SMART POND DESIGN

WESTCOUNTRY RIVERS TRUST

WATER NET GAIN

Westcountry Rivers Trust

Water Breakthrough Challenge

This report is an output from the Water Net Gain project funded by the third Ofwat Innovation Fund Water Breakthrough Challenge.

CONTENTS

THIS REPORT...

..**provides guidance on pond design**, construction and maintenance, with particular focus on water retention and release, as well as biodiversity. Ponds can provide other benefits which might need additional considerations during the design and construction, these are not covered here.

..**compiles information from many existing sources** and only focuses on the key information relating to WNG ponds. See the further reading and references sections for more details on the topics covered as well as additional pond guidance.

..**does not cover the permissions process** in detail. You may need to apply for abstraction licenses, planning and other permissions when installing a pond system. Further information on these aspects can be sought in other Water Net Gain deliverables.

WATER NET GAIN

Water Net Gain is exploring new ways we can support farmers to bolster drought-affected water supplies and ease associated river health pressures. The aim is to create a catchment scheme where farmers are paid to store water on their land in ponds and lakes which can act as 'water batteries'. This scheme could improve farms' resilience as well as benefit the wider society and rivers.

WHY PONDS?

- Ponds have been part of the farming landscape for a very long time. Due to agricultural intensification, they have often been removed or neglected.
- Ponds can be a biodiversity hotspot in the farming landscape.
- Ponds can provide water for the farm or store water for off-site uses.
- Ponds do not take up significant amounts of land.

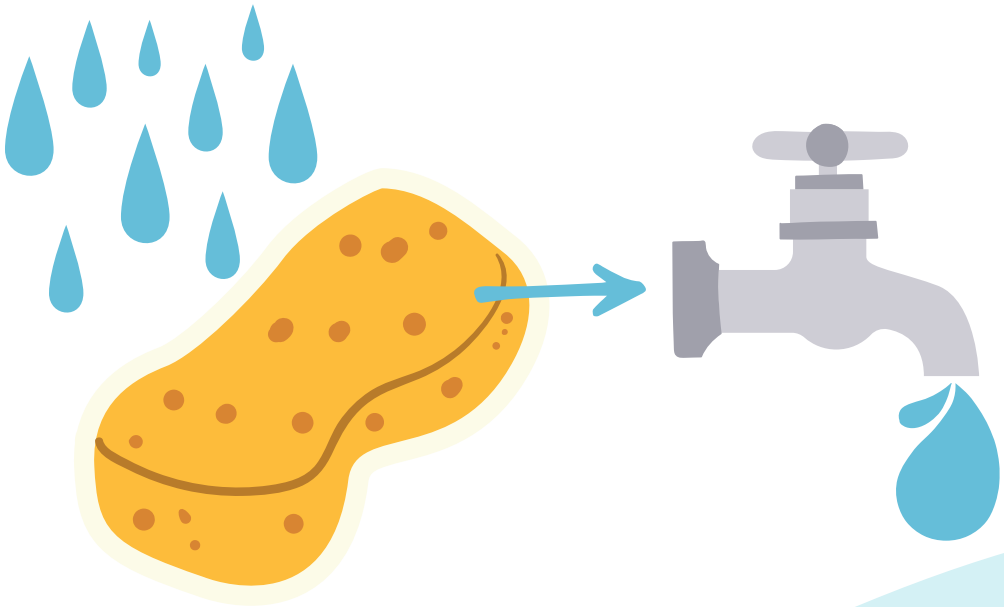
The Freshwater Habitats Trust defines ponds as "bodies of water which can vary in size between one square metre and 2 hectares, and which holds water for four months of the year or more."[1]

1. Freshwater Habitats Trust. Ponds. Online available at:1 Freshwater Habitats Trust. Ponds. Online available at: https://freshwaterhabitats.org.uk/habitats/ponds/

THE SMART WATER GRID

Water Net Gain forms part of the **Smart Water Grid** - this is an integrated system that captures, stores, and releases water in a coordinated way to improve water security, reduce flood risks, and support ecosystems. It combines natural (passive) processes with technologically controlled (active) infrastructure.

In essence, the smart water grid acts like a **catchment-wide sponge and tap system**—passively soaking up excess water during wet times and actively delivering it during dry times—ensuring water is managed for both people and nature.



01
Capturing Rainfall and Runoff

Instead of allowing rainfall to flow quickly off the land into rivers and out to sea, the smart water grid intercepts and stores water.

02
Slowing Surface Water Movement

To prevent rapid loss of water from the catchment:

- Vegetation, contour banks, and wetland systems slow down runoff.
- Water is given time to infiltrate into the soil, replenishing groundwater and improving **baseflows** in streams.
- These measures reduce erosion, protect soil health, and improve water quality.

03
Storage for Dry Periods

Water is stored in a network of ponds and wetlands across the catchment.

These act as:

- **Buffers** against drought.
- **Reservoirs** for irrigation, stock watering, or ecosystem needs.

04
Using and Releasing Stored Water

Stored water can be:

- Used **on-farm** for crops and livestock during dry spells.
- **Released strategically** to maintain environmental flows, supporting fish habitats, wetlands, and riparian vegetation during critical low-flow periods.

05
Smart Monitoring and Control

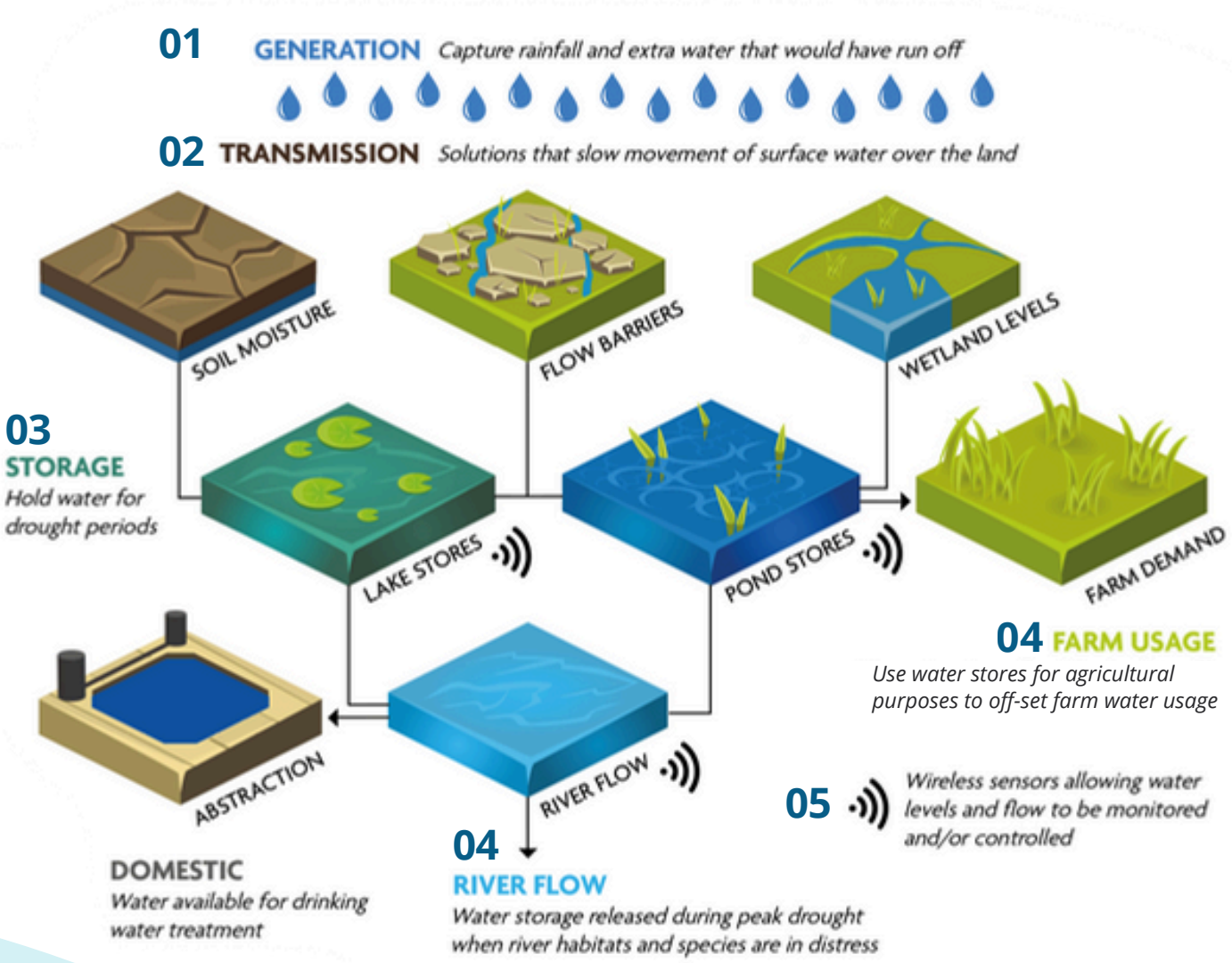
Sensors and remote operation tools turn the system into a **responsive water network**:

- **Sensors** monitor rainfall and water levels.
- **Remote control gates and pumps** release water precisely when and where it is needed.
- **Data-driven decisions** optimize the balance between agricultural use and ecological health.

06
Passive and Active Management

The smart water grid blends:

- **Passive elements:** Natural infiltration, wetland restoration, and soil-water retention that work continuously without intervention.
- **Active elements:** Infrastructure such as gates, pumps, and valves, controlled via smart tech to release or divert water in real time.



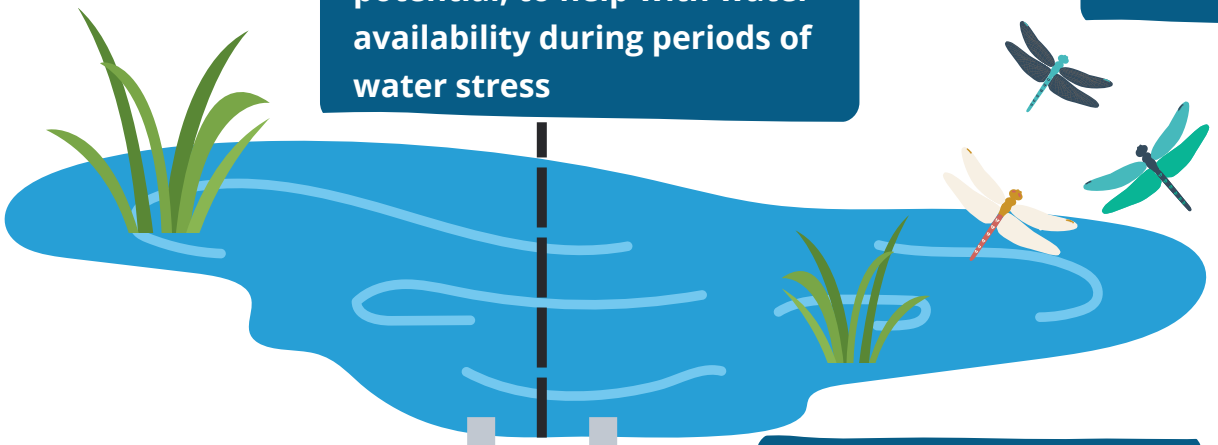
WATER NET GAIN PONDS

The Water Net Gain pond is designed to provide several functions which make it a water-resilient and biodiverse system.

Is monitored for water quality

Has water storage and release potential, to help with water availability during periods of water stress

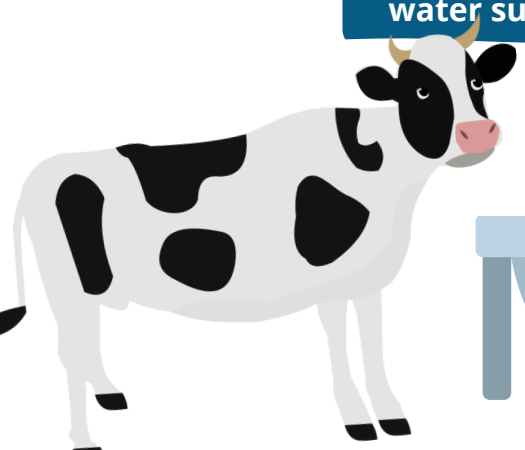
Is a biodiversity haven on the farm

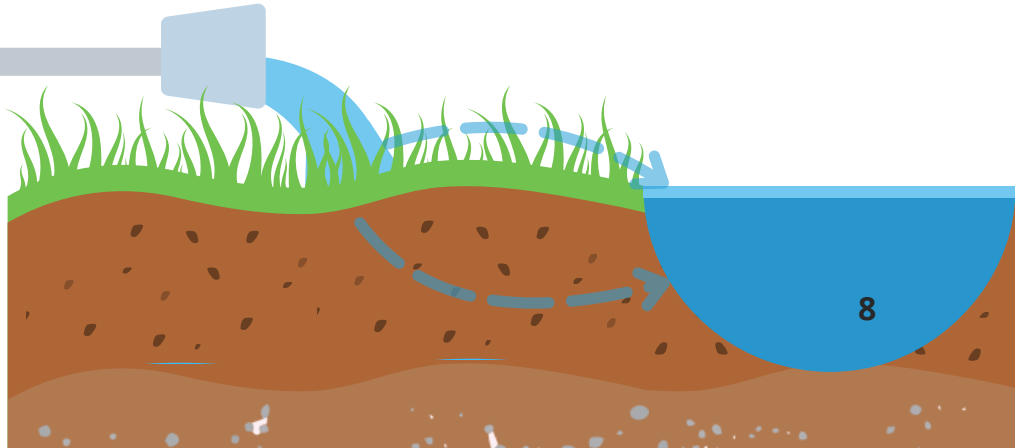


Is integrated into the farm water infrastructure, to provide resilience to the farm's water supply

OR

Can be released to environment to support river flows





SITE LOCATION, DESK-TOP STUDY AND SURVEYS

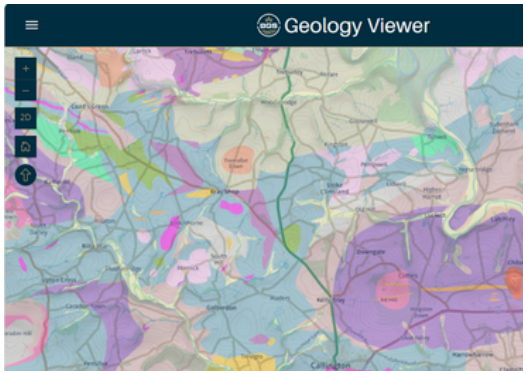
It is important to identify a suitable location, which has good conditions for pond creation, and does not impact on other important habitats or functions. The following pages give an idea of what to consider when deciding on the location of a pond.

MAGIC MAPS

Look especially for nearby designations (environmental and historic) and priority habitats.
https://magic.defra.gov.uk/MagicMap.aspx

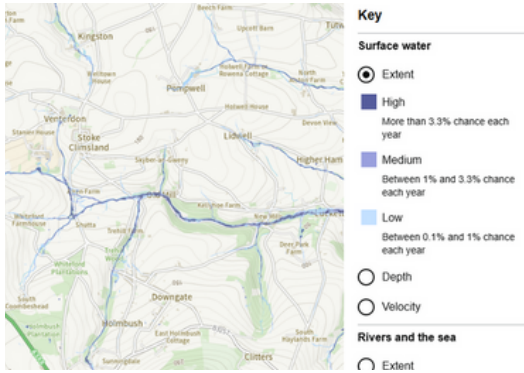
BGS GEOLOGY VIEWER

Identify the underlying bedrock and superficial geology.
https://geologyviewer.bgs.ac.uk/



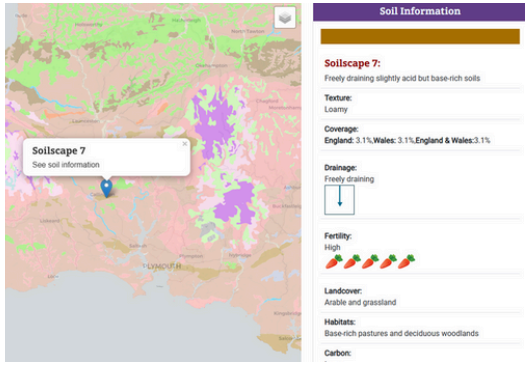
FLOOD RISKS

Check the flood risk from rivers and the sea, as well as from surface water.
https://check-long-term-flood-risk.service.gov.uk/map



SOILSCAPES VIEWER

Identify the soilscapes.
https://www.landis.org.uk/soilscapes/



The following spatial strategies should be considered at the screening stage, for identifying the best locations, and catchments for a Water Net Gain scheme and individual ponds, as well as opportunities for wider funding and impact:

- **Local Plans** (prepared by Local Planning Authorities) – considering policies on flood risk, biodiversity, green infrastructure and water management
- **River Basin Management Plans** (Environment Agency) – considering the current status of the water environment and environmental objectives for its protection
- **Water Resource Management Plans** (Water companies) – considering current and future abstraction and infrastructure plans, looking at water demand and supply
- **Local Nature Recovery Strategies** (Defra and Local Authorities) – Mapping priorities and opportunities for nature recovery, including pond and wetland creation and restoration
- **Catchment Plans** (Catchment-Based Approach) – Catchment Partnership plans to manage water in a catchment holistically
- **Flood Risk Management Plans** (Environment Agency) – Considering opportunities for applying Nature-based Solutions for Natural Flood Management, as well as drought management
- **Biodiversity Net Gain –** Relevance and opportunities in the catchment
- **Environmental Land Management Schemes (ELMs)** – To support or enhance the Water Net Gain system

OTHER CONSIDERATIONS

- Planning requirements
- Historic Environment Farm Environment Records (HEFER)
- Public Rights of Way
- Tree Preservation Orders
- Historic mapping - Side by side viewer (https://maps.nls.uk/geo/explore/side-by-side/)
- Communities, including neighbours and potential downstream impacts
- Local Nature Recovery Strategy
- Underground services (such as Line Search Before you Dig: lsbud.co.uk)
- Old land drains
- Topography
- Land registry - covenants

SURVEYS

- Soil survey (Soil type and texture, infiltration test)
- Ecology survey, and Biodiversity Net Gain Metric
- Water table, trial pits to maximum depth of planned pond
- Cat and Genny

Get advice where expertise is required or if anything is unclear!

USE

- MAGIC maps to identify if you are located within, or close to, a designated area such as a Site of Special Scientific Interest, Special Area of Conservation, Special Protection Area, listed building or priority habitat.
- Flood maps to ensure you do not locate your pond in Flood Zone 2 or 3 of rivers and see if surface water flooding could be diverted into the pond as a water source.
- BGS Geology viewer to identify the geology and how permeable it may be.
- Soilscapes to identify the potential soils on site and how well they hold water.
- Local Authority mapping to identify other constraints as listed above.
- The Side by Side viewer to identify whether there used to be ponds on the land.
- The Local Nature Recovery Strategy to identify where ponds could act as a stepping stone between priority areas.
- Cat and Genny to avoid utility strikes when digging.
- Knowledge of old land drains to avoid accidental draining of the pond, or to block and use that water for the pond.
- Topography to identify where water might potentially pool, or where construction may be helped by the topography.
- Land registry to identify if there are covenants on the land which are incompatible with a potential pond.
- HEFER to identify historic remains in farmland – do not build a pond there

NEIGHBOURS

How close is your neighbour's land? Will there be any visual impact by building a pond or embankments? Would there be any unintended impacts due to the Farming Rules for Water, i.e. nutrient restrictions, in vicinity to your neighbour's land? If you are looking to install the pond system close to your neighbour's land, it is a good idea to let them know about your plans.

POND DESIGN

SOILS

IMPERMEABLE SOILS

- Firm and compact
- Clay, clay loam, silty clay or sandy clay
- Hold water efficiently, with negligible leakage

PERMEABLE SOILS

- Low in clay and high in sand, exhibiting a grainy texture
- Good drainage and allow leakage
- Without the use of lining, make for a poor pond base

The higher the clay content of a soil, the more effective it will be for holding water.

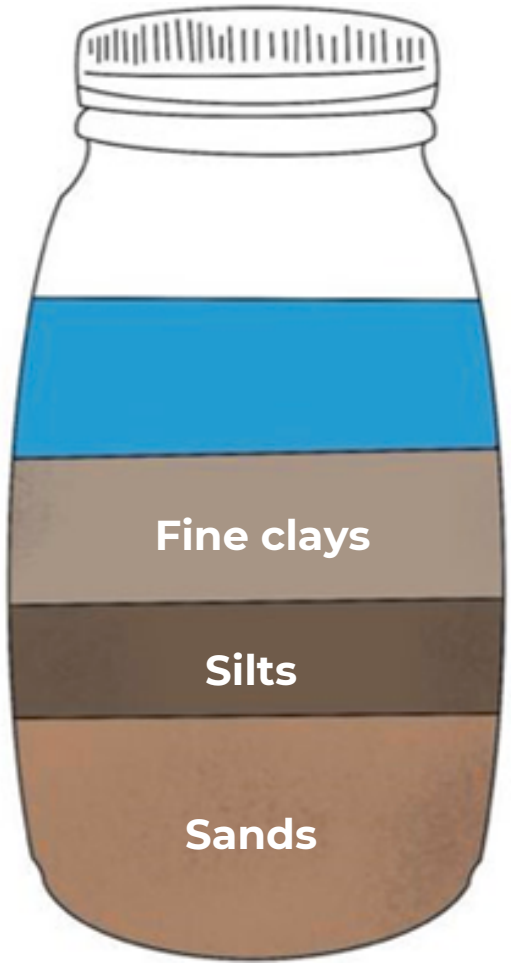
SOIL SAMPLING

Trial holes and soil sampling help to determine soil variability and positioning of the water table. This helps to assess whether the pond would hold water without being lined. Dig a hole and take a soil sample from the subsoil, i.e. the soil which will form the base of the pond.

Take samples with an auger across the entire site.
Excavate trial holes to the maximum depth of the proposed pond

SOIL TEXTURE TEST

1. Fill a jar with one part soil and two parts of water.
2. Shake the jar vigorously so that the contents are well mixed.
3. Leave to settle for around 48hrs.
4. Soil will settle in different fractions, based on their density. Coarse sand particulates will settle first, followed by silt, then fine clay.
5. For a suitable soil that will hold water, the upper fraction of fine clay should comprise roughly a third or more of the total fraction.

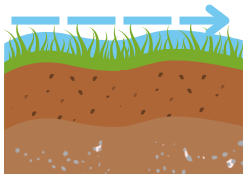


WATER SUPPLY

RAINWATER

- Dew ponds, only fed by rainwater
- Have traditionally been used for livestock watering where there was no other water source
- These are not likely to provide enough water for Water Net Gain

SURFACE WATER RUNOFF

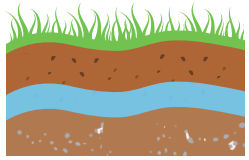


- Surface water runoff can be diverted into ponds, from hardstanding surfaces as well as field runoff
- High risk of sediment and nutrient loading of water

RAINWATER HARVESTING

- Rainwater can be collected from roofs of buildings and piped/ channelled to ponds
- Find more information here: Rainwater Harvesting: an on-farm guide

GROUNDWATER



- Marginal, already wet areas are often considered for pond creation - these are groundwater-fed
- Abstraction from ponds like these might require an abstraction licence
- Already wet areas (wetlands) might be high in biodiversity

SPRINGS, STREAMS AND WATERCOURSES

- Stream or spring water could be diverted into a pond before going back into the stream
- Abstraction from ponds like these might require an abstraction licence
- Ram pumps could be used to fill a pond in high-flow conditions in winter, and the water could be used in summer

SIZE

DEMAND MANAGEMENT PONDS

- Between 2200m^3 and 10,000m^3 (2.2 – 10ML) total volume – water for use approx. between 1700m^3 and 7300m^3
- Used on farm to substitute the use of potable water, borehole-sourced water or water abstracted from watercourses
- May be created under permitted development
- Shared benefit of demand reduction for water company, and increased farm resilience for farmers

Demand management pond: This farm pond has the following dimensions: Approx. 50m x 35m, approx. 1000m2 area, maximum depth approx. 3m

SUPPLY PONDS

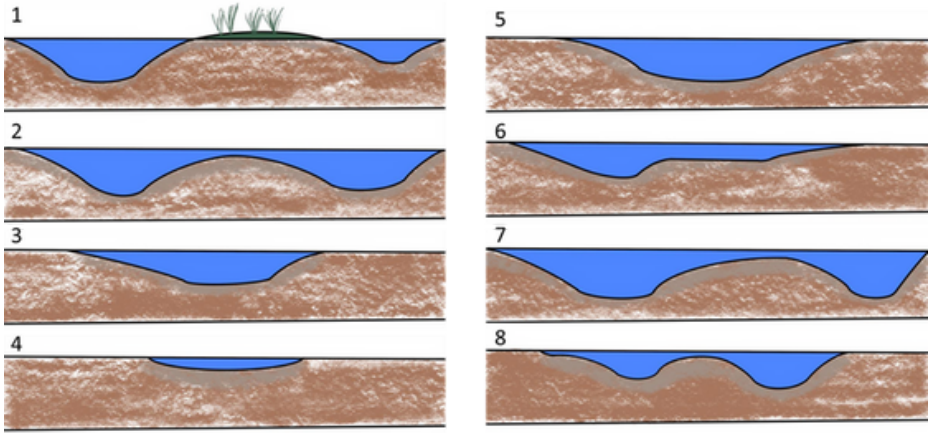
- Between 3,000m3 to 10,000m3 (3 -10Ml)
- Used to release water to buffer waterbodies during low flow situations, which can also increase abstraction resilience in those waterbodies
- Will be located in strategic locations within a catchment
- Will require planning
- Relatively high cost per cubic metre
- Could be used in the ten driest days of the year, for example to increase flows to above Q95 flows (which is a significant low flow parameter for rivers)
- Area: Up to 1 acre
- Estimated deployable volume: Approx. 2200m^3 to 7300m^3

Crazywell Pool. Credit: By Myself - Herby talk thyme - Own work, CC BY-SA 4.0: https://commons.wikimedia.org/w/index.php?curid=4900470

STRUCTURE & SHAPE

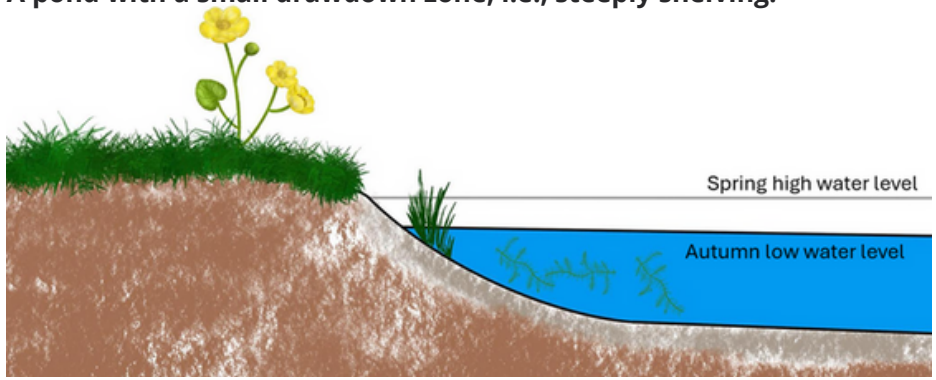
Create long, irregular shaped edges and shallow, undulating banks.

Aim to vary the depth of the pond.

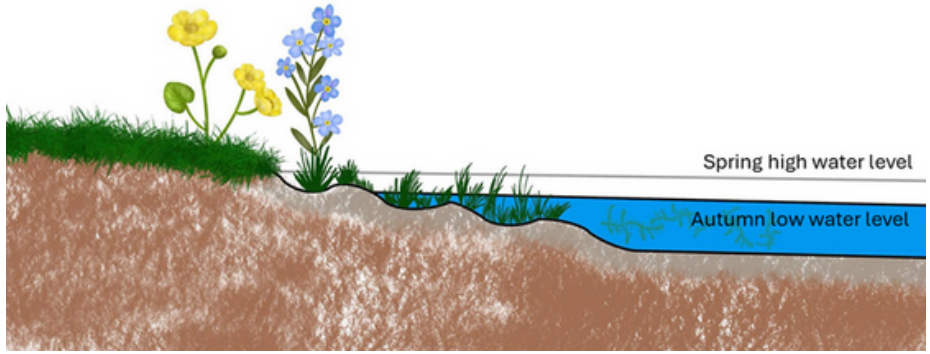


Slopes should be no more than 1:5 (12 degrees) and preferably less than 1:20 (3 degrees).

A pond with a small drawdown zone, i.e., steeply shelving.



Pond showing an extended drawdown zone with an uneven gradient providing a range of depths. Compared to the image with steep shelving, there is greater diversity of aquatic species which will attract a greater array of fauna.



DETAILED DESIGN

1. Identify the area of the proposed pond.
2. Design the shape and calculate approximate pond water area and volume.
3. Develop a plan with depth variations, side slopes, inlet and outlet.

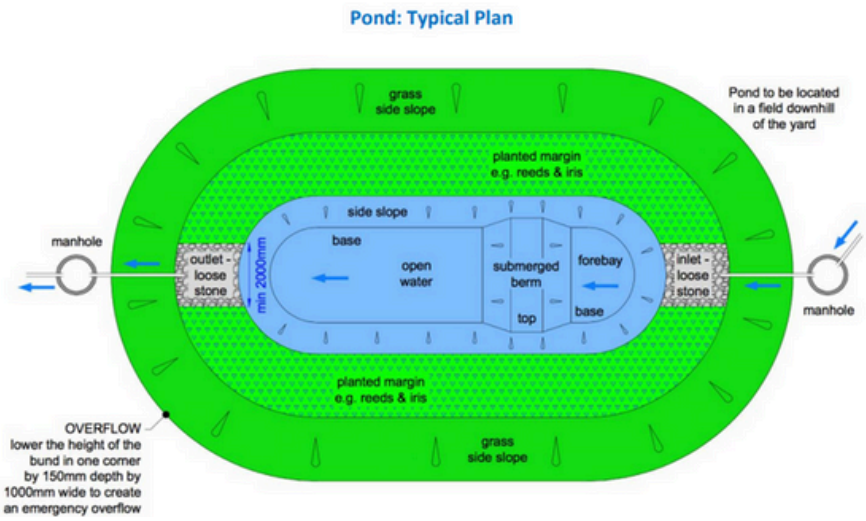


Illustration: CREW – Pond detailed design – Rural SuDS Design and Build Guide December 2016.pdf

OVERFLOWS & OUTLETS

Pond outlets can be designed via a pipe, a swale or ditch, a monk, sluices or U-pipes to prevent overflowing of the pond when the pond is full.

Pipe outfalls should have a bed of gravel/ rocks underneath, to prevent scouring of the bed.

Pipe outflow

Swale/ditch outflow

U-pipe outflow

Rock armouring to prevent scouring

Outflow rates when draining down or using the pond water should be within reasonable rates of outflow and time of draining, to not disturb ecology by flushing everything down at once. This will need to be considered depending on the pond design, but should for example consider to not increase the outflow rate by 100, and to not drain down to threshold within 6 hours.

FISH SCREENS

If your pond has an inlet or outfall, and is therefore connected to a watercourse, screening for fish will need to be considered. This is to avoid them entering ponds and getting trapped or injured. The screen might be a passive mesh screen of 2mm, however, expert advice will need to be sought to identify the most suitable structure. As any inlets and outfalls will require Land Drainage Consent or a Flood Risk Activity Permit, the Environment Agency or the Local Lead Flood Authority will provide further guidance or requirements for the appropriate solution. See Appendix II for more information on fish screening.

DEPTH AND DEAD STORAGE

Allow for some storage of water that cannot be used.

- Evaporation loss: 300mm/ 0.3m
- Seepage loss (with clay lining): 200mm/ 0.2m
- Additional 'dead water' (to prevent clay base cracking or to hold down liner): 300mm/ 0.3mm

Reduce water use potential by a depth of 800mm/ 0.8m

ESTIMATION OF WATER BUDGET

The water budget of a Water Net Gain pond will be monitored with level sensors. However, at the detailed design stage, it is important to get an idea of the water budget, to understand how much water can be stored and used from the pond.

Pond input = Inflow (rainfall and catchment area) - evaporation - seepage - outflow

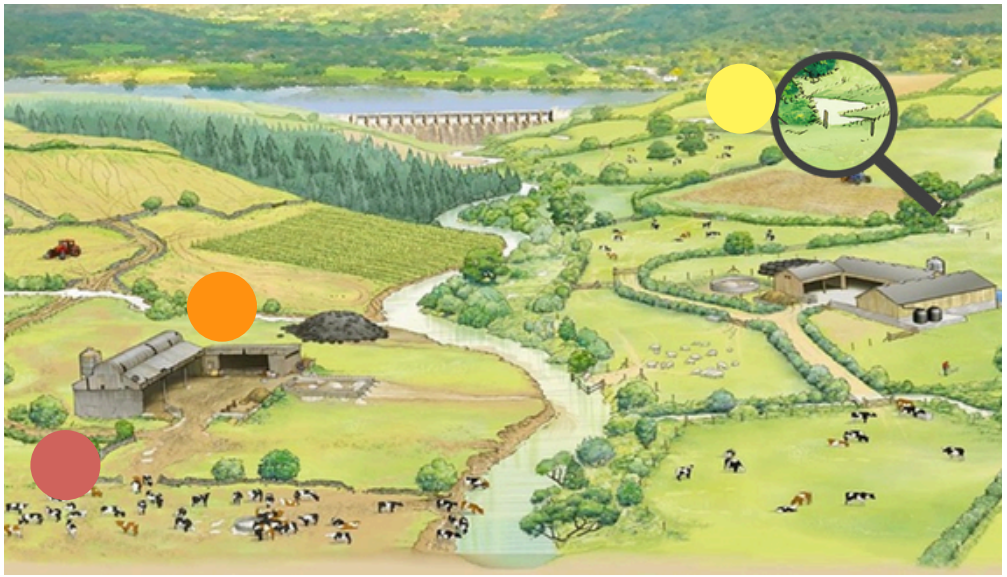
Ideally, this is calculated per year and separately for summer and winter months. Estimates for monthly evaporation and monthly average rainfall are needed. Using the maximum pond volume, the potential volume for intentional discharge for water trading can then be identified.

The Hydrology Data Explorer can be used to find local rainfall data during a high rainfall and a drought event, which can be used as example fluctuations in the pond.

WATER QUALITY

Farm pond water quality mostly depends on the surrounding farm management. The illustration below shows good on-farm practice (right-hand side of the river) and on-farm concerns (left-hand side of river). Nutrients are the most important factor for water quality issues in farm ponds, as there is a risk of sediment and nutrients running off from the agricultural land into the pond. This can result in algal blooms which can outcompete other plants and reduce the oxygen levels in the water.

More explanation here: https://wrt.org.uk/our-work-3/activities/land/



Regular pond monitoring is also very important to identify potential water quality issues. Find the draft monitoring and maintenance plan in Appendix III for what to look out for and suggested management measures.

Is there any land contamination potential in the catchment of the pond? Think about the history of the land and check current and historic landfills. Avoid having contaminated water running into the pond.

Check out the barley straw treatment as a way to prevent algal blooms:
Coping with algae in ponds |Suffolk Wildlife Trust.

Source
These issues should be addressed at source, by preventing nutrient runoff from the land.

Pathway
The pathway should be blocked, and the preferred flow corridor should be managed to act as an additional buffer, cleaning the runoff before entering the pond (or other water body).

Receptor
Pond sediment removal and plant removal may be required if too many nutrients have entered the pond.

POND LINING

If the underlying soils and geology are permeable, a form of pond lining is required for the pond to hold water. There are several options, depending on budget and availability of clay.

PUDDLED CLAY

If clay is available on-site or nearby, it can be used to line a pond. To puddle it, clay and water are pounded together in a dense mass, either by machine or traditionally by animal trampling. Clay pits can be used as infiltration features such as scrapes or smaller ponds.

This small pond/scrape was the clay pit for bigger ponds, and has now developed into its own pond with value for wildlife.

FLEXIBLE SYNTHETIC LINERS:

These are made of PVC, polyethylene or butyl rubber. They are flexible and relatively cheap. Their lifespan is limited and punctures cannot be easily fixed.

BENTONITE AND GEOSYNTHETIC CLAY LINER:

Bentonite is a very fine powder of clay particles which swells in contact with water to become waterproof clay. The geosynthetic liner uses bentonite in between two geotextile layers. These can self-seal around small punctures. They require specialist knowledge for installation.

CONSIDERATIONS

- If the pond needs lining, pond shapes might be more restricted to make best use of the lining.
- Trees, their roots and animal trampling can all physically damage pond linings. Varying water levels (such as clay cracking, or sun exposure to synthetic linings) can also be damaging.
- Cover the lining with subsoil, to protect it and create suitable pond bed substrate, but avoid stony soils to prevent puncturing the liner.
- If the underlying soils and geology are very permeable, maybe that location is not the right choice for a pond.

Further advice on pond liners, as well as pros and cons, can be found in the Freshwater Habitats Trust leaflet.

BIODIVERSITY

POND HABITATS

Varying pond shapes, slopes and depths provide different habitats. This encourages more species diversity in the pond. Due to the nature of Water Net Gain, water levels will fluctuate and parts of the pond may dry out if water is taken. However, marginal pond vegetation and organisms can tolerate and adapt to this fluctuation.

PLANTS

Ponds should not be planted, as plant communities will establish themselves relatively quickly.

FISH

Water Net Gain will require a water drawdown during periods of low water availability. This means that fish stocking will not be suitable for ponds used for Water Net Gain. Fish can also have a negative impact on other pond biodiversity.

TREES

There should be no trees along the southern edge of the pond, to avoid shading out the pond. Some trees can be around the northern edge of the pond to provide some shade and dappled light. Tree roots could damage the lining, so trees and shrubs around the pond need to be managed.

OTHER SPECIES

Ponds support many species such as amphibians, insects like damselflies and water beetles, water birds and mammals. Find out more about pond species and how to identify them:

WWT Pond species ID guide
Wildlife Trust Pond ID Chart
Natural History Museum Pond Life Facts
Field Studies Council Freshwater Name Trail

If you have questions about biodiversity and protected species, please ask an ecologist for advice.

PROTECTED SPECIES

It is prohibited to kill or disturb, or destroy the breeding and shelter places of protected species. This includes great crested newts and water voles. Ponds that are used by great crested newts or water voles cannot be used for Water Net Gain, as this would likely disturb these species. Ponds should not be designed and constructed to attract these species, to avoid concerns during the operational phase of Water Net Gain.

Water vole. Fred Dawson (Flickr CC)

Great crested Newt - Alexandre Roux (Flickr CC)

INVASIVE NON-NATIVE SPECIES

Invasive Non-Native Species (INNS) are defined as organisms that have been introduced to an ecosystem, either accidentally or intentionally. Through altering ecosystem structures and functions, INNS can have significant negative impacts on the local environment, costing the UK economy around £4bn a year, a 135% increase since 2010[2].

Ponds can harbour a range of aquatic INNS which can create issues for landowners due to the costs involved in managing and removing INNS. Therefore, early detection and prevention is better than eradication.

Being able to identify invasive species before they have established is key to reducing management time and costs.

Invasive aquatic plants can harm ponds, waterways, and the environment. To avoid legal issues and environmental damage, do not intentionally spread these plants outside your property. Even small plant fragments can cause significant problems, so handle pond maintenance and wastewater disposal carefully.

WHAT TO DO IF YOU FIND AN INVASIVE NON-NATIVE SPECIES IN YOUR POND.

If you find an INNS in your pond, follow these steps:

- Positively identify the Species: Confirm the species and that it is indeed invasive and non-native. Consult local guidelines or experts if unsure, and limit Water Net Gain usage until deemed safe for usage.
- Report the Find: Notify local environmental or wildlife authorities. They can provide advice and may coordinate removal efforts.
- Prevent Spread: Avoid transporting the species to other water bodies. Clean equipment and footwear thoroughly if they have been in contact with the area.
- Remove/control the Species: If safe and legal, manually remove the invasive species. You must follow local guidelines for management or disposal, which often involves proper containment and disposal methods to limit spread.
- Monitor and Manage: Regularly check the pond and local watercourses for reoccurrence and take steps to manage any future invasions. Implement preventative measures to reduce the risk of reinvasion.

See the Further Reading section for more helpful resources on INNS.

2. Eschen, R., Kadzamira, M., Stutz, S. et al. An updated assessment of the direct costs of invasive non-native species to the United Kingdom. Biol Invasions 25, 3265–3276 (2023). Freshwater Habitats Trust. Ponds. Online available at:1 Freshwater Habitats Trust. Ponds. Online available at: https://freshwaterhabitats.org.uk/habitats/ponds/

These are the main INNS to look out for when carrying out checks around your pond.

Use iRecord to help identify and log INNS.

NEW ZEALAND PIGMYWEED

Stiff shoots have narrow, parallel-sided leaves in opposite pairs, each 4-24 mm long. Small white flowers on stalk with four petals, bloom in summer above the water. Common and widespread throughout most of England, particularly in the South

FLOATING PENNYWORT

Large, fleshy stalk between lobes of kidney-shaped leaves Free-floating mat or rooted, growing up to 20 cm per day. Common in the southeast of England and spreading across the UK

PARROT'S FEATHER

Feathery leaves around 2cm, bright green, often with a bluish sheen. Partially submerged perennial with delicate, finely divided leaves Well established in Midlands and southern Britain, less common in north

CANADIAN PONDWEED

Fully aquatic with branching stems under 30cm with rounded tip; leaves (<2cm) spiral in groups of 2-4. Roots in mud and produces tiny white or pale purple flowers May to October Common and widespread across UK, spreads easily through fragmenting

NUTTALL'S WATERWEED

Similar to Canadian pondweed; however, has longer leaves (<3.5cm), widest at base and taper to a point. Grows densely in more nutrient-rich conditions. Widespread and abundant throughout UK, but less common than Canadian pondweed

CURLY WATERWEED

Brittle stems entwine up to 3m in length, with strongly curved leaves in spiral arrangement down to the base. Fully aquatic and prefers alkaline (lime rich) water, spread easily through stem fragmentation. Widespread across the UK, more common in mid to southern counties

WATER FERN (AZOLLA)

Dense branched fronds with overlapping bumpy green leaves, later turning reddish in the season. Individually small free-floating plants which forms dense mats, present all year but dies back in winter months. Widespread in low-lying areas across the southern half of the UK

LEAST DUCKWEED

Leaves are flat, 1-2.5 mm long, with pale grey-green surfaces and a translucent, delicate appearance. Possess a single root and vein, with nerve & air cells relative to the frond length Common in slow-moving waterways in Southern UK, some populations in northern counties.

HIMALAYAN BALSAM

Green, hollow stems with red ridges grow up to 2.5 m, grounded by weak, shallow roots Serrated whorled leaves up to 25 cm; flowers are pink to purple and emit a strong odour; mature seed pods pop explosively in summer Commonly abundant across the UK along waterways and in damp shaded places

AMERICAN SIGNAL CRAYFISH

Aggressive lobster-like appearance growing <18 cm, larger than native white claw crayfish, with red claws and a turquoise/white blotch Carapace bluish-brown to reddish-brown, with large orange to red claws. Widespread across the UK, establishes burrows in watercourse banks cause erosion and water quality issues. Not to be mistaken for the protected native white-claw crayfish

POND NETWORKS

IS THERE A BENEFIT TO HAVING MULTIPLE PONDS?

- A network of ponds can provide more functions and more benefits than a singular pond.
- One pond can only provide a certain number of functions before the main functions are diminished.
- Multiple ponds can have varying main functions, such as capturing stormwater, sediment trapping, biodiversity, water storage and deployment, and together they provide a resilient system.
- Most research into pondscapes is about the benefits to biodiversity.
- Whether pond networks also increase resilience of water quality and quantity is less researched.
- The design stage should look at the wider farm and landscape and identify whether there are other opportunities for ponds with varying functions across the landscape.

WATER NET GAIN POND NETWORKS

Water Net Gain's pond networks could be connected, process-driven sequential ponds. Each pond in the network and surrounding habitats are designed to a specific purpose, to fulfil the Water Net Gain objectives. This network can increase residence time of the water running through the system, helping to slow down and filter the water, and making the landscape more spongy. An example could look as follows:

Ponds in marginal areas, set aside for biodiversity, as well as contributing additional water to system

Pond to capture as much water as possible from surrounding land.

Set of ponds connected by drains and swales, to filter any sediment, nutrients or pollutants

Scrapes to capture water and infiltrate into ground

Pond to store water and use when required

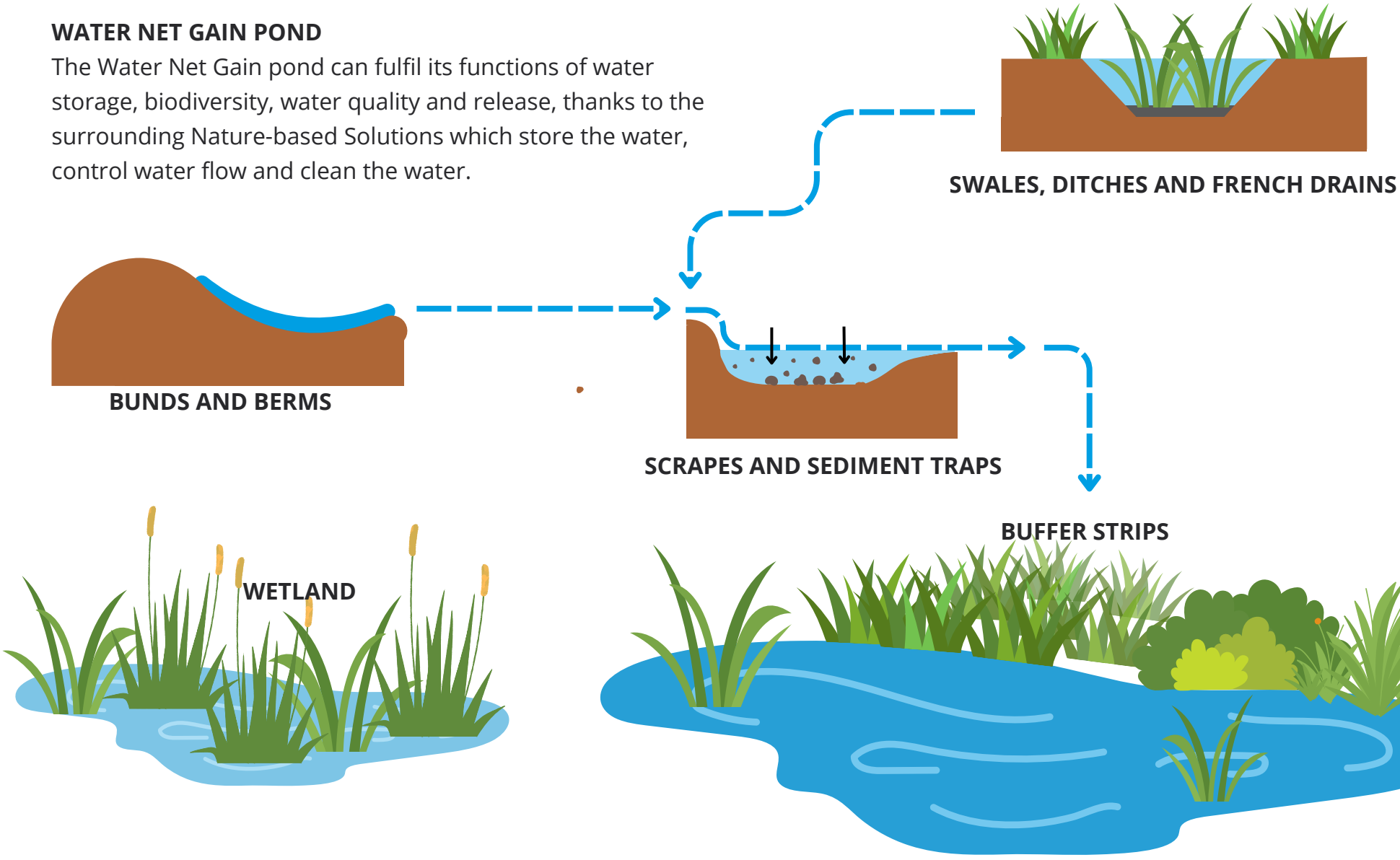
BIODIVERSITY AND PONDSCAPES

- A set of ponds can provide a wider variety of environmental conditions - this can then provide more habitats for different species.
- Networks of smaller ponds support more conservation value than one large pond.
- Higher pond density is associated with greater species richness.
- At a landscape scale, networks of smaller freshwater habitats (pondscapes) would benefit to be located alongside large-scale habitat networks (such as rivers or larger wetlands).
- Pondscapes favour connectivity and dispersal, acting as stepping stones between larger freshwater habitats - while pondscapes are not protected, they can provide resilience to larger habitats protected for nature conservation.

OTHER NATURE-BASED SOLUTIONS

WATER NET GAIN POND

The Water Net Gain pond can fulfil its functions of water storage, biodiversity, water quality and release, thanks to the surrounding Nature-based Solutions which store the water, control water flow and clean the water.



OTHER NATURE-BASED SOLUTIONS

“Ponds are not self-contained systems, but need sympathetically managed buffer zones around them of wetland, rough grass, shrubs, woods and other habitats.”

British Trust for Conservation Volunteers

Other Nature-based Solutions can be utilised in the Water Net Gain pond system, to slow, divert and clean water. Effectiveness of Nature-based Solutions depends on location-specific conditions, such as geology, soil types and topography. Therefore, they need to be assessed and adapted to local conditions.

FIELD MANAGEMENT

In-field vegetation management plays an important role in how water moves through the landscape. Measures such as low density agroforestry and herbal leys can increase soil organic matter and reduce compaction. This helps with infiltration, residence time, and reducing water, soil and nutrient runoff potential.

SWALES, DITCHES AND FRENCH DRAINS

Swales can be used to guide the water from one location to another. They can be implemented instead of pipes where appropriate.

Ditches and swales can include check dams, to slow and filter the water. French drains are another alternative to slow, filter and move water.

BUFFER STRIPS

Buffer strips of tussocky grasses, flowering plants and scrub protect ponds from nutrient leaching and sediment run-off, help improve water quality and provide a habitat for wildlife. Watch out for vigorous plants with underground stems growing at the edge of the ponds with flexible liners, as shoots can come up and puncture liner (e.g. couch grass, bramble, blackthorn, cherry). There is the potential to have some trees in buffer strips, although not on the southern edge of the pond. Light grazing is encouraged to keep the area open and to create bare patches.

SCRAPES AND SEDIMENT TRAPS

Scrapes are shallow depressions, created to store and infiltrate water. They may be a useful side-effect of a claypit excavated for lining a pond. They can also act as sediment trap - a containment area where surface water run-off is temporarily stored to allow sediment to settle out before the run-off is discharged. They are useful as the first of a series of measures improving the longevity and functioning of the downstream structures, such as a pond.

BUNDS AND BERMS

Earth bunds and berms can be constructed from the excavated material from the pond. They can help to guide the flow of water and slow it down.

WETLANDS

Reedbeds, wet woodlands and wet grasslands may naturally occur close to where ponds are installed. These habitats can complement the pond system by storing and filtering water, removing nutrients, as well as providing habitat for a variety of species. They can therefore act as wider buffer areas to ponds as well as provide flood protection and act as a carbon sink. If there is only a small area of wetland, the pond should not be installed in that area, to avoid damaging an already established, valuable habitat.

GHOST PONDS

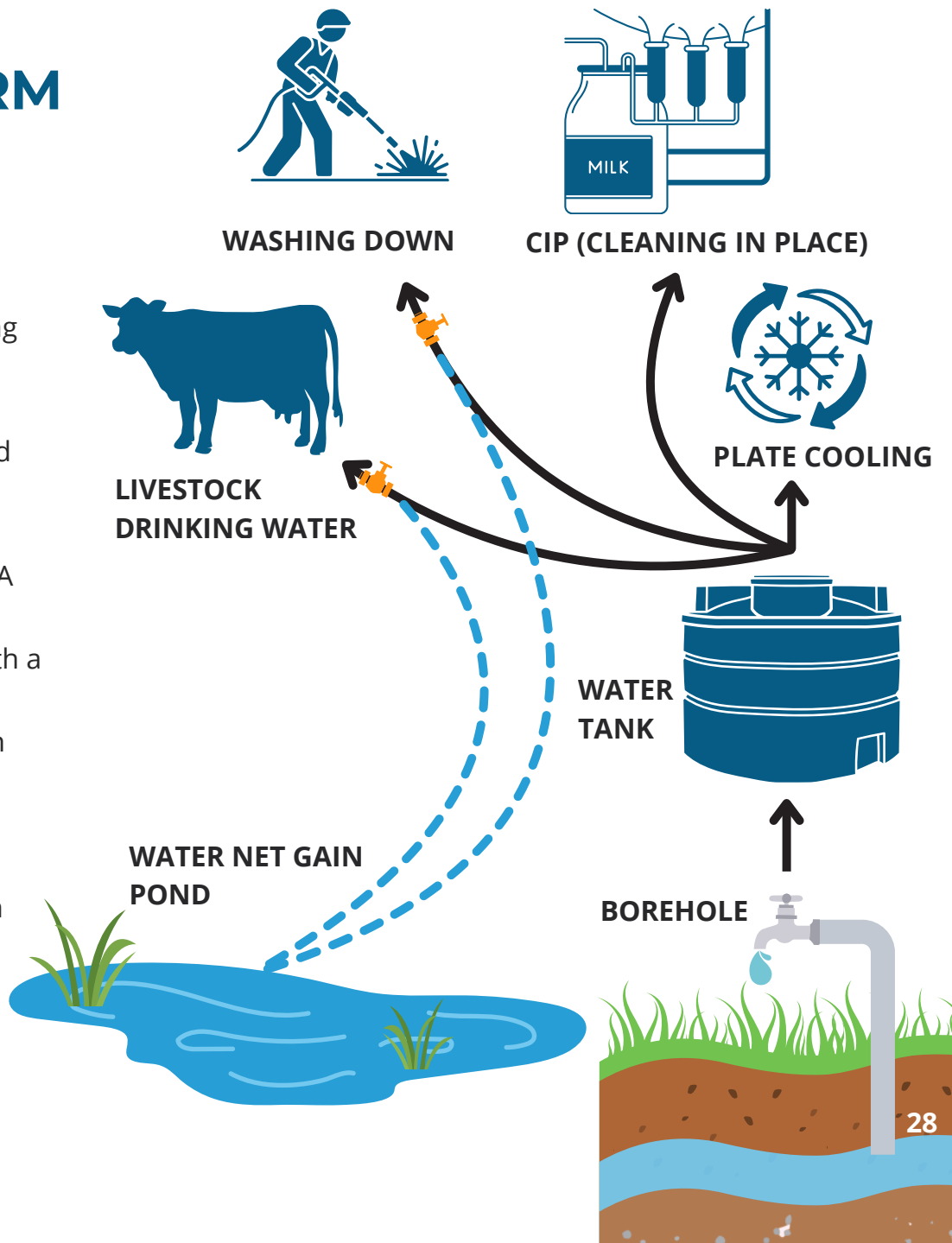
Ponds that have been neglected and silted up, or been filled in and do not contain water anymore, may benefit from restoration. However, they may also be valuable habitats themselves, and restoration may remove an established species community. It needs to be carefully considered whether it is better to restore the ghost pond, or to retain the ghost pond and construct a new pond nearby, which means that the landscape then features two different life stages of ponds, providing more habitat variety for species.

See more about pond restoration in Restoring Norfolk's Ponds Guidance Booklet.

WATER MANAGEMENT INFRASTRUCTURE: ON FARM

EXAMPLE: DAIRY FARM

- The main water needs on a dairy farm are for livestock drinking, washing down activities, cleaning of the milking equipment (CIP) and plate cooling.
- Due to functionality and hygiene requirements, pond water cannot replace borehole/ mains water for CIP and plate cooling.
- The pond water should be fed in at points where the destination is clear, to avoid accidental contamination. A secondary system to supply water in conditions of low water availability will include a pump from the pond with a nozzle and filter, feeding into the pipe infrastructure of the water troughs and potentially for washing down. An isolating switch controls when the pond water is used instead of the borehole water.
- The pond location needs to be considered carefully in relation to the existing water infrastructure on the farm
- Ideally, the water can be gravity-fed from the pond, or there would be access to electricity for the pumps.



NON RETURN VALVE

During periods of low water availability, heat stress is greater for animals, so more drinking water is required and sometimes sprayers are used for cooling down the livestock.

Using pond water instead of borehole water for part of the water demand can reduce the risk of the borehole running dry and it leaves more water in the groundwater system for the environment. This in turn also reduces the risk to having to switch to mains water, reducing cost for the farmer and leaving more water available for the public water supply.

WATER QUALITY SET-UP

To clean the water before use, and to reduce the risk of microbiological contamination, the water system will include ultrafiltration and UV disinfection between the pond and point of use (see figure 1.).
Further recommendations for the design of the water system include:

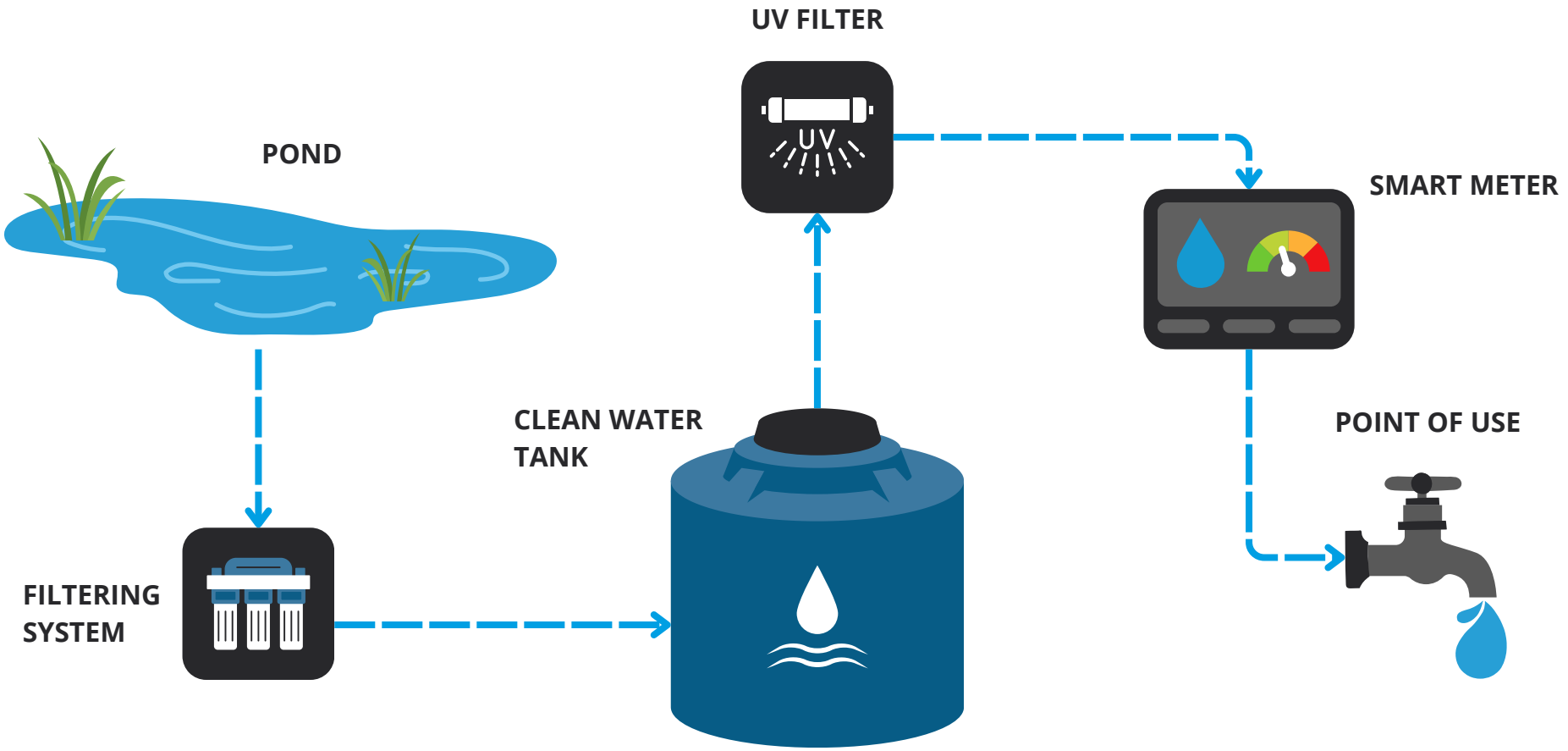
- Non-return valves will be required if the end point is served by both pond water and potable water, to ensure that no back flow of potentially contaminate water could enter the potable water network.
- A smart meter will be installed between the pond and point of use, to identify how much water is used, and when (see figure 1.). This can increase water efficiency by sending alerts when the system is leaking or not functioning well, and the farmer can reliably track the water use.
- Designing the system so that water is not taken from the top 0.3m and bottom 0.6m, where any toxins are most likely to occur (reference A guide on how to harvest rainwater on a farm - Farmers Weekly)
- The store should have a capacity of at least 5% of the annual volume of inflow (if rainwater harvesting, multiply area of roofs/ surface area by annual rainfall (in m)) (reference Milk Development Council (2007), Effective Use of Water on Dairy Farms)

ADDITIONAL WATER EFFICIENCY MEASURES

- Re-use plate cooling water, to minimise wasting water.
- Use ballcocks on the water troughs to ensure efficient water use.

A **Water Audit** can help to identify water need and potential water and cost savings.

Figure 1: Water treatment process for a Water Net Gain pond based on information from Disinfection of Rainwater for Economic Purposes.[3]



For a similar setup in a rainwater harvesting system, see https://rainharvesting.co.uk/wp-content/uploads/2018/10/Dairy-Farm-case-study.pdf

3. Zdeb, M., & Papciak, D. (2023). Disinfection of Rainwater for Economic Purposes. Sustainability, 15(22), 16121. https://doi.org/10.3390/su152216121

WATER MANAGEMENT INFRASTRUCTURE: OFFSITE DEPLOYMENT

GROUNDWATER SUPPLY POND

When planning a supply pond, the following should be considered: **(Bold = essential,** not bold = recommended)

- **Location close to a watercourse**
- **Opportunity for several supply ponds within the same river stretch**
- **Within catchments with river abstraction, or groundwater abstraction affecting river flows**
- Location above a catchment with combined sewers and known combined sewer overflow spills
- Within catchments with issues maintaining a suitable Environmental Flow Index due to abstraction pressures
- Within catchments where water company reservoirs are small and have limited upstream water sources
- Above water-dependent sensitive habitats
- Above fish spawning locations

The design should include:

- A **monitoring structure to measure water level**, plus a **remotely controlled outlet** to release water at specific outflow rates
- Potential for higher freeboard or pre-storm release in winter, to support flood management
- **Risk reduction measures to prevent watercourse pollution** - outflow to either follow the groundwater supply pond design (see next page), or pass through a French drain to aerate water and reduce residual sediment loading. Outlet pipe positioned at mid-depth within the pond.

DISCHARGE CONSIDERATIONS:

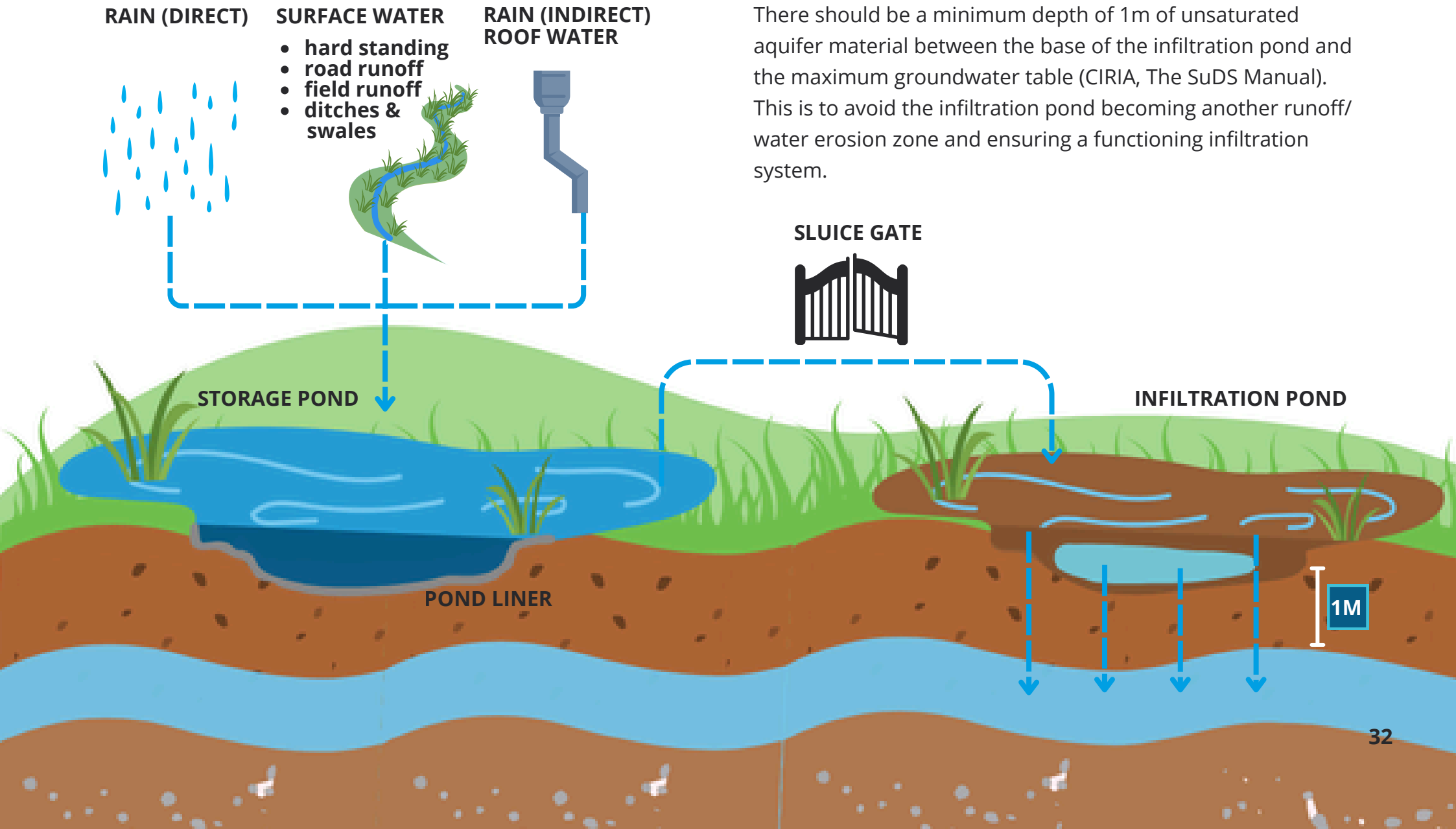
Permit Requirement: A discharge permit is required if polluted water enters a watercourse.

Potential pollution sources:

- High temperatures and low dissolved oxygen concentrations (summer months)
- Excessive nutrients from agricultural run-off contaminated with animal waste
- Excessive nutrient or chemical build up from sewage sludge applications on surrounding fields
- Algal blooms from uncontrolled nutrients
- High concentration of suspended solids from recently ploughed fields
- Pesticide pollution from recently treated/sprayed areas
- Spreading invasive species

→ **Design and management plans must demonstrate effective control of these risks, to avoid discharge permit requirements.**

GROUNDWATER SUPPLY POND

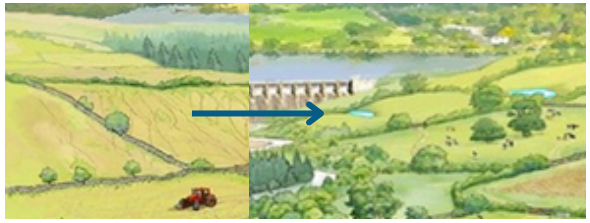


CONSIDERATIONS

There should be a minimum depth of 1m of unsaturated aquifer material between the base of the infiltration pond and the maximum groundwater table (CIRIA, The SuDS Manual). This is to avoid the infiltration pond becoming another runoff/ water erosion zone and ensuring a functioning infiltration system.

BENEFITS

The Water Net Gain pond system as a Nature-based Solution to climate resilience is designed to provide multiple benefits to nature and society.

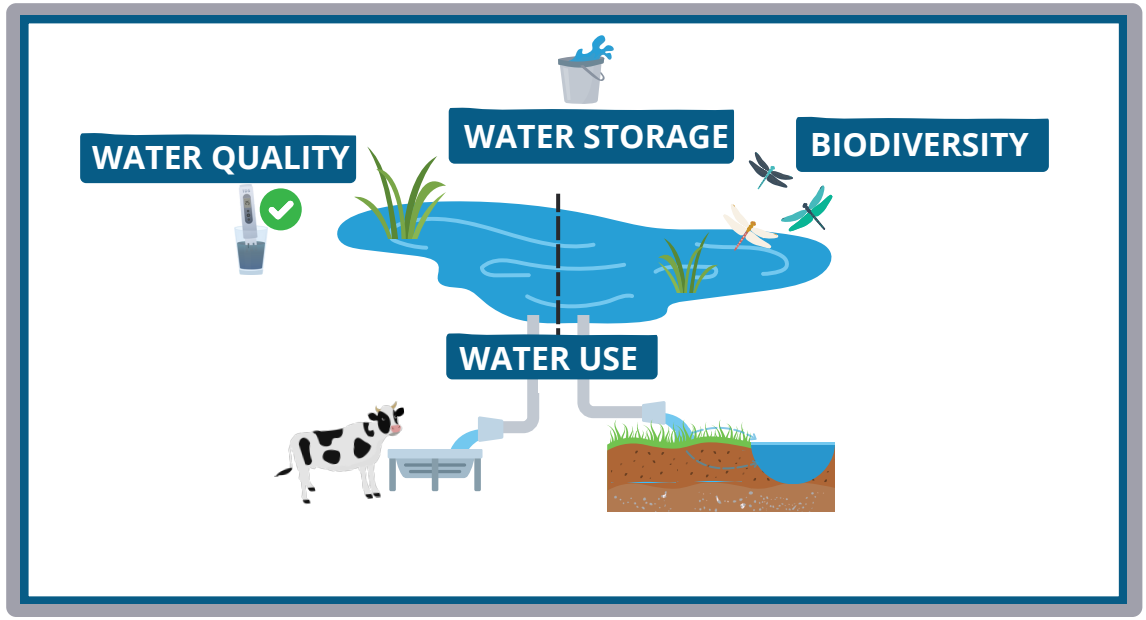


CULTURAL EFFECTS

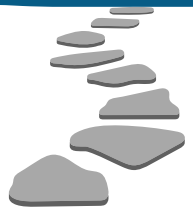
NUTRIENT MANAGEMENT

13 CLIMATE ACTION

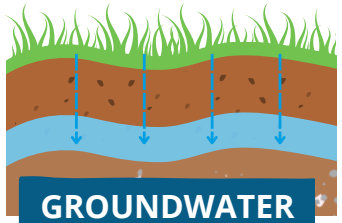
CLIMATE RESILIENCE



HABITAT STEPPING STONES



PROVISION OF ECOSYSTEM SERVICES



GROUNDWATER RECHARGE

FLOOD RESILIENCE

EDUCATION

LANDSCAPE AESTHETICS

CORE BENEFITS

- Water storage – Providing water in periods of low water resource availability.
- Water use – Using stored water for the benefit of farms and river ecosystems.
- Water quality – Improving water quality through interception and cleaning of water.
- Biodiversity – Contributing to a healthy ecosystem on the farm.

CO-BENEFITS

- Climate resilience – Water security will become more critical in the future due to climate change and drier summer periods. Water Net Gain as a project between farmers and water companies can benefit the resilience of food production as well as drinking water supply in a changing climate for the benefit of society and nature.
- Groundwater recharge – Pond systems slow down water which means that more water can infiltrate into soils and into aquifers.
- Habitat stepping stone – Ponds can provide valuable stepping stones for biodiversity depending on freshwater habitats in a fragmented and intensive agricultural landscape.
- Flood resilience – The implementation of pond systems can slow down water, and therefore reduce flood risk downstream.
- Education – There is a potential for Water Net Gain ponds to be used as educational tools, to connect local populations such as schools with farming, food production as well as climate change and resilience.
- Landscape aesthetics – Ponds which are designed to fit into the local landscape can improve the aesthetics of the landscape and in doing so, improve the agri-tourism value.
- Provision of ecosystem services – There is a potential for increased pollination in agricultural land which is linked to ponds, which can result in improved crops[4].
- Nutrient management – Pond systems can help with nutrient management, through capturing nutrients which could otherwise enter watercourses downstream.
- Cultural effects – The creation or restoration of ponds can restore historic farming practices and farm landscapes which have been lost.

4. Rebecca I.A. Stewart, Georg K.S. Andersson, Christer Brönmark, Björn K. Klatt, Lars-Anders Hansson, Valentina Zülsdorff, Henrik G. Smith, Ecosystem services across the aquatic–terrestrial boundary: Linking ponds to pollination, Basic and Applied Ecology, Volume 18, 2017, Pages 13-20, ISSN 1439-79, at: https://www.sciencedirect.com/science/article/pii/S143917911630161X

TRADE-OFFS

Water Net Gain aims to create multifunctional pond systems, with the aim to both increase water storage in the landscape and increase biodiversity hotspots on farmland.

However, there are trade-offs when providing both water storage and biodiversity functions in one pond.

WATER STORAGE TRADE-OFFS

- Various shapes and depths as well as islands are valuable for biodiversity, but reduce water storage potential.
- A higher surface area due to varying pond shapes causes more evaporation loss in summer.
- Vegetation roots at pond edges can potentially puncture pond lining and reduce water storage potential.

BIODIVERSITY TRADE-OFFS

- Protected species such as Great Crested Newts are not encouraged, as that would restrict the water use potential for Water Net Gain.
- A natural succession is not intended, and management of the pond will be required to ensure consistent water storage potential.
- It is likely that mostly marginal areas on farmland are chosen as pond locations, these are often already the most biodiverse areas on a farm.
- To store enough water, the pond will need to be quite deep, which is not required for biodiversity purposes.
- Smaller, diverse ponds are most beneficial for biodiversity. While Water Net Gain will encourage a pond system, the main element will need to be at least one bigger, deeper pond for water storage.
- A pond location might be considered in areas with higher nutrient loading due to intended use or water supply, e.g. close to a farmyard. This could reduce biodiversity and water quality values.

SOCIAL TRADE-OFFS

- It is most likely that there will be a positive visual impact from the pond creation, however if the pond system is not maintained or the water quality deteriorates, there may be a negative visual impact.
- Near public footpaths, the pond could increase the recreational/enjoyment value of the landscape. However, this might also introduce trespassing or public safety risks.

Figure 2. shows how many times a certain ecosystem service has been an objective for pond creation or management. Generally, most ponds are created and managed for biodiversity.

This means that there is not much knowledge about the benefits and trade-offs of ponds managed for biodiversity as well as water quality and quantity[5]. Water Net Gain has the opportunity to contribute to this knowledge gap. The design suggestions in this report may need to be revised following lessons learnt in practice.

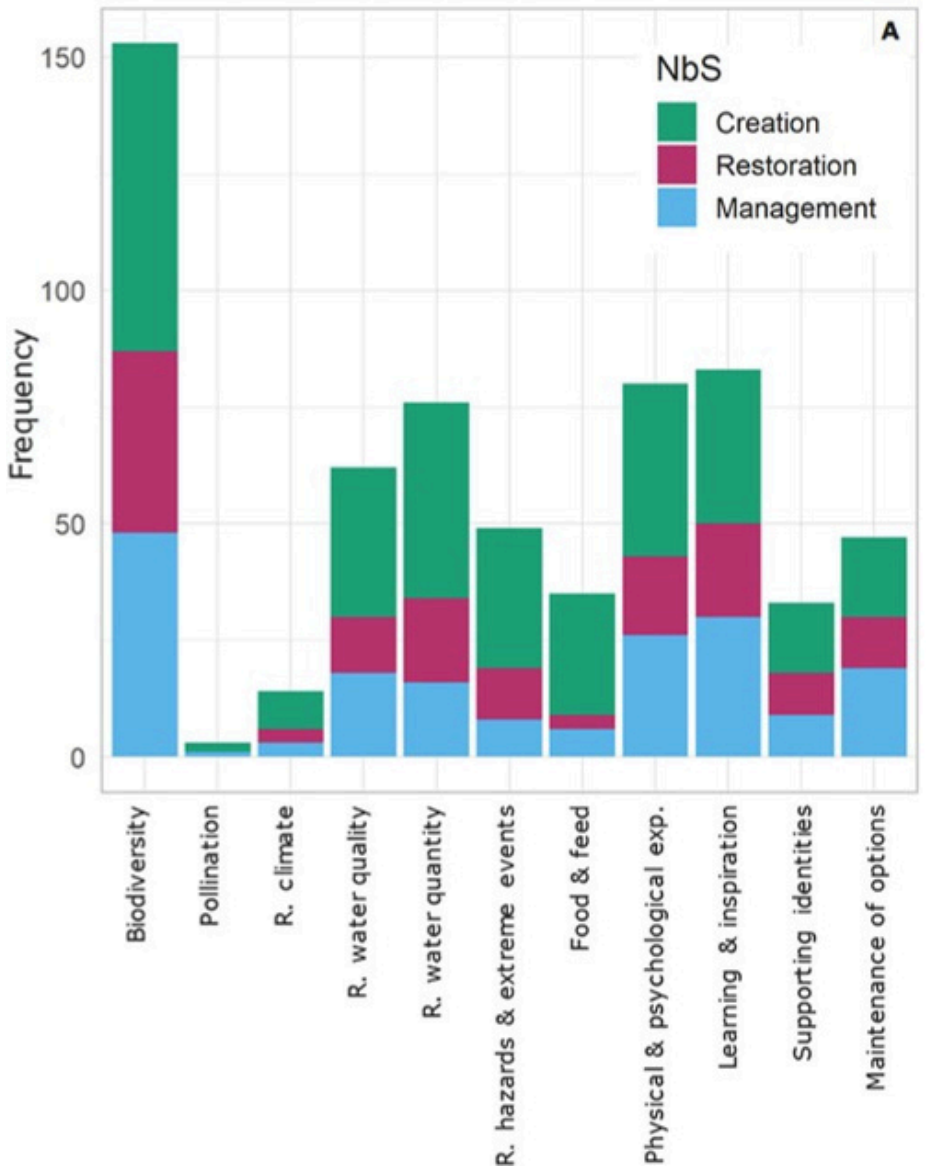


Figure 2. Frequency of each of the 11 Nature Contributions to People selected as objective for each of 183 NbS measures in ponds/pondscapes[5].

5. Mireia Bartrons, Carolina Trochine, Malgorzata Blicharska, Beat Oertli, Manuel Lago, Sandra Brucet, Unlocking the potential of ponds and pondscapes as nature-based solutions for climate resilience and beyond: Hundred evidences, Journal of Environmental Management, Volume 359, 2024, 120992, ISSN 0301 4797, at: https://www.sciencedirect.com/science/article/pii/S0301479724009782

CONSTRUCTION

REGULATIONS

The Construction (Design and Management) Regulations (CDM Regulations)[6] need to be followed when moving quantities of soils, therefore they apply to pond projects. The CDM Regulations aim to help ensure that construction projects are safe to build, safe to use, and safe to maintain.

KEY ELEMENTS TO SECURING CONSTRUCTION HEALTH AND SAFETY

4 They key elements include:
(a) managing the risks by applying the **general principles of prevention;**
(b) **appointing** the right people and organisations at the right time;
(c) making sure everyone has the **information, instruction, training and supervision** they need to carry out their jobs in a way that secures health and safety:
(d) duty holders **cooperating and communicating** with each other and **coordinating** their work; and
(e) **consulting workers and engaging** with them to promote and develop effective measures to secure health and safety and welfare.

6. Health and Safety Executive. The Construction (Design and Management) Regulations 2015, at: https://www.hse.gov.uk/construction/cdm/2015

CONSTRUCTION TIMINGS

- Summer is the best time for construction, as access is usually better, the ground is not wet and it is easier to control the earthworks.
- Bird nesting season is typically between February and August. If the works take place in that timeframe, and vegetation needs to be removed for the construction, a pre-works survey needs to be conducted by a competent person, to ensure no birds or nests are disturbed or destroyed.
- Excavation is best done during spells of dry weather, to prevent ground damage by machinery. The operator should check the ground conditions before works start, to lessen the chance of machines getting stuck.

CONSTRUCTION STEPS

- If there is a risk of utilities in the location of the excavation, a CAT and Genny scan should be conducted before starting the excavation.
- Strip the topsoil from the pond area as well as the embankments. Always sort topsoil and subsoil and store them separately. Topsoil should not be used for the pond construction, but it can be used elsewhere as it has valuable nutrients for the farm.
- Use the subsoil to prepare the pond size and shape. The subsoil can also be used to build an embankment if the pond is built on a gradient, with a small dam as the lower border of the pond.
- Use surplus subsoil to create different depths to the pond bed and to sculpt a varied shoreline. Also create other Nature-based Solutions as part of the pond system (see p. 25 and 26 on NbS).
- If there is still surplus soil and it needs to be transported offsite, a Waste Transfer Note would be required.
- Don’t deposit any soil in floodplains.

The Freshwater Habitats Million Ponds Project fact sheet provides great advice on construction aspects such as site management, machinery and spoil management.

Be vigilant for old land drains. If found, they need to be blocked or diverted, to prevent the pond from draining.

MONITORING

WATER STORAGE

Water Net Gain ponds will be able to show the amount of water stored at any one time, to show how much is stored and available for use.

The newly dug pond will be measured to identify area as well as depth. This will show the maximum pond water volume and therefore the maximum water storage potential.

A level sensor will be installed at the pond which monitors the pond water level.

Software displays the pond water level continuously. This information will be available for all Water Net Gain stakeholders.

The water level information will be used to calculate the current water volume in the pond, using the water level data as well as the maximum pond water volume.
This will be the dashboard informing water use/ deployment decisions.

MONITORING AND MAINTENANCE

Water Net Gain ponds will show current waters levels, indicating how how much is stored and available for use.

MONITORING

Regular monitoring of the pond system and technology is important to identify how well it is working, as well as potential issues. This can then help to make management decisions.

HABITAT MANAGEMENT

General recommendations:

- It's better to do a small amount of management each year rather than large-scale operations after long intervals of neglect.
- The management of the surrounding habitats is an integral part of the pond system management.

Pond vegetation:

- Remove vegetation if most of the pond surface is covered.
- If algae cover the pond, identify pathways of nutrients into the pond and adapt your system to have less nutrients entering the pond.

Tree and scrub management:

- Cut back/ coppice/ pollard scrub and trees that are taking over in rotation, where shade percentage of the pond is too high - especially leave the southern side of the pond open to sunlight. A small amount of shade on the pond can be beneficial.

Sediment removal:

- If the pond is silting up and terrestrial plants are encroaching the pond, the sediment might need to be removed from the pond bed. No more than 50% of the pond bed should be disturbed in any one year.
- The dug-up substrate can be used as fertiliser on agricultural land.

Fencing and grazing:

- Intermediate grazing intensity or mowing is preferable, and limited access by livestock can be beneficial.
- Livestock trampling can damage pond lining, so grazing should be avoided if the pond is lined.
- If the stocking density of the surrounding land is high, then the pond should be fenced off and the buffer strips managed with mowing.
- The best time to graze or mow the pond buffer area is late summer.
- It is important to comply with the Farming Rules for Water, which means appropriate management measures such as no fertilising and livestock feeders within 10m of each pond system.

Adapt the draft monitoring and management plan in Appendix III to work for your pond system.

COST CONSIDERATIONS

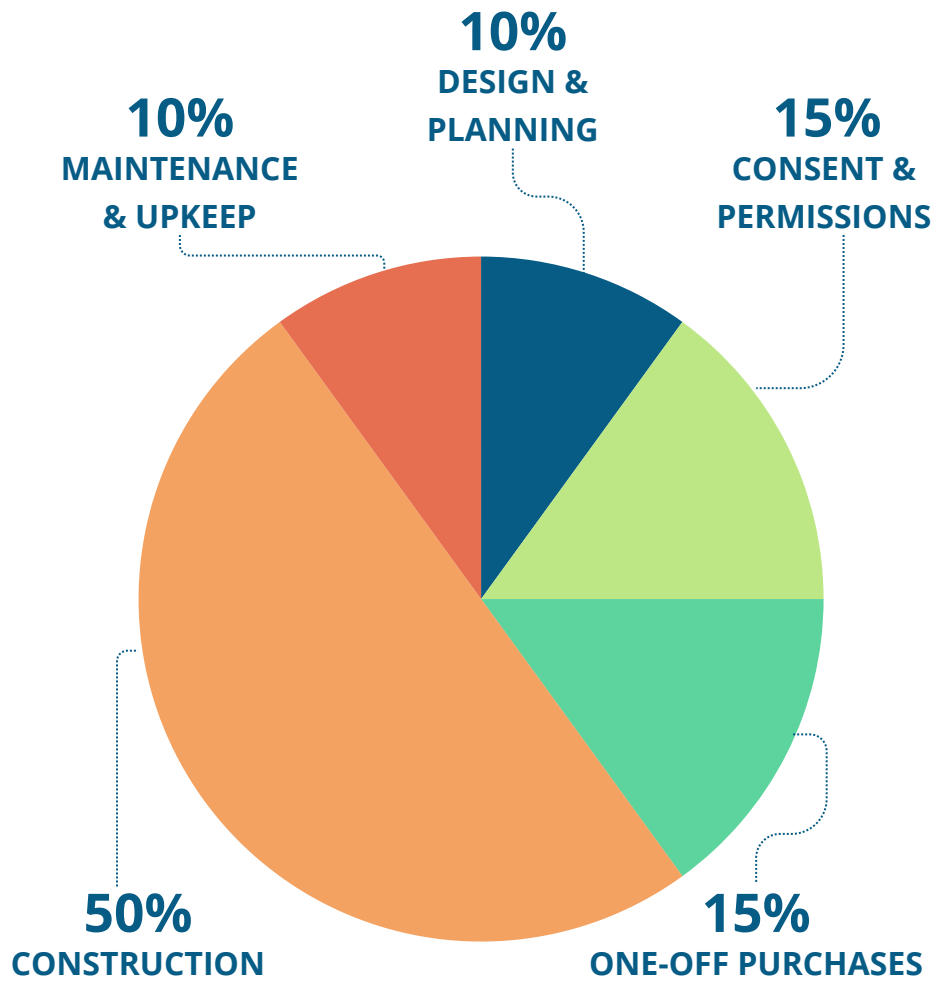
Costs for pond design and construction depend on many factors, such as site location, size and depth of the pond, soil type, required infrastructure, and environmental considerations, among others.

Use the Pond feasibility tool in Appendix IV to get a first understanding of potential risk and cost implications at your chosen site.

To ensure an accurate and thorough cost estimate, meticulous planning is essential. This involves breaking down the expected ball-park figures for each phase of the project, from initial planning/ design (10%) to construction (50%) and long-term upkeep (10%).

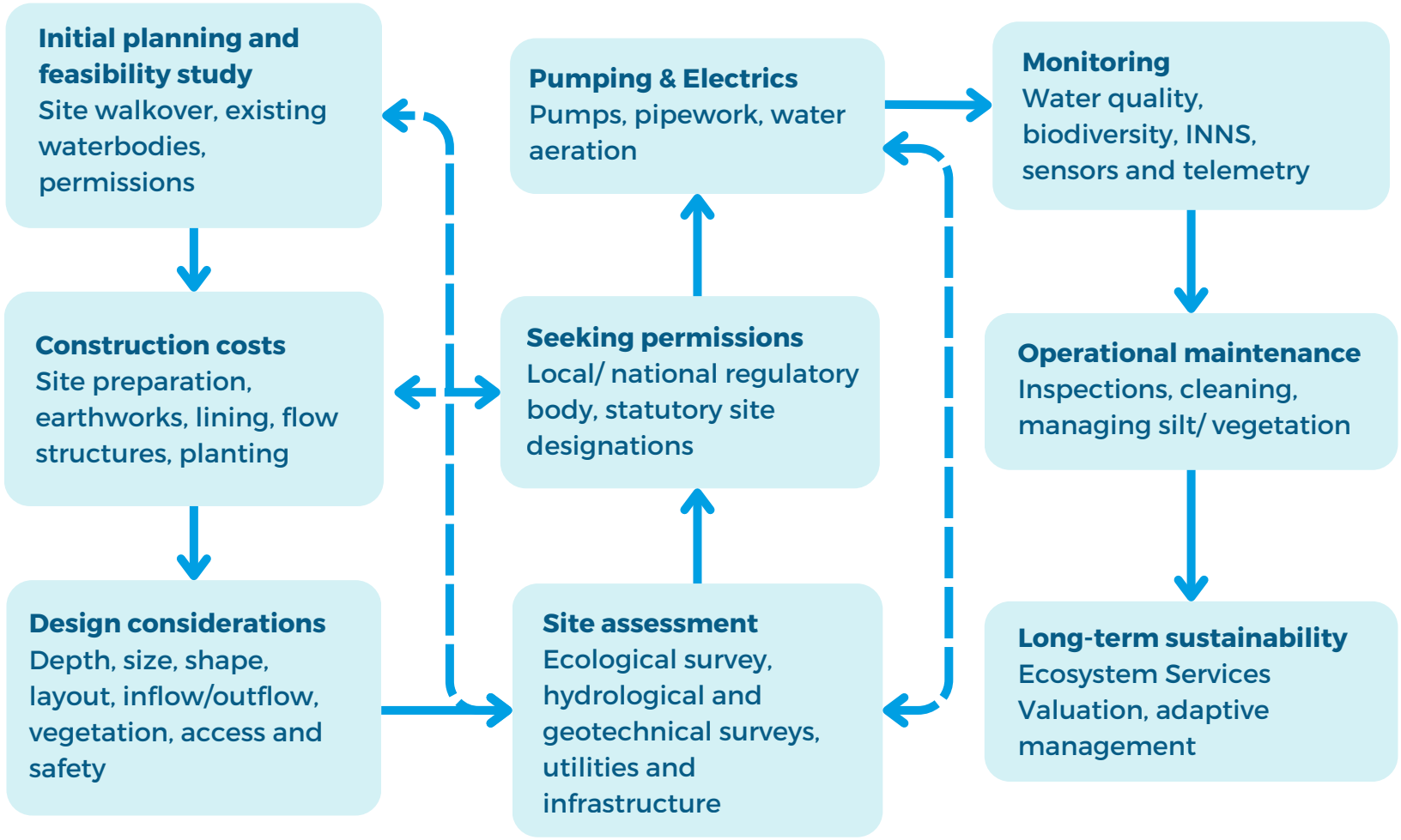
Once the planning, permissions/ consents (15%) and design stages are complete, it is worth setting aside a contingency budget to cover unexpected expenses (15%) which may occur during construction and post-work[7].

COSTS ASSOCIATED WITH POND CREATION



7. Ecologic Institute. 2024. Cost-benefits indicators linked to the DEMO-sites, at: https://dataportal.ponderful.eu/dataset/cba-data-linked-to-demo-sites

Use the graphic below to develop a project timeline, including phases for design, construction, and post-construction monitoring and maintenance. plan for financing options, grants, or funding from government agencies, environmental organisations or private investors.



COMPREHENSIVE PLANNING AND COST BREAKDOWN

INITIAL PLANNING PHASE

Conduct site assessments, feasibility studies, ecological surveys, and obtain necessary permits. Include costs for legal fees and stakeholder consultations. The cost of these surveys depends on the site location and size, as well as the number of buildings, trees, ponds, and watercourses involved.

DETAILED DESIGN PHASE

Account for hiring professionals such as engineers and ecologists, for designing inflow/outflow structures, pond lining, and landscaping. Prepare maps, design drawings/ illustrations, Risk Assessment Method Statement (RAMS) on how to safely carry out the proposed work. This phase may require you to go back over the planning and permissions phase until an agreement is reached.

CONSTRUCTION PHASE

Estimate costs for earthworks, materials, lining, and building structures. Consider site access and potential difficulties. Identify and plan for potential risks such as weather, regulatory changes, and construction delays.

The cost of this phase varies based on factors such as the size, shape, depth, vegetation, fencing and required infrastructure. Contractors may be needed to construct the pond, but it is also possible to complete the work in-house if the necessary equipment is available. If contractors are used, request a fixed price rather than hourly for the entire project to avoid unexpected expenses.

POST-CONSTRUCTION PHASE:

Regularly monitor the ponds and adapt management strategies as needed to address issues and optimise benefits. Account for:

- Long-term maintenance costs such as sediment removal and vegetation management.
- Costs for monitoring of water quality, biodiversity, water storage and release.
- This may include cost of machinery hire, waste disposal, monitoring equipment and general repairs.

CASE STUDIES

PORSHAM FARM – CASE STUDY OF A WHOLE-FARM WATER APPROACH

THE CHALLENGE: WHEN THE WATER SUPPLY RUNS LOW

- Porsham Farm is located north of Plymouth in the Tamar catchment.
- Natural springs dry out in summer, and the limited mains water supply is insufficient for a dairy farm in extremely dry periods of the year.
- Water availability runs low, just when dairy cattle need water the most – around 175,000 litres per week for drinking alone, plus additional water for cleaning the yard, and operations in the dairy parlour.
- Water availability is a limiting factor on the farm during the summer months.

THE SOLUTION: WORKING WITH NATURE, NOT AGAINST IT

Farmers Will and Tanya have decided to look at the whole farm and introduce water management techniques to slow and store water. This includes:

Rainwater harvesting

Collecting rainwater from roofs into drinking troughs.

Swales and berms

To channel the water away from tracks, and from the primary runoff pathways. The berms in their silage fields are designed to be only gently sloping so that a mower can still mow the grass on top of the berm. Therefore, no land has been lost from silage production (Photo A).

Keyline design and contour ploughing

To slow, intercept and distribute water across the landscape. Keyline ploughing redistributes water across elevation curves in the landscape through ploughing paths for the water to run up on higher elevations instead of gathering in the valleys.[8]

Ponds

To hold water during high rainfalls, and to store spring water even when the spring has dried out (Photo B).

A new swale and berm system acts like a funnel, directing surface water runoff into a specially designed pond during periods of heavy rainfall (Photo C). By capturing and temporarily storing this water rather than letting it flow straight downstream, the system helps prevent flooding in the valley below. The stored water could be made available for farm use with minor modifications to the current design.

8. Emma Li Johansson, Sara Brogaard, Lova Brodin, Envisioning sustainable carbon sequestration in Swedish farmland, Environmental Science & Policy, Volume 135, 2022, Pages 16-25, ISSN 1462-9011. https://doi.org/10.1016/j.envsci.2022.04.005.

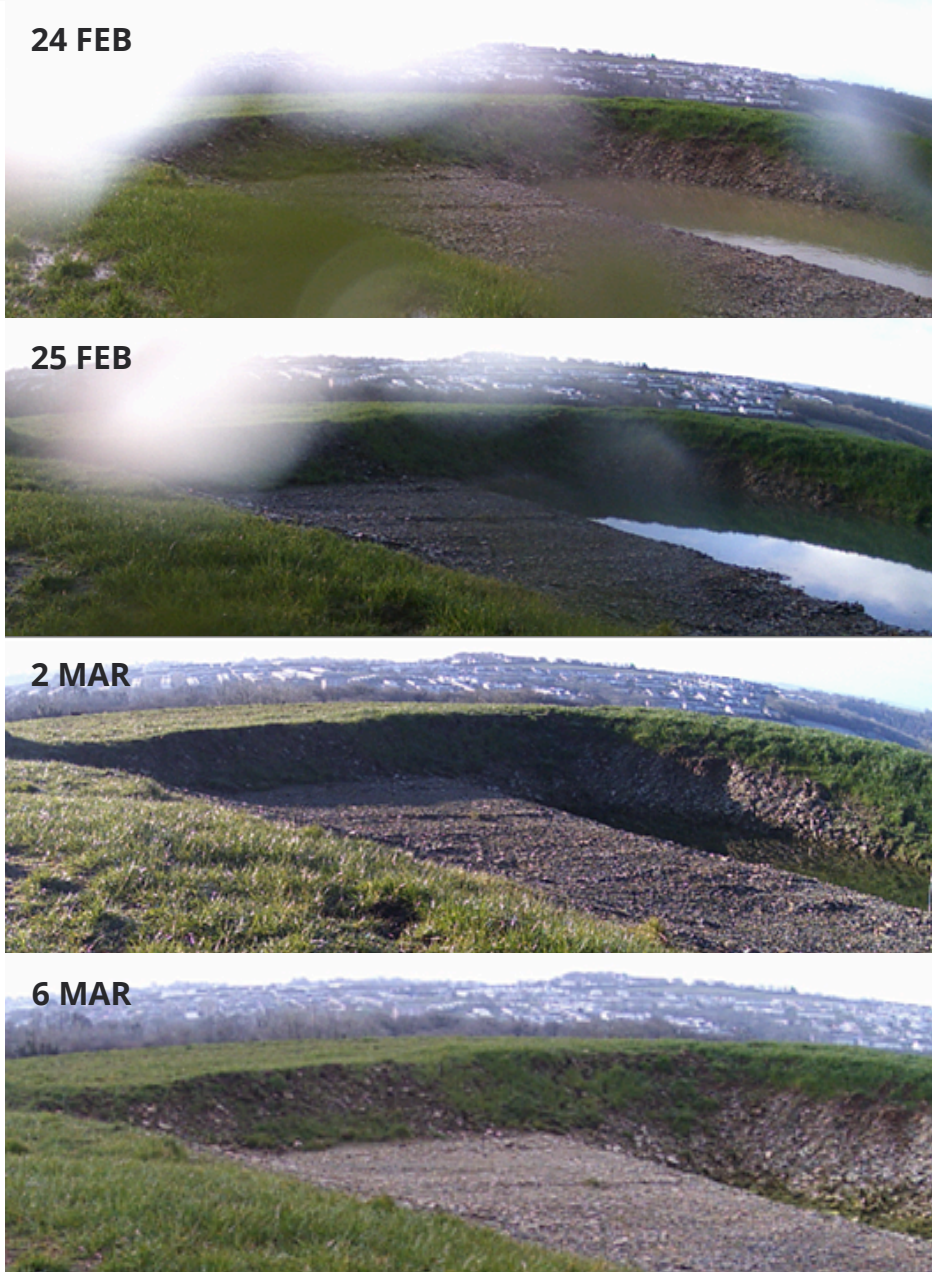
EARLY RESULTS: SEEING WATER MANAGEMENT IN ACTION

As part of our initial monitoring setup, we installed a simple timelapse camera— and it's already revealed some fascinating things about how ponds interact with rainfall and surface water runoff.

Here's what we've seen so far:

- **22 FEB**: A rainfall event.
- **24 FEB**: The pond captures water loaded with sediment.
- **25 FEB**: Sediment settles out, improving water quality.
- Over the next 12 days, the pond **slowly releases** the water back into the ground — instead of letting it run off immediately.
- **6 MAR**: The pond is dry again — having stored and filtered about **64,000 litres** of water!

This pond sits on freely-draining soils, meaning it's temporary and designed to **infiltrate water slowly**, not hold it forever. With further monitoring tools — like level sensors, telemetry, and knowing the pond's shape — we can track exactly how much water is being intercepted.



FURTHER READING

There are many more great resources to get inspired when planning to build a pond. Here is a selection of useful websites and guidance documents:

- **Suffolk Wildlife Trust** – Pond restoration and management, at: https://www.suffolkwildlifetrust.org/pond-restoration-and-management
- **Scotland's centre of expertise for water** – Rural Sustainable Drainage Systems, A Practical Design and Build Guide for Scotland's Farmers and Landowners, at: https://www.crew.ac.uk/sites/www.crew.ac.uk/files/sites/default/files/publication/Rural%20SuDS%20Design%20and%20Build%20Guide%20December%202016.pdf
- **Department for Environment, Food and Rural Affairs** – Create ponds and lakes, at: https://defrafarming.blog.gov.uk/create-ponds-and-lakes/
- **Department for Environment, Food and Rural Affairs** – Maintain and enhance ponds and lakes, at: https://defrafarming.blog.gov.uk/maintain-and-enhance-ponds-and-lakes/
- **Freshwater Habitats Trust** – Pond Creation Toolkit, at: https://freshwaterhabitats.org.uk/advice-resources/pond-creation-hub/pond-creation-toolkit/
- **Freshwater Habitats Trust** – Advice and Resources, at: https://freshwaterhabitats.org.uk/advice-resources/
- **Farming for Nature** – Building a Wildlife Pond on your Land, at: https://www.farmingfornature.ie/your-farm/resources/best-practice-guides/building-a-wildlife-pond-on-your-land/
- **Norfolk Wildlife Trust** – Norfolk Ponds Project, at: https://www.norfolkfwag.co.uk/wp-content/uploads/2016/02/NPP-Restoring-Norfolks-Ponds-Guidance-booklet.pdf
- **UCL and Freshwater Habitats Trust** – Guide to the restoration, creation and management of ponds, at: https://farmwildlife.info/wp-content/uploads/2024/01/UCL_FHT_pond_conservation_guide.pdf
- **Ponderful** – Publications, at: https://ponderful.eu/publications/

- **Rural Payments and Services** – Supporting guidance for Pond Creation for Wildlife, at: https://www.ruralpayments.org/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/pond-creation-for-wildlife/guidance-for-pond-creation-for-wildlife/guidance-for-pond-creation-for-wildlife.pdf
- **Natural England** – Illustrated to ponds and scrapes (TIN079), at: https://publications.naturalengland.org.uk/publication/23020
- **Rural Payments Agency and Natural England** - WN5: Pond management (less than 100 square metres), at: https://www.gov.uk/countryside-stewardship-grants/pond-management-first-100-sq-m-wn5
- **Rural Payments Agency and Natural England** - WN6: Pond management (more than 100 square metres), at https://www.gov.uk/countryside-stewardship-grants/pond-management-areas-more-than-100-sq-m-wn6
- **Environment Agency** - Screening for Intake and Outfalls: a best practice guide Science Report SC030231, at: https://assets.publishing.service.gov.uk/media/5a7c9293ed915d6969f45d2d/scho0205bioc-e-e.pdf
- **UK Gov Environment Agency** - UK guidance on managing INNS and their impact on water environments, at: https://www.gov.uk/guidance/prevent-the-spread-of-harmful-invasive-and-non-native-plants
- **NNSS** - GB Non-native Species Secretariat (NNSS) - provides information and support for managing non-native species in Britain, at: https://www.nonnativespecies.org/legislation/england-and-wales/
- **The Wildlife Trusts** - local wildlife trusts in managing and reporting these species at: https://www.wildlifetrusts.org/
- **Scottish Natural Heritage** - invasive species management in Scotland and coordinates regional efforts, at: https://www.nature.scot
- **Invasive Species Scotland** - Managing INNS in Scotland, offering resources and advice for identification and control, at: https://www.invasivespecies.scot
- **Westcountry Rivers Trust** - Best Practice, at: https://wrt.org.uk/our-work-3/activities/land/

PHOTO CREDITS

The information below provides photo credits for the Invasive Non-Native Species (INNS) shown on pages 21,22

Photo credits:
American Signal Crayfish – Credit: By Astacoides - Own work, CC BY-SA 3.0.
https://commons.wikimedia.org/w/index.php?curid=25113795
Himalayan Balsam – Credit: CABI
Least Duckweed – Credit: By Gordon Leppig & Andrea J. Pickart.
http://www.fws.gov/humboldtbay/plantguide/genus/lem_min_1.html, Public Domain,
https://commons.wikimedia.org/w/index.php?curid=4068171
Water Fern (Azolla spp.) – Credit; By Kurt Stüber [1] - caliban.mpiz-koeln.mpg.de/mavica/index.html part of www.biolib.de This specific image can be found at [Junwer29 here]., CC BY-SA 3.0.
https://commons.wikimedia.org/w/index.php?curid=6070
Curly Waterweed – Credit: By Dr Mary Gillham Archive Project - Lagarosiphon major. Howardian, 1992, CC BY 2.0.
https://commons.wikimedia.org/w/index.php?curid=86569960
Nuttall's Waterweed – Credit: By Christian Fischer, CC BY-SA 3.0
https://commons.wikimedia.org/w/index.php?curid=15559437
Canadian Pondweed – By Christian Fischer, CC BY-SA 3.0.
https://commons.wikimedia.org/w/index.php?curid=15478526
Parrot's Feather (myriophyllum aquaticum) – Credit: Forest & Kim Starr - CC BY 4.0
Floating pennywort – Credit: CABI
New Zealand Pigmyweed – Credit: By ashley BALSAM baz - Flickr, CC BY 2.0.
https://commons.wikimedia.org/w/index.php?curid=21022252

APPENDICES

APPENDIX I REFERENCES

As in footnotes throughout text

1. Freshwater Habitats Trust. Ponds. Online available at:1 Freshwater Habitats Trust. Ponds. Online available at: https://freshwaterhabitats.org.uk/habitats/ponds/
2. Eschen, R., Kadzamira, M., Stutz, S. et al. An updated assessment of the direct costs of invasive non-native species to the United Kingdom. Biol Invasions 25, 3265–3276 (2023). https://link.springer.com/article/10.1007/s10530-023-03107-2
3. Zdeb, M., & Papciak, D. (2023). Disinfection of Rainwater for Economic Purposes. *Sustainability*, *15*(22), 16121. https://doi.org/10.3390/su152216121
4. Rebecca I.A. Stewart, Georg K.S. Andersson, Christer Brönmark, Björn K. Klatt, Lars-Anders Hansson, Valentina Zülsdorff, Henrik G. Smith, Ecosystem services across the aquatic–terrestrial boundary: Linking ponds to pollination, Basic and Applied Ecology, Volume 18, 2017, Pages 13-20, ISSN 1439-79, at: https://www.sciencedirect.com/science/article/pii/S143917911630161X
5. Mireia Bartrons, Carolina Trochine, Malgorzata Blicharska, Beat Oertli, Manuel Lago, Sandra Brucet, Unlocking the potential of ponds and pondscapes as nature-based solutions for climate resilience and beyond: Hundred evidences, Journal of Environmental Management, Volume 359, 2024, 120992, ISSN 0301 4797. https://www.sciencedirect.com/science/article/pii/S0301479724009782
6. Health and Safety Executive. The Construction (Design and Management) Regulations 2015. Online available at: https://www.hse.gov.uk/construction/cdm/2015
7. Ecologic Institute. 2024. Cost-benefits indicators linked to the DEMO-sites. Online available at: https://dataportal.ponderful.eu/dataset/cba-data-linked-to-demo-sites
8. Emma Li Johansson, Sara Brogaard, Lova Brodin, Envisioning sustainable carbon sequestration in Swedish farmland, Environmental Science & Policy, Volume 135, 2022, Pages 16-25, ISSN 1462-9011. https://doi.org/10.1016/j.envsci.2022.04.005.

APPENDIX II POND DESIGN FISH SCREENING

CONSIDERATION FOR FISH

Operators of water intakes and outfalls have legal responsibilities where there is a risk to fish through impingement and/or entrainment. This may be relevant when designing and creating smart ponds.

Diadromous fish are migratory fish species that spend part of their lives in both freshwater and saltwater environments and they migrate upstream and downstream to complete life cycles and are particularly at risk of entrainment.

Eels are a protected species and often get accidently drawn into water intakes and outfalls. Adult silver eels are particularly vulnerable when they follow currents downstream, as they might follow intake flows instead of the main watercourse current, getting trapped between a screen and the current. Juvenile glass eels, elvers and smaller yellow eels are vulnerable during active migration upstream as outfalls can be attractive for eels to enter and there is a risk of injury by attempting to enter the discharges.

LEGISLATIVE DRIVERS FOR SCREENING

Some of the earliest legislation which set out specific powers to screen intakes and outfalls for the ingress and egress of fish was the Salmon and Freshwater Fisheries Act (SAFFA) 1975 but measures only apply to migratory salmonids. Since then, more specific and comprehensive screening legislation to facilitate eel are:

1. Article 2 of Council Regulation (EC) No. 1100/2007 (The Eel Regulation).
2. The Eels (England and Wales) Regulations 2009 Statutory Instrument No. 3344 (The Eel SI).
3. Part 7 (Fisheries), chapter 3 (Migratory and freshwater fish) of the Marine and Coastal Access Act 2009 (c.51) (The Marine Act).
4. The Water Framework Directive 2000/60/EC.
5. Sections 24 or 25 of the Water Resources Act (WRA) 1991 (c.57).
6. Land Drainage Act 1991 (c.59) section 61 A-D.
7. United Kingdom Biodiversity Action Plan (UKBAP) and The Natural Environment and Rural Communities (NERC) Act (2006).

A.W.H.Turnpenny & N. O'Keeffe (2005) Screening for Intake and Outfalls: a best practice guide. Science Report SC030231

SCREENING AND GUIDANCE TECHNIQUES

For yellow and silver eels there are five main types of physical screening techniques that are suitable:

1. Traditional passive mesh screens – these screens are commonly used to exclude fish, but usually require manual cleaning;
2. Self-cleaning vertical or horizontal bar screens;
3. Self-cleaning Coanda screens – these wedge-wire spillway screens are mainly used with upland hydropower schemes;
4. The 'Smolt-Safe™' screen – another type of spillway screen;
5. Band- or drum-screens that have been modified for fish recovery and return (FRR).

For juvenile and smaller fish, there are four main physical screen choices:

1. Passive wedge wire cylinder (PWWC) screens – this is the most widely used method for juvenile and larval fish protection;
2. Small-aperture, wedge-wire panel screens;
3. Sub-gravel intakes and wells – these use the riverbed as a filter;
4. Self-cleaning belt screens such as Hydrolox™

While the presumption is for physical screening, behavioural technologies can be used where this is not possible and when designed correctly and operated in suitable environmental conditions can be effective against fish and eel for 75-95%. The five main types include:

1. Louvre screens – this semi-physical barrier may have some potential for silver eels;
2. Bubble curtains – this most basic behavioural barrier provides relatively poor protection but is sometimes useful as a temporary measure;
3. Electrical barriers, such as the 'Graduated Field Fish Barrier (GFFB™)', are suitable for outfalls (provided that they contain no descending fish) but not for intakes;
4. Acoustic fish deterrents – as yet there are no forms suitable for eel;
5. Artificial lighting – such as strobe lights – either illuminate physical structures or act as an attractive or repellent stimulus.

A.W.H.Turnpenny & N. O'Keeffe (2005) Screening for Intake and Outfalls: a best practice guide. Science Report SC030231

The cost of installing fish screens or barriers is highly site specific and will depend on a number of factors, including: whether the application is new-build or retrofit, the existing structures, the ground conditions, the degree of exposure to flood and other damage, and whether power (if required) is available. Table 1 attempts to provide indicative costs for some of the main techniques described but in most cases the costs are for the screening/barrier hardware only.

Effective screening must, first of all, be targeted to the species and life stages of fish that are to be protected. This will determine the method best suited, the critical times of the year and the specific design details for the fish screen.

Although many of the options may not be suitable or required for smart ponds it will depend on the design of the pond with the above considerations but the most suitable application will likely be traditional passive mesh screen of 2mm which will ensure that juvenile eel and larval stage and eggs for salmonids are excluded.

Screen or barrier type		
Size of abstraction	≥1 m3s-1	10 m3s-1
Positive exclusion screens		
Flat mesh panel, 12mm	24	50
PWWC screen, 3mm	50	285
Band, drum and cup screen modified for FRR	129	129
Under-gravel filter	160	-
Raked bar screen	40	250
Coanda-effect	13-17	-
Smolt-Safe TM screen	17	-
Behavioral screens		
Bubble screen	5	15
Louvre screen	24	50
Continuous light	5	20
Strobe light	10	40
Electric GFFB	12	18

Table 1. Approximate purchase costs (£k) for fish screens and barriers.

A.W.H.Turnpenny & N. O'Keeffe (2005) Screening for Intake and Outfalls: a best practice guide. Science Report SC030231

APPENDIX III DRAFT MONITORING PLAN

SITE INFORMATION

Water Net Gain reference	
Name of landowner and address	
Responsible person/ organisation for creating and	
Period covered by this management plan	
Planning authority and planning reference (if applicable)	
Central OS grid reference and What 3 Words	
Required consents and licences	*List the relevant consents and licences required as part of this management plan*
Funding	*Provide an overview of how funding has been secured to deliver this management plan*
Legal agreement	*Provide an overview of any legal agreements that secure the delivery of the management plan.*

Note: Insert site plan, with clear references to different features (e.g. Pond 1, Pond 2, Ditch 1, Ditch 2, etc.)

MANAGEMENT AND MONITORING SCHEDULE

Feature	Method	Interval and timing	Responsible person/ organisation
Pond	Monitor: Percentage of shade – if vegetation shades out the pond, cut back vegetation Manage: Cut back vegetation in rotation or at the southern site	Monitor: Annually in summer Manage: As required, taking into account bird nesting season and reptile hibernation, last winter	
Pond	Monitor: Percentage of plants in pond – if covering most of the pond surface, remove vegetation Manage: Remove vegetation in pond	Monitor: Annually in summer Manage: As required in late summer	
Pond	Monitor: Algae and water colour – if very green, too many nutrients likely enter the water Manage: Ensure less nutrients enter the pond	Monitor: Annually in summer Manage: As required, throughout the year	
Pond	Monitor: Annual testing for pH, nitrates, sulphates and total dissolved solids Farmers Weekly recommends: "To test, use clean containers and collect eight, one-pint samples at random intervals. Mix in a container and send off to a lab for analysis (ask your vet). Recommendations: • The pH should be between 6.0 and 9.0 for most livestock species • TDS content of less than 1,000 parts per million (ppm) is ideal for dairy cows, but levels below 3,000ppm are generally considered safe to drink. For nitrates, below 20ppm is recommended • The maximum sulphate level should be less than 1,000ppm for adult animals and less than 500 for calves."[1]... cont.	Monitor: Annually in early summer Manage: As required	

[1] Farmers Weekly. Water provision for dairy herds. Online available at: https://www.fwi.co.uk/collections/water-provision-for-dairy-herds

	Manage: Avoid using the water for cattle if deemed unsuitable. Use the water for washing down activities as an alternative. Identify the reason for issue and manage at source.		
Pond	Monitor: Is the pond silting up and are there (not aquatic) plants/ shrubs/ trees encroaching into the pond? Manage: Remove sediment, maximum 50% of the pond area in one year, use sediment as fertiliser on agricultural land (Additional measures: Rake off leaves from trees in the autumn, remove water plant growth in late summer)	Monitor: Annually in summer Manage: In autumn/ winter: • Post harvest/September for arable field edge ponds that are effectively dry or completely silted and shaded with little wildlife interest • Between November and February for ponds where great crested newt might be present to ensure most have left the pond[2]	
Pond	Monitor: Is the lining intact? Manage: Seal/ repair lining if required	Monitor: Monthly Manage: As required, ideally end of summer due to minimum water depth in pond	
Pond	Monitor: Is the pond water level fluctuating / decreasing in an unexpected way – is there a leak in pond/ pipe/ infrastructure/ lining? Manage: Repair leak if required	Monitor: Monthly Manage: Repair as soon as possible	
Sediment traps upstream of pond	Monitor: Is the sediment trap filling up with sediment? Manage: Remove sediment frequently, to ensure functioning of the trap. Spread sediment on agricultural land.	Monitor: Monthly, and after heavy rain Manage: As required	
Pond infrastructure	Monitor: Are pipes, inlet and outlet in working order? Manage: Repair or remove blockages if required	Monitor: Monthly Manage: As required	

[1] Suffolk Wildlife Trust. Pond restoration and management. Online available at: https://www.suffolkwildlifetrust.org/pond-restoration-and-management

Pond infrastructure	Monitor: Measure depth between the sediment at the bottom of the pond and the outflow to make sure that the sediment does not reach the point of outflow. Manage: Remove sediment, maximum 50% of the pond area in one year, use sediment as fertiliser on agricultural land	Monitor: Annually in summer Manage: In autumn/ winter: • Post harvest/September for arable field edge ponds that are effectively dry or completely silted and shaded with little wildlife interest • Between November/ February for ponds where great crested newt might be present to ensure most have left the pond[1]	
Smart pond technology	Monitor: Is technology in good working order? Check on site, and online data Manage: Arrange repair if required	Monitor: Monthly Manage: Repair as soon as possible	
Smart pond technology	Annual servicing (prior to potential low water availability to ensure system is working).	Late spring	Broker / WNG technician
Water Net Gain zone	Monitor: Take photos of the pond system, to have evidence of year-to-year changes	Monitor: Annually	
Water Net Gain zone	Monitor: Take note of wildlife/ biodiversity observations	Monitor: When checking the pond	
Water Net Gain zone	Monitor: Evidence of invasive species Manage: Arrange management !Specialist contractor may be required! If INNS observed, avoid spread as outlined in the section on INNS in the report, and ensure that there is no pathway from the pond into any adjacent waterways.	Monitor: Monthly, especially during spring and summer Manage: Identify correct management timings with specialist	
Pond buffer zone	Monitor: Are fences in working order? Manage: Repair fences if required	Monitor: Before stock enters field parcel Manage: As required before stock enters field parcel	
Pond buffer zone	Monitor: Vegetation around ponds Manage: Graze or mow pond buffer zones, remove, coppice or pollard trees surrounding the ponds	Monitor: Annually in summer Manage: Annually late summer (mowing), as required and in rotation in late winter (coppicing or pollarding)	

[1] Suffolk Wildlife Trust. Pond restoration and management. Online available at: https://www.suffolkwildlifetrust.org/pond-restoration-and-management

APPENDIX IV POND FEASIBILITY TOOL

POND FEASIBILITY TOOL

SITE NAME: _____

DATE:__/__/__

The following questionnaire aims to assess the feasibility and potential costs and risks associated with constructing a pond at the specified site. Higher scoring indicates increased complexity which may incur additional costs and risks for project delivery as well as requirements for permissions. This questionnaire is only indicative as pond design and construction needs to be considered case by case, the questionnaire highlights potential risk where professional advice will need to be sought.

		Scoring	No impact	Low impact	Medium impact	High impact*
1	Site Designations					
1.1	Does the site come under any UK site restrictions such as NNR's, SPA's, SAC, Ramsar, SSSI's, National Landscapes	0 – None present 1,2, 3 – Consult expert guidance	0	1*	2*	3*
1.2	Does the site contain or overlap any priority habitats or those of high ecological value (e.g. natural springs or damp, wet depressions)	0 – None present 1,2, 3 – Consult expert guidance	0	1*	2*	3*
1.3	Are there any number of protected species present on the site?	0 – None present 1,2, 3 – Consult expert guidance	0	1	2	3*
1.4	Does the site have any potential for historical or archeological features?	0 – None present 1,2, 3 – Consult expert guidance	0	1	2	3

1.5	Are you aware of any Invasive Non-Native Species (INNS) present on or close the site?	0 – None present 1 – Possible presence 2 – High probability presence 3 – Already present	0	1	2	3
2	Flood Risk					
2.1	Is the site within a Flood Zone 1, 2 or 3	0 – Flood Zone 1 20 – Flood Zone 2 or 3	0			20*
2.2	Is there infrastructure (e.g. road or building) present close to the proposed pond location?	0 – >50m 1 – 30-50m 2 – 30-10m 3 – <10m	0	1	2	3
3	Planning Permission					
3.1	Does the pond come under permitted development (score 1) or will it need planning permission (2)?	1 – Permitted development 2 – Planning permission		1	2	
4	Detailed Design					
4.1	Do you intend to use the water on your farm or do you intend to release the pond water into a watercourse	1 - Onsite/ on farm 2 – Release water into watercourse		1	2	
4.2	Is the pond location above/ in vicinity to the point of water use?	0 - Potential for gravity feeding 1 - Relative proximity to site of use 2 - Small pumping requirements, 3 - Distance and pumping requirements	0	1	2	3
4.3	What soils are underlying the site? Will lining be required?	0 - Clay soils and no lining 1 - Mixed soils with potential for clay puddling from local source	0	1	2	3

		2 - Medium soils and no potential for clay puddling from local source 3 - Sandy soils and lining required				
4.4	What is the source of water?	0 - Collected solely through rainwater 1 - Rainwater & clean surface runoff 2 - Surface water runoff with potential for high sediment loading 3 - Groundwater fed, existing watercourses	0	1	2	3
5	Construction					
5.1	Is there existing pipework and/or utilities onsite which may impact design and construction?	0 - Confirmed absence 1 - Presence unlikely, but possible 2 - Confirmed presence, unlikely to significantly impact delivery 34 - Confirmed presence, likely to significantly impact delivery	0	1	2	34
5.2	Would you intend to construct the pond using existing machinery, or would you require a contractor(s)?	1 - Experienced contractor, likely expensive, but safer 2 - Local, qualified contractor without pond construction experience 3 - Built with on-farm resources resulting in lower costs, but higher risks		1	2	3
5.3	Using existing depressions on land vs. extensive digging works	1 – Existing depressions with minimal excavation 2 – Flat, even or minor depressions, with partial excavation 3 – Major earthworks required		1	2	3
5.4	Can the excavated spoil be used on the farm?	0 - Spoil used within pond system 1 - Spoil disposed of on site, elsewhere	0	1	2	3

		2 - Spoil has intended purpose off-site via a Materials Management Plan 3 - Spoil going to landfill				
5.5	Do you intend to plant the area with vegetation, whether for aesthetic, sediment capture or pollution management	0 – Allow for natural regeneration of vegetation around site 1 – Mix planting & natural regeneration 2 – Planting	0	1	2	
5.6	Do you intend to add fencing around the pond?	0 – No 1 – Partial or full fencing	0	1		
5.7	Would members of the public be able to access the pond site, or surrounding area?	0 – No public access, private land 1 – Permissive access, fencing implemented 2 – Publicly accessible, no fencing implemented	0	1	2	
*Professional guidance and advice should be sought if this score applies					**FINAL SCORE**	

Total Score	Feasibility
0 - 11	Low Risk - The site has been identified as **Low Risk (0-11).** The proposed site could be an ideal location for pond construction. This does not mean risk is absent, but costs are expected to be low with few obstacles impacting delivery.
12 – 22	Medium Risk - The site falls into **Medium Risk (12–22).** The project will have some notable risks due to planning requirements or other factors, which will increase costs and require professional expertise but does not present insurmountable obstacles.
23 - 33	High Risk - The site has been classified as **High Risk (23-33).** The project is expected to encounter significant challenges and risks that will require careful planning and mitigation. These factors could result in substantial costs, and it may be advisable to consider relocating the proposed pond to a more suitable site if feasible.
34 +	Significant risk - Sites with a score **of 34 and higher are considered impractical or not cost-effective** for implementation. Constructing a pond in such a location is not recommended, as the risks to the environment, infrastructure, or other critical factors may be considerable.


Westcountry Rivers Trust