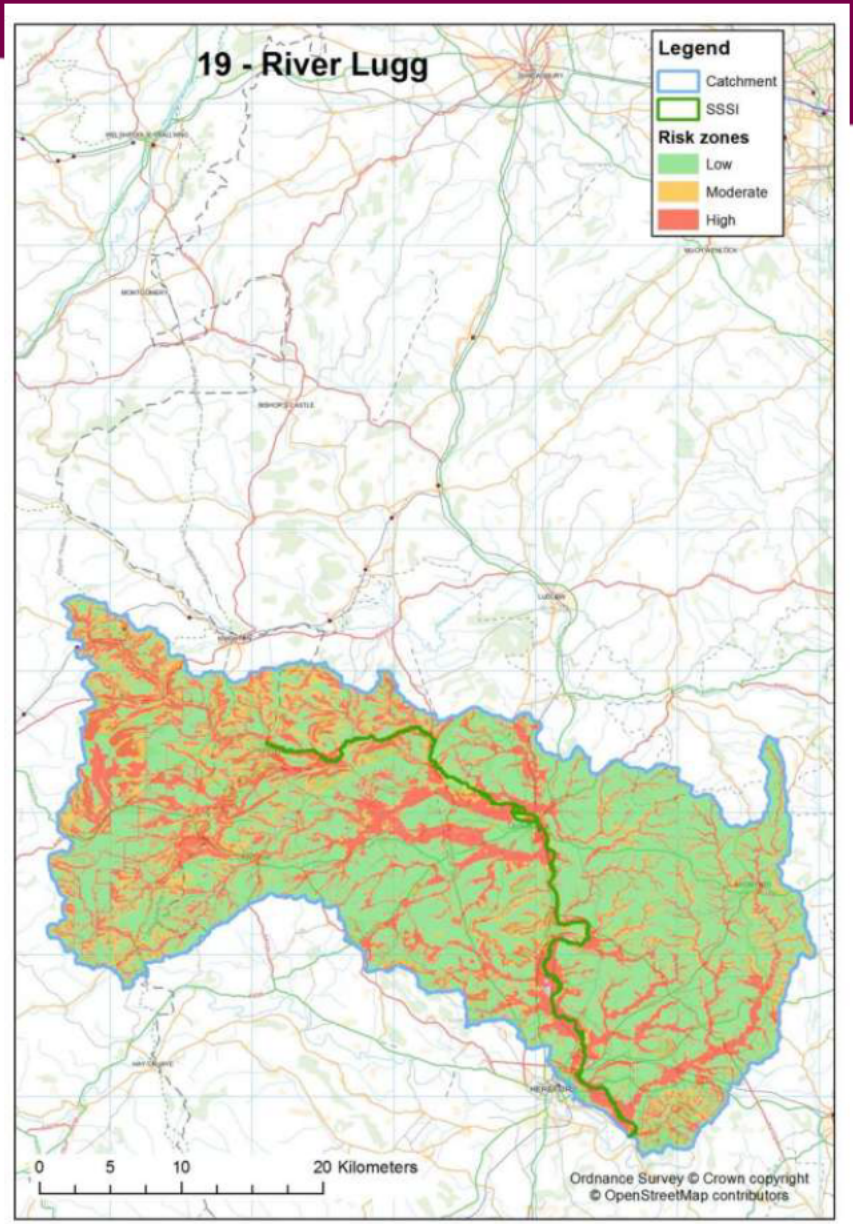
- 01-Leighton Moss
- 02-Hawes Water
- 03-Yare Broads & Mosses
- 04-Upper Thurne Broads & Marshes
- 05-River Till
- 06-West Sedgemoor
- 07-Tealham & Tadham Moors
- 08-Bassenthwaite Lake
- 09-River Camel Valley & Tributaries
- 10-River Avon
- 11-River Clun
- 12-Dacre Beck
- 13-River Itchen
- 14-Oak Mere
- 15-River Mease
- 16-River Lambourn
- 17-Ant Broads & Marshes
- 18-River Axe
- 19-River Lugg
- 20-Ullswater

Phase 2 – Risk Maps





Phase 2 – Risk maps



Phase 2 – Conclusions

Overarching conclusions

- The catchment size, number of SDDs and the risk from the SDDs was very variable between the different catchments.
- While a general methodology can be applied at national scale, the management of each catchment to reduce SDD impacts on receiving waters requires a more bespoke approach

National targeting of catchments - sites with higher densities of SDDs situated in high risk areas could be prioritised so that limited resources and improvements could be targeted more effectively.

  - For example, the greatest density of SDDs in high risk areas is in Oak Mere catchment (7.8km-2) and smallest in the River Itchen catchment (0.4km-2). Therefore highest priority for mitigation of potential impacts perhaps should be Oak Mere even though the actual number of SDDs in the Itchen catchment (5,701) far exceeds that in the Oak Mere catchment (233).

Phase 2 – conclusions cont.

Targeting within sites

- The risk zone maps could help identify areas that are likely to be unsuitable for the siting of new SDDs and where more detailed site evaluation or recommendations on improved methods of effluent processing may need to be made.

- The map of likely SDD locations and relative risk combined could be used at the site specific scale to identify existing systems that may be causing pollution problems with a view to targeting any necessary mitigation measures more cost-effectively.

Phase 3 – Aims & Methodology

Aims

- Characterise the different SSD systems available, highlighting key differences between them, and their effectiveness at removing P from domestic waste water before it is discharged to the environment.

- Review the options for reducing the phosphorus pollution risk from these systems and their applicability under different environmental conditions.

- Identify the key knowledge gaps in this area highlighting priorities for further research.

Methodology

- Literature review

Phase 3 – Key findings

- Data suggested the P concentration in effluents from PTPs is not lower than that from STs effluents. Although very limited data available in the published literature on the P content of discharges from PTPs.
- Most PTP systems are not designed to remove P – could be changing due to NN
- Unclear from the studies reviewed the extent to which effluent P concentrations vary over time
- Uncertain over if desludging a ST or replacement with PTP will reduce P or is may make situation worse.
- Important to recognise that de-sludging is beneficial to the effective operation of SDD systems in many other ways e.g. stopping solids blocking soakaway, and as such, should continue to be encouraged.
- In areas where the water table is high, ie <1.5 m below soil surface, impacts on nearby watercourses/groundwater can probably be reduced by installing mounded soakaway systems

Phase 4 – Aims & Methodology

This project was undertaken to test two hypotheses:

- The level of P in the effluent from a PTP is similar to that from a comparable ST
- There is considerable temporal variation in the levels of P in the effluent of any given PTP, so a single sample collected on one occasion does not adequately reflect the longer term situation and is inadequate for monitoring purposes

Methodology

- Effluent sampling of 6 PTPs in different forms of P
- Roughly 3 weekly intervals over 6 months (apart from Tank 4, which was sampled at 1-2 week intervals over a shorter period of only 3 months)

Phase 4 – Tanks descriptions and concentrations in the effluent

TANK NUMBER	TANK TYPE	ESTIMATED SIZE (AS POPULATION EQUIVALENT)	AVERAGE EFFLUENT CONCENTRATIONS (MG P L^{-1})				Comment
			SRP	TDP	PP	TP	
1	WPL Diamond	10-15	5.2	5.5	0.5	6.0	Very high effluent TDP concentrations in early samples; may have been caused by pump failure; no related increase in PP concentrations.
2	Klargester BioDisc®	5-8	4.7	4.8	1.0	5.8	Relatively high discharge of PP throughout, especially in final sample; reason unclear but indicative of system failure.
3	Klargester BioDisc®	8	1.1	1.5	0.6	2.1	Tank effluent quality very good in relation to P concentrations; no evidence of system failure.
4	SAF Conder	350	9.9	10.1	2.3	12.4	Tank effluent quality mostly good in relation to P concentrations; possible evidence of system failure in final sample where PP concentrations were high.
5	Klargester BioDisc®	25	4.0	4.7	1.1	5.7	Tank effluent quality mostly good in relation to P concentrations; possible evidence of system failure in final sample where PP concentrations were high.
6	Klargester BioDisc®	20	8.5	17.1	9.0	26.0	Tank effluent quality variable with high TDP on one occasion and high PP later; may indicate intermittent system failure.

Phase 4 – Conclusions

- The average TP concentration in effluent from the PTPs monitored in this study was 9.7 mg l^{-1}. This value is lower than that from single source STs (12-15 mg l^{-1} TP), but greater than that reported for potentially more comparable multi-source STs (7 mg l^{-1} TP)
- It seems unlikely that PTPs discharge effluent with lower concentrations of TP than traditional STs, when systems are compared like-for-like, which raises a question over if these systems can be discharged safely to a watercourse.
- Considerable temporal variation was observed in effluent P concentrations from the six PTPs studied.
- It is unclear why P concentrations in the effluent from STs and PTPs vary so dramatically over time, but these results raise questions over whether a single effluent sample collected for monitoring purposes adequately represents the longer term situation.

Phase 4 – Conclusions cont.

- Most studies of P pollution from on-site waste water treatment systems focus on determining effluent P concentrations, but P loads are more likely to be important drivers of water quality and environmental impact where the downstream waterbodies are standing waters. Estimating P loads requires rates of flow of effluent to be measured in addition to P concentrations.
- A better understanding of the impact of in-stream dilution on resultant P concentrations in the environment is required. This applies, especially, to how far downstream of an effluent discharge point effects on water quality can still be observed and how the pattern of impact is affected by the mode of delivery, eg via a soakaway or through a direct discharge.

Summary of key conclusions from all reports

Septic Tanks (discharging to ground)

- P travels up to 1.5m in depth and up to 20-30 laterally within the soakaway. Therefore 10m distance from watercourse in Building Regs not sufficient to protect sensitive waterbodies.
- Soakaway effective at retaining P, as long as not compromised by enhanced hydrological connectivity e.g. via groundwater, drains/ditches, fissures, flooding etc
- Uncertain over if desludging a ST reduces or increase P concentration in effluent. However still need to desludge to stop blocking of soakaway.
- Most effective options to reduce P in the effluent – reducing P inputs to tank e.g. detergents (already happening)
- In areas where the water table is high, ie <1.5 m below soil surface, impacts on nearby watercourses/groundwater can probably be reduced by installing mounded soakaway systems

Summary of key conclusions from all reports

Risk Assessment of Septic Tanks (Discharging to Ground)

Developed methodology for assessing risk of STs which could be used to:

- Prioritise SSSI/N2K catchments where STs pose greatest risk
- Identify locations of existing STs within those catchments which pose the greatest risk, to effective target further investigation
- Inform decision making around risk posed by potential new STs

Summary of key conclusions from all reports

Package Treatment Plants (discharging direct to water)

- No evidence that effluent from a PTP is lower in TP than that from a STs, which raises a question over if these systems can be discharged safely to a watercourse
- Considerable temporal variation was observed in effluent P concentrations from the six PTPs studied, which raises a question over whether a single effluent sample collected for monitoring purposes adequately represents the longer term situation.

All conclusions based on limited data still, even with additional work that has been undertaken.

Work done post SSD research

- NE worked with NRW/EA to develop the PTP/ST screening criteria, which we now use for HRAs based on these reports as well as additional factors.
- We have also had a project looking at the British Standards certification method – which may be useful in terms of explaining the different types of ST/PTPS as there are different classes and whether they provide primary/secondary or tertiary treatment.
- GBRs were updated although there are no changes re protected site distances.

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