Ponds, pools and lochans

Guidance on good practice in the management and creation of small waterbodies in Scotland

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Pond Action

Sir Frederick Snow & Partners (Scotland) Ltd

Chairman's Foreword

The Scottish Environment Protection Agency (SEPA) aims 'to promote the conservation and enhancement of the natural beauty and amenity of controlled waters and the conservation of flora and fauna dependent on aquatic environments'.

Historically, environmental improvements have been secured by SEPA through regulation, but new initiatives and new partnerships with external organisations are enabling more non-statutory opportunities for encouraging environmental gain. With the launch of the Habitat Enhancement Initiative (HEI) in July 1998 such opportunities are extending to habitat and conservation issues.

For SEPA to maximise these opportunities a range of resources has been developed through HEI, which provide guidance on good management practice for aquatic habitats. This document, 'Ponds, pools and lochans', is the first in a series of documents to be produced to provide, to both internal and external staff, simple clear guidelines for the management of Scotland's small waterbodies.

'Ponds, pools and lochans' has been produced in partnership with key environmental organisations in Scotland, in association with Pond Action, for whose contribution SEPA is extremely grateful. The document has been developed over the past two years through workshops and task groups and SEPA would like to take this opportunity to thank all those who have contributed to the production of Ponds, Pools and Lochans.

In Scotland, 50% of the small bodies of water have been lost through infilling, urban development and drainage for agricultural intensification. Take the opportunity to learn from this working document how you can help to protect and enhance these important Scottish habitats.

Ken Collins
Chairman, Scottish Environment Protection Agency

Executive Summary

This guide provides best practice guidance on the management of ponds, pools and lochans in Scotland (man-made and natural waterbodies up to 2 hectares (ha) in area). Collectively, small water bodies represent about 95% of all discrete standing waters in Scotland and are an important ecological, heritage and amenity resource.

The guide has five main sections dealing with:

- general background information about ponds and pools in Scotland, including information on numbers, status, threats and legislation;
- assessment of the ecological, historical, archaeological and amenity value of small water bodies;
- pond management and
- design of new ponds.

A special section is also included on the design of ponds in Sustainable Urban Drainage Systems (SUDS).

The guide is intended for statutory environmental agencies and environmental NGOs, farmers and landowners, local authority engineers and planners, developers, environmental consultants and landscape architects. Local action groups and members of the public may also find the guide useful.

Scottish Environment Protection Agency

The Scottish Environment Protection Agency (SEPA) aims to provide an efficient and integrated environmental protection system for Scotland, which will both improve the environment and contribute to the Government's goal of sustainable development. The Habitat Enhancement Initiative (HEI) has been developed to focus on SEPA's duty to promote the conservation of habitats and the wildlife dependent upon them and therefore recognises the importance of small waterbodies in Scotland. HEI aims to help secure measurable improvement in the way in which aquatic and riparian habitats are managed.

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1. Introduction

1.1 Using the handbook

This handbook provides guidance on good practice in the protection, management and creation of ponds and pools in Scotland. The guide covers both man-made and natural waterbodies, including upland lochans and moorland pools. The guide also provides advice on incorporating ecological design principles into Sustainable Urban Drainage Systems.

The main aim of the handbook is to provide a summary of new information about the conservation and management of small water bodies, and to point the way towards additional sources of technical advice and information. The guide is not a practical management handbook; further information about pond management and design is available in The Pond Book (Williams et al., 1999).

The guide includes information on:

- the ecological management of man-made and natural small water bodies.
- protecting the historical and archaeological interest of small water bodies.
- the amenity use of ponds and pools, and the integration of this with nature conservation management.
- the design of new ponds for nature conservation.
- techniques for maximising the biodiversity value of ponds and wetlands that are installed in sustainable urban drainage systems.

The handbook does not cover wet grasslands, peatlands or reed beds for which management guides are already available[1]. However, advice is included about small waterbodies associated with more extensive semi-natural habitats, such as upland pools and lochans.

1.2 SEPA's role in pond protection

The handbook has been prepared as part of the Scottish Environment Protection Agency (SEPA) Habitat Enhancement Initiative (HEI). The HEI is a national initiative which has been developed to help SEPA fulfil its aims and duties with regard to conservation, biodiversity and sustainable development in relation to habitat issues.

Overall, SEPA's objectives in pond protection within the HEI are to:

- promote the protection of existing ponds, pools and lochans
- encourage pond creation
- work in partnership with organisations and encourage community involvement in the conservation of small waterbodies
- help develop public understanding of aquatic habitat conservation issues
- promote the use of ponds within Sustainable Urban Drainage Systems to protect and conserve biodiversity.

Who is this guide for?

This guide is aimed at:

- Statutory environmental protection agencies and NGOs
- Farmers and landowners
- Local authority planners and engineers
- Developers, environmental consultants and landscape architects
- Local action groups and members of the public may also find this guide useful.

How to use this guide

This guide summarises information available about pond management, creation and protection.

- General information about ponds is given in Section 2.
- Pond assessment is described in Section 3.
- Pond management is described in Section 4.
- Pond creation is described in Section 5.
- Sustainable Urban Drainage System (SUDS) pond design is described in Section 7.
- The key aspects of pond management and design are described in summary boxes in each chapter.
- Technical terms are explained in the Glossary.

[1] Information on the management of wet grasslands, peatlands, bogs and reed beds is available in Benstead et al. (1997), Rowell (1988), Brooks and Stoneman (1997) and Hawke and José (1995), respectively. Specific information on the management of invertebrates in all of these habitats is available in Kirby (1995).

2. General information about ponds

2.1 Definitions

In this guide, ponds are defined as:
'Man-made or natural bodies of freshwater between $1m^2$ and 2 hectares in area, which hold water for all or part of the year'.

This definition is deliberately broad. It includes lochans, peat pools and other naturally formed small waterbodies, as well as the full range of man-made ponds. It also includes seasonal pools - a distinctive type of pond which dries up in summer and which usually supports specialised, and sometimes valuable, pond communities.

Figure 1. The geological record shows that ponds and pools were a natural feature of the landscape long before human activity began to shape the surface of the earth. This 1.5 ha natural lochan in Abernethy on Speyside was created during the last glaciation. © *Pond Action*

Ponds are often perceived as essentially artificial habitats. This is not surprising since many ponds in the modern British landscape are, indeed, man-made. However, geological evidence and studies of pristine landscapes little altered by human activity, show that ponds and pools have always been a natural feature in landscapes worldwide. Long before human activity came to be the dominant force shaping the land, ponds were widespread and often abundant. In fact, it is clear that ponds are a very ancient and natural habitat type.

Scotland still retains many naturally formed ponds including lochans, dubh lochs (bog pools), dune slack pools and ponds formed from naturally cut-off river meanders. Many tiny natural pools also occur, particularly in areas with seasonally high water tables. For example, in undrained woodlands, tree-fall pools are often created in the depressions left when trees are uprooted in storms. Seasonal ponds can be especially common in the more natural landscapes where almost any depression on impermeable soils can hold water for part of the year.

Figure 2. The creation of new ponds, like this one in the Auchenrodden Forest near Lockerbie, simulates the natural processes of pond formation. © *Pond Action*

In the more intensively managed areas of the Scottish landscape, processes such as drainage and river channelisation have considerably reduced opportunities for natural pond formation. In these areas, man-made ponds, dug either deliberately (e.g. field ponds, moats) or created as a by-product of human activities (e.g. quarry pools), have largely replaced ponds created by natural processes.

However, whether called ponds, pools or lochans, and whether man-made or natural, small water bodies provide an essentially similar habitat type for pond wildlife. We know this because when the plant and animal communities from high quality man-made and natural ponds are classified using computer-based statistical techniques, the analyses show no discernible differences in their community types.

It is environmental factors such as water depth, geology, exposure to pollution and proximity to long-established wetlands which influence the biological communities in ponds, not the way in which the waterbody was made in the first place.

Ponds are, in fact, a very unusual type of freshwater habitat. The pond environment as a whole is both persistent and ancient. But many individual ponds, such as meander cut-offs and tree-fall pools, are naturally short lived, often infilling within decades, to be replaced by new ponds which would, in pre-human landscapes, have been continually recreated by natural processes[2]. For these individually short-lived ponds, human activity, creating new ponds, has simply added a variety of new ways in which this ancient and natural habitat type is maintained in the modern landscape.

[2] Exceptions to this include bog-pools and seasonal ponds, both of which can be much more long-lived and persistent in the landscape.

2.2 The number of small waterbodies in Scotland

Scotland has many small waterbodies: over 150,000 in total, representing about half of the ponds and pools in the British countryside as a whole (Table 1).

Table 1.

The number of waterbodies in Scotland in 1990

Ponds, pools and lochans up to 2.0 ha[3]	150,700
Lochs greater than 2.0 ha[4]	4,500

From: Barr et al., 1994

Fortunately, some evidence suggests that, in recent years, Scotland has suffered less pond loss than England and Wales where the number of ponds has dropped by about 75% this century (PCG, 1994).

The National Amphibian Survey (Swan and Oldham, 1993) estimated loss rates of small waterbodies since 1950. It showed that in areas of Scotland for which information was available[5] pond numbers declined in the agricultural centre and east of the country, increased in the south-west and declined slightly in the Highlands. These data should be treated with some caution however, particularly for the more remote parts of the country, where fewer surveyors were working. An increase in pond numbers is also reported from Central Scotland over the period 1860 - 1990 (Lassiere, 1992). However, this analysis was based on interpretation of 1:63,000 and 1:50,000 scale maps which do not show the majority of smaller ponds.

Figure 3. There are at least 150,000 ponds and pools in Scotland, about half of the total in the British countryside.
© *Pond Action*

[3] Assumes that 25% of ponds in the size range 1.0-5.0 ha in CS1990 were 2.0 ha or below. Sources: Barr et al., 1993; Barr et al., 1994.

[4] Estimates of loch and reservoir numbers in Scotland were made by Smith and Lyle (1979). From counts of 1:250,000 scale maps they found 3788 water bodies of greater than about 4 ha (this was the smallest size water body they estimated was recorded on the 1:250,000 map). By extrapolation from 1:63,000 scale maps they estimated that there were a further 27672 water bodies less than 4 ha in Scotland (though no information was available about the lower size limit of waterbodies shown in the 1:63,000 scale map). Since OS 1:63,000 maps show ponds down to about 0.25 ha, this count seems largely consistent with the 1990 Countryside Survey data.

[5] Dumfries and Galloway, Argyll and Bute, North, East and South Ayrshire, Renfrewshire and East Renfrewshire, North and South Lanarkshire, Falkirk, West Lothian, Midlothian, East Lothian, Fife, Moray and Aberdeenshire.

Figure 4. Shortwood Common Pond (Surrey) is one of the richest ponds so far surveyed in Britain by Pond Action, with over 70 macroinvertebrate species in a single 3 minute hand-net sample and 58 wetland plant species.
© *Pond Action*

2.3 Biological importance of ponds

Ponds are often very rich habitats, particularly important for aquatic invertebrates, wetland plants and amphibians. They are also used by a variety of mammals, birds and fish, especially where ponds form part of a mosaic of wetland habitats.

Even compared to other freshwater ecosystems, such as lakes and rivers, ponds are surprisingly rich. For example, comparing river invertebrate data from a 600 site national database collected by the Institute of Freshwater Ecology with a similarly-collected but smaller data set (156 sites) from the National Pond Survey suggests that, at a national scale, small water bodies support: (i) at least as many invertebrate species as rivers and (ii) considerably more uncommon and rare species (see Table 2).

The importance of ponds in supporting rare species is underlined by the number of freshwater UK Biodiversity Action Plan (BAP) species that are found in permanent and temporary ponds. In Scotland, these include: great crested newt (Figure 9), natterjack toad (below), pillwort (Figure 10), slender naiad, marsh clubmoss and medicinal leech. For other BAP species, such as water vole, otter, reed bunting, common scoter and red-necked phalarope (Figure 7), ponds may be an important component of the species' habitat.

Figure 5. The natterjack toad *(Bufo calamita)* is Britain's most endangered amphibian. In Scotland it occurs in coastal ponds in the south-west. Information on the management of this species is contained in the natterjack toad conservation handbook (Beebee and Denton, 1996).
© *Pond Action*

Table 2.

Macroinvertebrate biodiversity in ponds and rivers in Britain. Ponds in Britain support: (i) at least as many invertebrate species as rivers and (ii) considerably more uncommon and rare species.

Invertebrate Groups	Species richness		Nationally Scarce spp.		Red Data Book spp.	
	Ponds	Rivers	Ponds	Rivers	Ponds	Rivers
Flatworms	8	9	1	0	0	0
Snails and orb mussels	34	33	1	2	4	2
Leeches	10	14	1	0	0	0
Shrimps, slaters and crayfish	6	10	0	0	0	0
Mayflies	19	37	0	1	1	3
Stoneflies	7	27	0	1	0	0
Dragonflies	26	13	4	2	1	0
Water bugs	45	27	2	0	1	0
Water beetles	170	100	60	27	13	4
Alderflies and spongeflies	2	3	0	1	0	0
Caddis flies	71	95	3	7	1	4
Total number of species	398	368	72	41	21	13

Sources: National Pond Survey unpublished data; Wright et al. (1996). The comparison is based on all invertebrate groups sampled in both surveys for which reliable published national distribution and status data are available.
Note: Numbers of taxa given by Wright et al. (1996) in their Table 1 were modified as follows to enable comparisons to be made: *Argulus foliaceus* was omitted from the Crustacea total; *Sigara (Sigara)* sp. was omitted from the Hemiptera total; water beetles in the family Scirtidae (4 taxa) were omitted from the Coleoptera total; Hydroptilidae (seven taxa) were omitted from the Trichoptera total.

Figure 6. Many damselfly species are found in semi-permanent and temporary ponds, including acid waters, throughout Scotland. © *Lorne Gill/SNH*

Figure 7. Man-made and natural pools are an important component of the breeding habitat of the red-necked phalarope *(Phalaropus lobatus)* which usually nests amongst flooded peat cuttings or other shallow pools in northern and western Scotland. © *RSPB*

2.4 Historical and archaeological value of ponds

Ponds may be considered to be of historical significance for two main reasons:

1. They may be important historic features in their own right e.g. moats, fish ponds, duck decoys, places with literary or community associations (see Table 3).
2. Both their structure and their sediments may contain important historical information relevant to the history of the waterbody, its surrounds and the wider environment (pollen record, historical artefacts etc.). In some cases, particularly in more remote areas, these sediment records may span thousands of years.

Table 3.
Historical and cultural uses of ponds identified by the Pond Conservation Group (unpublished data)

Mill ponds	Duck ponds	Dye ponds
Old farm ponds	Subsidence ponds	Fish ponds
Ornamental garden ponds	Livestock watering ponds	Moats
Extraction ponds	Peat ponds	Marl pits
Reclamation ponds	Stew ponds	Dew ponds
Drinking water tarns	Droving ponds	Traction engine ponds
Artesian ponds	Ice ponds	Silt ponds
Decoy ponds	Pond bays	Heathland ponds
Hammer ponds	Forge/furnace ponds	Distillery ponds
Curling ponds	Watercress beds	
Flax retting ponds	Swannery ponds	

In practice, the historical and archaeological interest of ponds is often poorly documented and overlooked.

In England and Wales, less than 1% of all ponds are listed on the National Monuments Record (NMR) as important historic features (no equivalent analysis has been undertaken on the National Monument Record for Scotland). However, even this listing is probably rather unrepresentative of the true interest of ponds as, of the 2500 records including the term 'pond' in the NMR for England and Wales, 89% fall into just two classes: 'fishponds' and unspecified 'ponds'. All remaining pond types make up only 11% of total records.

In contrast, a survey undertaken by the Pond Conservation Group (PCG) in 1996 estimated that about 10% of all lowland ponds in England, Wales and Scotland had a historic value, and at least 30 different pond types of pond were identified (Table 3). In reality, it is probable that most ponds will have at least some archaeological or historical interest but, for the vast majority of sites, this is, as yet, unrecorded and unresearched.

Figure 8. Curling ponds are a distinctive feature of the Scottish landscape. © *K Walker*

2.5 Amenity value of ponds

Some ponds can have considerable amenity value. The DETR[6] Lowland Pond Survey carried out in 1996 showed that at least 15% of all ponds in the lowland landscape are used for shooting, fishing or some other leisure activity. Since this was a conservative estimate based on field observation rather than consultation with landowners, the true value is likely to be considerably higher.

Ponds also have an important visual and aesthetic value and have long been used by landscape designers to create focal points in designed landscapes.

Table 4.

Amenity use of ponds and pools in lowland England, Wales and Scotland (data from Williams et al., 1998a)

Amenity activity	% of ponds
Fishing	13%
Shooting	7%
Ornamental fish	3%
Pond dipping, nature reserve	3%
Ornamental wildfowl	3%
Golfing hazard	1%
Boating and water sports	1%

Note that categories are not mutually exclusive; some ponds had more than one amenity use.

2.6 Threats to ponds

Pond loss

It is often assumed that pond loss is the main threat to ponds in Britain - but this is only partly true. Pollution and mismanagement are also important problems facing ponds.

During the 20th century, large numbers of ponds have been destroyed. However, data from the DETR Lowland Pond Survey suggests that net loss rates may now be slowing. Instead there is now a high turnover of ponds in lowland Britain with about 1% of the total number of ponds lost and replaced every year. This means that, although a lot of ponds are being filled in, similar numbers are being created. At first sight this might seem quite satisfactory - however, we do not know whether the new ponds being created are better or worse than the old ones being filled in. It is quite likely that some high quality ponds are being lost by this process; the DETR survey also showed that the majority of new ponds are being created for fishing, which means that these ponds will be unsuitable for the many plants and animals that prefer shallow fish-free water (Williams et al., 1998a).

Although nationally, pond numbers may be comparatively stable, there is probably marked regional variation in the rate of pond loss and gain. As noted in Section 2.2 above, numbers in some parts of Scotland may be stable and possibly increasing. In some English regions (e.g. Lancashire, Cheshire), there is evidence that pond loss continues at a high rate (around 1% per annum) with relatively little compensatory pond creation (Nicolet, 1998).

Pollution

Recent evidence from a range of pond surveys suggests that, in the modern landscape, pollution now has an even more pervasive and damaging influence on ponds than pond loss (Williams et al., 1998a,b).

The DETR Lowland Pond Survey provides evidence of extensive damage to pond quality in many countryside ponds, particularly those associated with intensive arable land use. This includes widespread evidence of eutrophication (Williams et al., 1998a). In areas of base-poor soils, acidification may also be a significant impact (Beebee et al. 1990).

Ponds are particularly vulnerable to pollution because of their small size and the small volumes of water available to dilute pollutants. Ponds which are connected to streams and ditches are at particular risk since, in many areas, these watercourses carry significant pollutant loads.

On the plus side, however, there is at least the potential for ponds to be better protected from pollutants than is often possible with larger waterbodies such as lochs and rivers. Many ponds have quite small surface water catchments. In these instances it is quite feasible for the whole of the pond catchment to be maintained in a semi-natural land use (e.g. woodland, extensive grassland, moorland) to protect the pond from polluted surface water, a difficult thing to achieve with freshwater ecosystems that have large catchments, such as rivers and lochs.

Specially designed ponds can also be used to help control pollution. Section 7 describes designs for Sustainable Urban Drainage System ponds which are used to trap and improve the quality of the polluted water.

Mismanagement

A surprising threat to ponds comes from mismanagement. Until recently, there has been little information about the ecology of ponds and traditional management practices had developed in the absence of any real understanding of their effects. Techniques, such as ‘cleaning-out’ ponds and ‘rescuing’ ponds that dry out, can often be far more damaging than doing nothing and just leaving the pond alone. New guidance on pond management, in the light of more recent information, is given later in this handbook.

[6] DETR: Department of the Environment, Transport and the Regions.

Figure 9. The great crested newt is a protected species in Britain; it is threatened by pond loss, fish stocking, mismanagement of ponds (including over-zealous vegetation removal) and fragmentation of terrestrial habitat. © *Sue Scott*

Table 5.

Biodiversity Action Plan species associated with ponds in Scotland

- Violet crystalwort
- Sea bryum
- Baltic bog-moss
- Lesser bearded stonewort
- Slender stonewort
- Pillwort
- Shetland pondweed
- Slender naiad
- *Donacia aquatica* (a reed beetle)
- *Hydroporus rufifrons* (a diving beetle)
- Medicinal leech
- Natterjack toad
- Great crested newt
- Reed bunting
- Water vole
- Otter

Contact points for each of the organisations mentioned in this section are given in Appendix 1.

2.7 Legislation and policy initiatives relating to ponds

Four main areas of legislation and associated policy provide or encourage protection for ponds and small water bodies in Scotland. These are described in the following section under the headings of natural heritage conservation, land-use planning, water pollution control and agri-environment schemes, although there is inevitably some overlap between these. Environmental protection in Scotland is overseen by SERAD, the Scottish Executive Rural Affairs Department which is responsible for advising Ministers on United Kingdom and European Union policy relating to agriculture, environmental issues and fisheries, and for the implementation of those policies in Scotland.

Natural heritage conservation legislation

Designation of SSSIs and NNRs. Scottish Natural Heritage (SNH) is the Agency responsible for advising central and local government on all aspects of Scotland's natural heritage. In fulfilling these responsibilities SNH has a duty to notify as Sites of Special Scientific Interest (SSSIs) any area of land which in its opinion is of special interest by reason of its flora, fauna, geological or physiographical features. Areas of land of national importance for nature conservation may be designated as National Nature Reserves (NNRs).

Many SSSIs and NNRs protect a range of high quality ponds, although sites are only rarely designated specifically for their ponds. Ponds on sites designated as SSSIs may qualify for a range of financial and technical assistance from SNH and others.

UK Biodiversity Action Plan. At the UN Conference on Environment and Development in 1992 the UK signed the Biodiversity Convention which requires that the components of the Earth's biological diversity should be used in ways which do not lead to their decline. The commitments contained in the convention are reflected in UK and Scottish programmes for sustainable development, and in the responsibilities of the statutory agencies.

Practical measures to safeguard biodiversity are described in the UK Biodiversity Action Plan (BAP), and a number of these measures are important for the protection of small waterbodies (UK Biodiversity Steering Group, 1994).

In Scotland, the Scottish Biodiversity Group is taking forward the programme of work identified in the UK BAP in a partnership of statutory agencies, local authorities, non-governmental organisations and local communities. The UK BAP is primarily implemented through the identification of species and habitats at risk, for which agreed conservation measures are published in species- and habitat-specific action plans.

Ponds supporting Biodiversity Action Plan species (known as BAP species) are likely to be a priority for action for a number of organisations. BAP species associated with ponds in Scotland are listed in Table 5. Further information about BAP species (including contact points) is available in individual Species Action Plans, which are accessible through the Joint Nature Conservation Committee (JNCC) website (www.jncc.gov.uk). Local Biodiversity Action Plans (LBAPs) are also targeting ponds (or standing waters) as priorities for action in some areas (e.g. North Lanarkshire).

At present a relatively small number of LBAPs have been published in Scotland but as the remainder are produced it is likely that a number will focus local action from a wide range of organisations on pond habitats. Further information on LBAPs can be obtained from the Biodiversity Secretariat of SERAD, or from the Scottish Biodiversity Group website www.scotland.gov.uk/biodiversity.

Some ponds in Scotland may also fall within the scope of the Habitat Action Plans (HAPs) for eutrophic standing waters and mesotrophic lakes. The eutrophic waters plan covers natural and man-made waters including lakes, reservoirs and gravel pits but excludes 'field ponds, small pools and brackish waters'. However, some water bodies covered by the definition used in the current report (see Section 2.1) may still fall within the eutrophic waters definition as no lower size limit is specified.

The mesotrophic lakes HAP includes water bodies down to 1 ha in area. Consequently, there are likely to be a number of small water bodies in Scotland which fulfill both this size criterion and the mesotrophic lake biological and chemical criteria (total phosphorus concentrations in the range 10-35 microgram phosphorus/litre).

An Interim Report on the conservation of mesotrophic lakes is available from SEPA offices (UK Steering Group for Mesotrophic Lakes, 1999). HAPs for mesotrophic and eutrophic lakes can also be accessed through the JNCC website.

Figure 10. An unnamed lochan on Rannoch Moor National Nature Reserve, one of the National Pond Survey sites in Scotland. © *Pond Action*

Planning legislation and policies

NPPG 14 (National Policy Planning Guidance 14: Natural Heritage) provides a statement of Government policy on nationally important land use and other planning matters of relevance to Scotland. Implementation of these policies is the responsibility of local planning authorities and other statutory bodies.

NPPG 14 notes that, as part of the wider heritage (i.e. land outside designated sites) lochs, ponds, watercourses and wetlands are often both valuable features and important wildlife habitats which planning authorities should seek to safeguard with in the context of a wider framework of water catchment management. Local authorities may also designate Local Nature Reserves because of high natural heritage interests or particular value for education and enjoyment.

In order to achieve these objectives, Structure Plans and Local Plans should include a range of policies to protect features outside of the designated network (i.e. SSSIs, NNRs etc.). These are likely to be of particular importance for pond and small water body conservation (see Table 6).

Table 6.

Policies which should be included in Structure Plans and Local Plans which are likely to be of particular importance for pond and small waterbody conservation.

Structure Plans should:

- provide for the conservation of biodiversity and the protection and enhancement of the natural heritage outwith designated areas.
- include policies for the protection and, where appropriate, enhancement of any sites identified as being of regional importance for nature conservation.
- identify appropriate strategic opportunities for promoting enjoyment and understanding of the natural heritage.

Local Plans should:

- identify all international, national, regional and local heritage designations on the Proposals Map (distinguishing between international or national sites and sites of more local importance).
- include policies for any areas identified as being of regional or local importance for the natural heritage and safeguard any landscape features of major importance for nature conservation or amenity.
- identify opportunities to maintain and enhance wetlands
- provide for the conservation of biodiversity and the protection of the natural heritage outwith designated areas
- identify appropriate opportunities to improve public access for the purposes of enjoying and learning about the natural heritage.

To fulfill legislative requirements a number of local authorities in Scotland have developed planning policies which offer specific protection to ponds or other small-scale wetland features. For example, Glasgow City Council has consolidated its existing wildlife and nature conservation policies by proposing the following draft policy ENV/G3 which will increase the protection for Sites of Importance for Nature Conservation:

POLICY: There will be a presumption against any development or change of use likely to have an adverse effect on any land or water identified now, or as a result of further survey work, as being a Site of City-wide Importance for Nature Conservation (SCINC), including the level or quality of water supply within the catchment area of wetland sites.

In order to conserve an integrated system of wildlife habitats, the Council will take into account the nature of the conservation value of Sites of Local Importance for Nature Conservation (SLINCs) when assessing proposals that might adversely affect them.

To assist planning authorities to protect ponds, specimen policies have been prepared by the Pond Conservation Group which can be adapted to suit local conditions (see Table 7). See also Box 9 on Ponds and the Law.

Table 7.

Specimen planning policies for pond conservation. In 1995, the Pond Conservation Group published a set of specimen planning policies for pond conservation. Examples of these policies are given below.

P1. The council will promote the conservation of ponds and wetlands, especially where they contain scheduled species, rare species or support a rich assemblage of plants, invertebrates or amphibians.

P2. The council will protect archaeological features from any work which results in the demolition, or destruction, or any damage to historic sites, including dew and decoy ponds, fishponds, moats or curling ponds, which are of historic value.

P3. In areas where there has been significant loss of ponds, the council will encourage the recreation of ponds and, as far as is within its power, require that new ponds and wetlands are designed to be sympathetic with the landscape and to provide rich and varied wildlife habitats.

P4. The council will not normally permit development which would lead to the loss or significant alteration of important habitats such as heathland, woodland, unimproved grassland, wetlands, streams or ponds, especially those which support legally protected or rare species or a rich assemblage of invertebrates, plants or amphibians.

P5. The council will not normally grant planning permission for development which would adversely affect the landscape, historical or wildlife value of any existing pond or watercourse.

Pollution control legislation

SEPA's overall aim is to provide an efficient and integrated environmental protection system for Scotland, working with others to both protect and improve the environment and contribute to the Government's goal of sustainable development. SEPA is also committed to the strategic objective of conserving, and where possible, enhancing biological diversity within the UK.

More specifically, SEPA has a statutory duty to control discharges to controlled waters, which include:

"....inland freshwaters, that is to say, the waters of any relevant loch or pond or of so much of any relevant river or watercourse as is above the freshwater limit...."

(Section 30A, Control of Pollution Act 1989 (as amended))

where "relevant loch or pond" means:

"....any loch or pond which (whether it is natural or artificial or above or below the ground) discharges into a relevant river or watercourse or into another loch or pond which is itself a relevant loch or pond...."

(Section 30A, Control of Pollution Act 1989 (as amended))

As groundwaters are also controlled waters, many other small waterbodies in direct contact with groundwater (but without a surface inflow or outflow) may be regarded as controlled waters.

SEPA also has statutory duties to promote, as far as it considers desirable, (a) the conservation and enhancement of the natural beauty and amenity of land and coastal waters and the land associated with such waters (b) the conservation of flora and fauna which are dependent on the aquatic environment (Section 34.2 Environment Act (1995)).

In the future, the implementation of the proposed Water Framework Directive will also have an important role to play in maintaining and enhancing wetland habitats both in designated areas and more generally.

Agri-environment schemes

EC Council Regulation 2078/92, the 'agri-environment regulation' makes available Common Agricultural Policy (CAP) funds to encourage environmentally sensitive farming practices. Agri-environment schemes are administered by SERAD (Scottish Executive Rural Affairs Department).

Agri-environment schemes have the potential to be of considerable benefit for pond conservation particularly where these schemes can:

- support the conversion of whole pond catchments to a semi-natural land use (e.g. extensively managed grassland).
- establish buffer zones around ponds where catchments are managed intensively (i.e. with heavy applications of fertilisers or use of biocides).
- give priority to pond creation over potentially damaging management (normally termed 'restoration') which is not inevitably beneficial to wildlife or the protection of archaeological features.

Grants and advice are available within agri-environment schemes to encourage the protection and creation of ponds. Advice to landowners on pond conservation issues is available from the Farming and Wildlife Advisory Group (FWAG) and other independent advisors.

A new agri-environment programme, the Rural Stewardship Scheme (RSS), is to be the single successor to the Environmentally Sensitive Areas (ESA) Scheme and the Countryside Premium Scheme (CPS). This new scheme will include local and national biodiversity habitats and species, which may encourage both pond creation and management in certain areas. Further information is available from the Scottish Executive Rural Affairs Department (SERAD) local offices or the SERAD agri-environment branch in Edinburgh.

2.8 Sources of assistance and funding

Organisations providing help and advice

Organisations able to provide practical assistance, help and advice in pond conservation and management are listed in Appendix 1.

Funding

Grant aid and funding for pond conservation work is available from a variety of sources.

Agri-environment schemes. Farmers, landowners and crofters may be able to obtain funding for pond creation and management work as part of a whole-farm plan. For more advice on possible sources of funding for ponds on farmland contact FWAG or SWT.

Buffer strips. As part of the Set-aside Scheme farmers, landowners and crofters can apply for funds to create buffer strips around landscape features including ponds and other small water bodies. More information is available from FWAG, SWT or SERAD.

Local authorities. There are no formal local authority schemes specifically providing grants for pond conservation in Scotland. However, a number of authorities provide discretionary awards to assist local citizen groups with pond conservation work where this has a clear benefit for the community or the protection of wildlife (e.g. promoting the conservation of BAP species).

SEPA. SEPA does not award grants but may be able to provide limited funding for schemes which further the aims of the Habitat Enhancement Initiative in conservation of the aquatic environment, particularly the conservation of BAP species.

Scottish Natural Heritage (SNH). SNH may award grants to managers of SSSIs, NNRs and other areas of high conservation interest for the management or creation of ponds. Grants may also be made to individuals involved in pond conservation work.

Heritage Lottery Fund. The Heritage Lottery Fund (HLF) may grant aid pond conservation work if it is undertaken by a bona fide community group (normally the group will need a simple constitution and a bank account). Applications should be made to the HLF but it is advisable to contact HLF first to determine whether a project is likely to qualify for assistance.

Other grants and awards. Many small trusts and charities exist which may give grants for pond conservation work.

3. Assessing pond ecological quality

3.1 Is it necessary to survey?

It is always helpful to have good ecological and historical information about a pond before management decisions are made - for many ponds it will be essential if management is to be effective and damage to the pond avoided.

Circumstances where it is particularly important to base management decisions on the results of an ecological survey are:

(i) Ponds which are located in areas designated for their conservation interest or with extensive areas of semi-natural habitat (e.g. SSSIs, unimproved grasslands, ancient woodlands, moorland). These ponds are likely to be of high value (supporting uncommon or protected species) - and are easily damaged.

(ii) Ponds where it is suspected that protected or Biodiversity Action Plan species may occur.

(iii) Ponds where extensive invasive management or destruction is considered. This includes deepening of temporary ponds, or ponds where there is going to be clearance of 25% or more of the sediment or vegetation.

In addition, ecological information is virtually essential where ponds are mainly being managed for nature conservation purposes - without good data about which species are already using the pond it is not really possible to know whether management will be of benefit or cause irrevocable damage.

Archaeological surveys are particularly recommended where the pond is known to be older than 100 years or where the pond is known not to have been dredged for more than 100 years and may, therefore, contain biological or historical remains in its sediments.

Figure 11. Pillwort *(Pilularia globulifera)*, an inconspicuous and declining fern found in the margins of ponds, pools and lochs. This BAP species can easily be overlooked without careful survey work. © *Pond Action*

3.2 Conservation assessment methods using wetland plants and aquatic macroinvertebrates

Standard conservation assessment methods have been developed by Pond Action for plant and aquatic macroinvertebrate communities of ponds. These assessment methods are based on the plant and invertebrate survey methods developed for the National Pond Survey (NPS) (Pond Action, 1998). Standard wetland plant and aquatic invertebrate species lists are available from Pond Action. These provide information on species status (common, local, nationally uncommon or Red Data Book), including rarity values for the calculation of Species Rarity Index scores.

3.3 Using the assessment criteria given in Table 8

To assess pond conservation value using the standard criteria given in Table 8 it is necessary to:

1. obtain a list of plant and/or invertebrate species from the pond, collected using National Pond Survey standard plant and invertebrate survey methods.

2. use the species lists generated to calculate either (i) the number of species present (ii) numbers of ‘uncommon’ species (local, nationally uncommon or Red Data Book species) (iii) a Species Rarity Index value for the site.

Calculation of these scores enables the value of the site to be assessed on a national scale. For ease of interpretation, these data can be used to place ponds in one of four conservation value categories: low, moderate, high, very high.

Figure 12. To assess the conservation value of ponds, follow the techniques of the National Pond Survey to obtain a standard list of wetland plants and invertebrates from the pond or pool. © *Lorne Gill/SNH*

3.4 Collecting plant or invertebrate data to assess pond conservation value

To place ponds in the categories shown in Table 8, plant and invertebrate surveys should use the standard National Pond Survey methods. For plants, the standard NPS method consists of making a list of wetland plant species present based on the wetland plant recording list used for the National Pond Survey. This list is available from Pond Action in the guide to the methods of the National Pond Survey (Pond Action, 1998). A skilled botanist assessing a typical 1000 m^2 waterbody should take 1 to 2 hrs. Sites of 1 ha or more may take up to one day to survey.

To assess the conservation value of invertebrate assemblages a standard three minute hand-net sample should be collected, also following National Pond Survey methods. A description of the method is given in the guide to the methods of the National Pond Survey (Pond Action 1998). For an experienced invertebrate biologist a standard three minute sample (which refers to three minutes 'net-in-the-water' time) may take about one hour to collect, 8-12 hours to sort in the laboratory and 8-12 hours to identify at species level.

3.5 Assessing species 'richness' (the number of species), occurrence of uncommon species and calculating Species Rarity Indices

To assess species richness simply add up the total number of species recorded and compare to the value in Table 8.

To assess the number of local, nationally uncommon or Red Data Book species, note the number of these species occurring in the pond and compare to the values in Table 8. Species rarity is assessed by allocating a numerical rarity score to each plant and invertebrate species. The scores used for plants and invertebrates and their definition is given in Tables 9 and 10. The Species Rarity Index (SRI) is simply the average rarity value of the species at a site. It is calculated in the following way:

- All species present are given a numerical value depending on their national rarity status as shown in Tables 9 or 10.
- The values of all the species present are added together (to give a total rarity score).
- The total rarity score is divided by the number of species present at the site to give the SRI.

Once the calculations of species richness, occurrence of uncommon species or a Species Rarity Index value have been made, compare the values with those given in Table 8. This allows ponds to be placed in one of four conservation value categories (Very High, High, Moderate and Low).

When assessing conservation value put the pond into the highest conservation value category it can go into using any of the measures. In other words if a plant assemblage had only six species but a SRI of 1.2 (because it had a rare plant), it would have a HIGH conservation value. Note that in Scotland many sites may naturally have a low number of species; care needs to be taken to ensure that such sites are not assumed to be of low conservation interest.

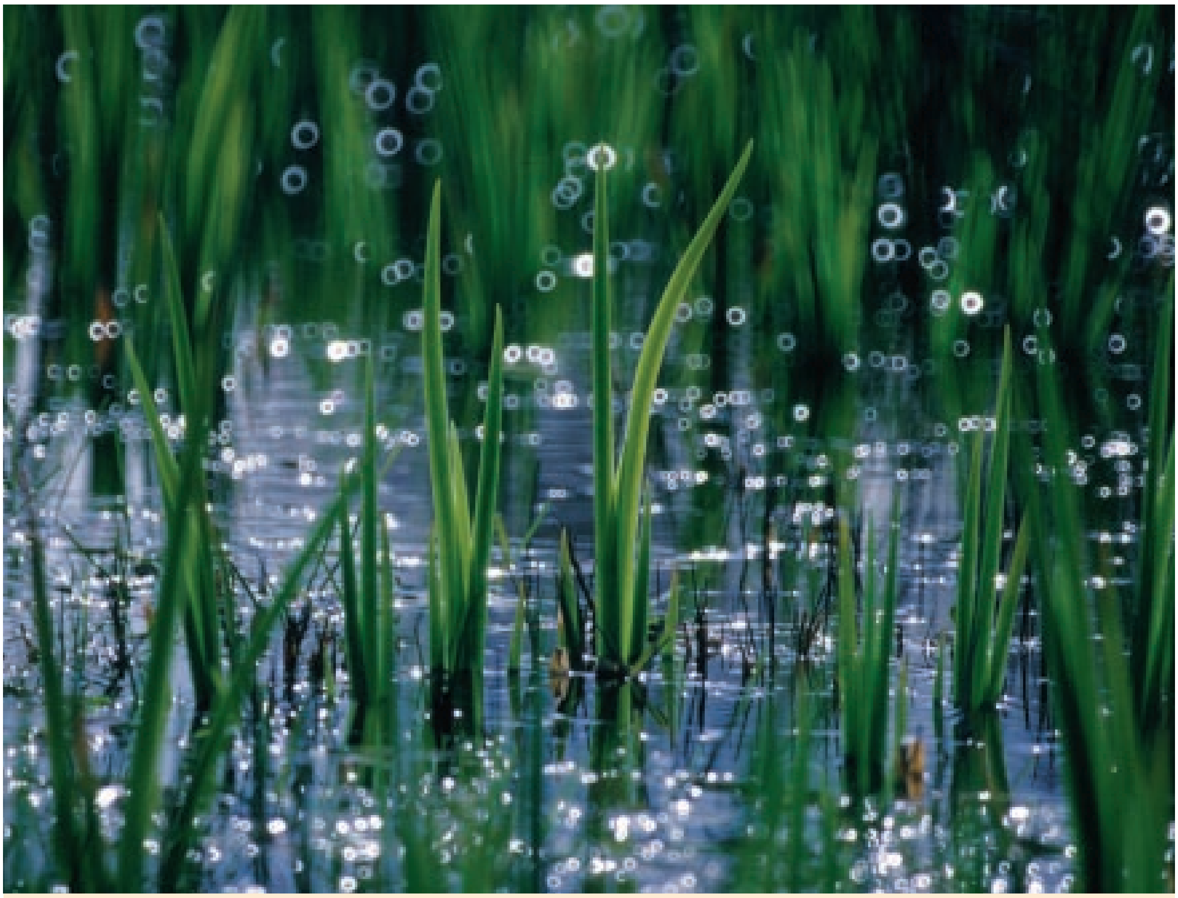


Figure 13. A standard NPS plant survey will take a skilled botanist 1 to 2 hours on a medium sized pond; large sites may take up to a day to survey. © *Graham Burns*

Table 8.

Provisional categories for assessing pond conservation value based on wetland plant and macroinvertebrate assemblages

Wetland plants:

Categories for assessing conservation value of ponds (based on the check-list of wetland plants in the National Pond Survey methods booklet).

Low	Pond with few wetland plants (8 species). Species Rarity Index score = 1.00 with no local[1], nationally uncommon[2] or Rare[3] species.
Moderate	Pond supports a below average number of wetland plant species (9-22 species) and/or below average number of local species (maximum of one local species). Species Rarity Index score = 1.01-1.24.
High	Ponds supports an above average number of wetland plant species (23 species) and/or 2 or more local species and/or Species Rarity Index Score = 1.25-1.49. No nationally uncommon or Red Data Book species.
Very High	Supports one or more nationally uncommon or Red Data Book species and/or an exceptionally rich plant assemblage (40 species) and/or Species Rarity Index score = 1.5 or above.

Aquatic macroinvertebrates:

Categories for assessing conservation value of ponds (based on a single season, three minute pond-net sample).

Low	Pond supports few invertebrate species (0-10 species) and/or Species Rarity Score = 1.00. No local[1], Nationally Scarce[2] or Red Data Book [3]species present.
Moderate	Pond supports below average number of invertebrate species (11-30 species) and/or Species Rarity Score = 1.01-1.24.
High	Pond supports above average number of invertebrate species (31-50 species) and/or Species Rarity Index = 1.25-1.49.
Very High	Supports one or more Red Data Book species and/or an exceptionally rich invertebrate assemblage (50 species) and/or Species Rarity Score = 1.50 or above.

1 Local: recorded from between 101 and 700 10 x 10 km grid squares in Britain; 2 Nationally uncommon: recorded from between 15 and 100 10 x 10 km grid squares in Britain; 3 Rare: listed in the UK Red Data Books.

Table 9.

Invertebrate species rarity terms and scores

Status	Score	Distribution
Common	1	Species generally regarded as common.
Local	2	Species either (a) confined to limited geographical areas, or (b) of widespread distribution but relatively low population levels.
Nationally scarce	4	Recorded from 16-100 10x10 km grid squares in Britain.
RDB3	8	Red Data Book: Category 3 (Rare).
RDB2	16	Red Data Book: Category 2 (Vulnerable).
RDB1	32	Red Data Book: Category 1 (Endangered).

Invertebrate RDB categories are not yet based on the new IUCN (IUCN, 1994) categories. It is likely that they will be modified as invertebrate Red Data Books are updated.

Table 10.

Wetland plant species rarity terms and scores

Status	Score	Distribution
Common	1	Species generally regarded as common. For wetland plants, these are species recorded from more than 700 10x10 km grid squares in Britain.
Local	2	Local species recorded from between 101 and 700 10x10 km grid squares in Britain.
Nationally notable B	4	Nationally scarce. Recorded from 31-100 10x10 km grid squares in Britain.
Nationally notable A	8	Nationally scarce. Recorded from 16-30 10x10 km grid squares in Britain.
RDB3	16	Red Data Book: Category 3 (Lower Risk).
RDB2	32	Red Data Book: Category 2 (Vulnerable).
RDB1	64	Red Data Book: Category 1 (Endangered and Critically Endangered).

Note: exotic species are given a score of 1, as are uncommon native species (e.g. Water Soldier, *Stratiotes aloides*) which are known to have been introduced to a site.

Figure 14. The horny orb mussel *(Sphaerium corneum)* is locally distributed in Scottish ponds, lochs and rivers
© *Pond Action*

3.6 Assessment of the conservation value of ponds using other groups of animals

Techniques are available for assessing the conservation value of ponds in terms of amphibians, dragonflies or water beetles alone.

Amphibian survey methods

Methods for surveying amphibians, and assessing the conservation value of amphibian populations, are given in the Herpetofauna Workers Guide (Gibb and Foster, 2000) and in the advisory leaflet 'Surveying for amphibians' published by the British Herpetological Society (BHS, 1996). Site quality can be assessed using the system developed for SSSI designation which is summarised in Table 11. For more detailed monitoring of amphibian populations (particularly newts), survey methods have been recommended by Griffiths, Raper and Brady (1996).

All exceptional great crested newt sites (which may comprise several ponds) are eligible for designation as SSSIs. For the other widespread species, exceptional populations with four out of the five native species are needed to qualify for SSSI status. Gibb and Foster (2000) describe the scoring system used by JNCC for identifying sites of high importance for amphibians. A simple identification guide to amphibians has been published by Froglife (1999).

Water beetle survey methods

Field survey techniques for water beetles are given in Foster and Eyre (1992). The conservation value of water beetle assemblages in ponds and other habitats can be assessed using the Species Quality Score system (see Foster and Eyre, 1992). A large body of data on water beetles supporting this method has been collected by members of the Balfour-Browne Club (contact address: see Appendix 1).

Dragonfly survey methods

Standard dragonfly recording methods are described by Brooks (1993). The British Dragonfly Society (BDS) records dragonflies at a range of sites in Scotland (contact address: see Appendix 1).

Figure 15. Frogs are widespread in Scotland: an exceptional population is one where more than 500 spawn clumps can be counted (see Table 11).
© *Graham Burns*

Table 11.
Assessment of pond conservation value based on amphibian population size

Standard survey methods described in BHS (1996) should be used to estimate the size of amphibian populations, allowing pond value to be assessed according to the criteria given below.

The survey method shown for each species is the optimum technique. The table indicates whether numbers of animals recorded should be regarded as low, good or exceptional populations.

Species	Survey method	Low population	Good population	Exceptional population
Great crested newt	Seen/netted in day Counted at night	Less than 5 Less than 10	5 - 50 10 - 100	More than 50 More than 100
Smooth newt	Netted in day or counted at night	Less than 10	10 to 100	More than 100
Palmate newt	Netted in day or counted at night	Less than 10	10 to 100	More than 100
Common toad	Estimated Counted	Less than 500 Less than 100	500 to 5000 100 to 1000	More than 5000 More than 1000
Common frog	Spawn clumps counted	Less than 50	50 to 500	More than 500

Natterjack toads are excluded from Table 11. All important and established colonies of natterjack toads are in sites with SSSI status where established means evidence of a viable colony over a period of 5 years or more and Important means: (1) all sites with more than 100 adults or 25 spawn strings for at least two of the previous 5 years; (2) all heathland sites; (3) the best or sole representative in a Watsonian vice-county (Gibb and Foster, 2000).

3.7 Future method developments - PSYM

In recent years a new method for assessing pond ecological quality (PSYM: the Predictive SYstem for Multimetrics) has been developed by the Environment Agency and Pond Action. At present the PSYM method is not available in Scotland as the relevant baseline datasets have not been collected. The PSYM method enables a surveyor to assess the overall quality of a waterbody using a number of aquatic plant and invertebrate measures (metrics)[7], which are combined together to give an overall waterbody quality value. The method is expected to be released for general use in England and Wales in 2000. Discussions are currently in progress to establish the databases needed to extend the technique to Scotland (Williams et al. 1996, 1998b; Biggs et al., 2000).

3.8 Assessing the archaeological and historical value of ponds

Information about the archaeological and historical value of ponds can be obtained from a number of sources, though at most sites it will be necessary to collect primary information. In general, to ensure adequate assessment of the quality of sites, professional archaeological advice should be sought (see contact addresses in Appendix 1).

Note that any activity which disturbs the ground surface of a site which is a Scheduled Ancient Monument, including the excavation of sediment, requires Scheduled Monument Consent from Historic Scotland.

Sources of information about the history of ponds are listed in Table 12 and may be accessed by non-specialists seeking to make initial enquiries about sites in which they have an interest.

Provisional criteria for assessing the historical importance of ponds were developed for the DETR Lowland Pond Survey and are summarised in Table 13.

[7] Metrics are measures such as species richness or rarity which can be used to help identify how damaged a waterbody's community is.

Table 12.
Methods for detailed investigation of the historical value of ponds

Documentary research: At the individual site level, detailed analysis of documents and maps can assist in interpreting identified archaeological remains. Examples of data sources which may be relevant include:

- Early maps e.g. Estate Maps (generally from 17th century onwards), Tithe and Enclosure Maps.
- Ordnance Survey maps (from 1800 onwards).
- 1930s Land Utilisation Survey.
- Aerial photographs (generally from 1940s onwards).
- Estate Records.
- Historic Scotland/SNH inventory of gardens and designed landscapes of special interest.
- Research literature relating to history and environmental archaeology (including literary references).

Assessment of aerial photographs: Aerial photography has been extensively used in the identification of archaeological features.

Fieldwalking: Methodical walking, usually of ploughed fields, collecting and plotting artifacts. Analysis of the material found and its distribution can indicate areas of settlements, burials or industrial activities.

Geophysical surveys: Sensitive electrical surveys used to locate buried features and designed to suit the scale of the project and the type of features suspected.

Test pits: Excavation of small holes down to bedrock usually done at regular intervals in areas of grassland, not available for fieldwalking. This process, with total or sample sieving of all soil, is designed to find artifacts and environmental information[8].

Trial excavations: Excavations of trenches to test the depth of stratification, and extent and survival of features on known archaeological sites

Sediment coring: Extensively used for environmental reconstruction, coring to collect biological and anthropogenic remains has been undertaken successfully on a variety of small shallow water bodies. This technique is also used to assess the likely impact of desilting ponds.

Table 13.
Provisional criteria for assessing the historical importance of ponds

Degree of significance	Criteria
National importance	• Outstanding examples in terms of the period, rarity, documentation, group value, survival/condition, fragility/vulnerability, diversity and potential.
Regional importance	• Sites which would not normally be regarded as outstanding examples which are still documented historical sites. • Present on a regional database.
Local importance	• Ponds typical of the local area or likely to have strong local associations e.g. marl pits. • Ponds that are little managed and likely to contain a valuable sediment record.

[8] Note that any test pits, trial excavations or sediment cores in scheduled Ancient Monuments require a license from Historic Scotland.

3.9 Assessing amenity value

Methods for assessing the amenity value of ponds were developed for the DETR Lowland Pond Survey and are now included as standard in the National Pond Survey (Pond Action, 1998).

Amenity value was assessed in the DETR survey in terms of (i) the visibility of the pond from public rights of way (ii) evidence of amenity uses of the pond (fishing, shooting etc.).

The visibility of the ponds can be assessed in two ways:

(i) in terms of visibility from areas to which the public has access as rights of way or to which open access is available, assessed on a 1 to 5 scale from 1 = view obscured to 5 = pond clearly visible;

(ii) the number of people likely to use rights of way, gauged in terms of their importance, with 1 = footpath to 5 = road.

Amenity use of ponds can be assessed from on-site evidence of the following leisure activities, which are simply recorded as occurring: fishing, shooting, ornamental fish keeping, keeping of wildfowl, pond dipping and other wildlife interests, boating, model boating and others. Assessing amenity use in this way provides a minimum estimate of use, since landowners are not directly questioned about the use to which ponds are put. However, it has the advantage of being much quicker than interviewing landowners.

3.10 Sources of biological data on ponds, pools and lochans in Scotland

A range of information is available from existing biological surveys on small water bodies in Scotland. These data sources are briefly summarised below.

Scottish Natural Heritage (SNH) botanical survey of Scottish freshwater lochs

The SNH botanical survey of Scottish lochs was undertaken between 1983 and 1998. Location, geological and other background data are held for all standing freshwaters recorded on OS 1:50,000 scale maps in Scotland (approximately 27,000 sites). Approximately 3500 of these were surveyed for their aquatic macrophytes of which several hundred were small waterbodies down to 0.1 ha in area. All data are held by SNH in a relational database which can be used to generate maps on a Geographic Information System (GIS).

Operation Brightwater Central Region Loch and Pond Survey

The Operation Brightwater survey of Central Region lochs and ponds was carried out between 1990 and 1992. Counts of ponds shown on 1:50,000 scale maps were made and detailed surveys undertaken at 30 sites. Plant and invertebrate survey methods followed those of the National Pond Survey (Lassiere, 1993).

National Amphibian Survey data from Scotland and on-going recording by members of the Herpetofauna Groups of Britain and Ireland (HGBI).

Amphibian data were collected from a range of sites throughout Scotland for the National Amphibian Survey which ran from 1988 to 1990 (Swan and Oldham, 1989, 1992). Data is held by JNCC at Peterborough. Survey work is also being undertaken by members of the Herpetofauna Groups of Britain and Ireland (HGBI) at various sites in Scotland. HGBI contacts are available from Froglife (see Appendix 1).

National Pond Survey

National Pond Survey data collected by Pond Action is available from approximately 30 minimally impaired reference ponds throughout Scotland, and from a further 10 partially degraded sites. NPS data will be publicly accessible through the National Ponds Database on the Internet (see below).

Biological Records Centres and BRISC (Biological Recording in Scotland Campaign)

Local Biological Records Centres hold data relevant to ponds and other small water bodies throughout Scotland. Contact local records centres for more information. Biological recording in Scotland is currently being coordinated through the BRISC project.

Balfour-Browne Club water beetle collections

Members of the Balfour-Browne Club have made collections of water beetles at a large number of sites in Scotland. Results of surveys are available in Foster and Eyre (1992).

National Ponds Database

Pond Action, in collaboration with a wide range of other organisations, is currently developing a National Ponds Database which will make pond data accessible over the Internet. The project is funded by WWF-UK.

The project is currently establishing a Phase 1 database at www.brookes.ac.uk/pondaction.

Contact points for each of the organisations mentioned in this section are given in Appendix 1.

Figure 16. The Scottish Natural Heritage botanical survey of Scottish freshwater lochs includes plant survey data from many small waterbodies between 1 - 2 ha. © *SEPA*

4. Management of ponds

4.1 Introduction

This section summarises the main principles of pond management, encompassing the need for the protection of both biodiversity and cultural heritage.

More detailed information on pond management is available in The Pond Book, available from the Ponds Conservation Trust (Williams et al., 1999).

4.2 Myths about ponds

Until quite recently, pond management for nature conservation was dominated by a series of myths about ponds. Most of these myths arose because of lack of information about the ecology of ponds. As a consequence management for wildlife was largely undertaken on the basis of what looked attractive to the human eye.

Although ponds that look attractive are often good for wildlife, some of the most valuable wildlife habitats can be visually unappealing. Dense stands of vegetation, heavily shaded ponds and ponds which dry out in the summer are often aesthetically dull, but can provide critical wildlife habitats.

Some of the more important myths about ponds are:

- **Drying out is disastrous for pond wildlife:** in fact occasional or regular drying out is natural for many ponds. Although drying out inevitably excludes some animals and plants (especially fish) a remarkably large proportion of freshwater species tolerate or require periods of drought.
- **Ponds should be at least 2m deep:** studies show that shallow water is normally the richest area for wildlife; deep water is not a requirement of all ponds.
- **All pond zones, from deep open water to shallow margins, should be created and maintained:** to maximise wildlife diversity in a pond it was long believed that creating different water depths in the same pond was the key; in fact, to maximise diversity it is better to have a mosaic of waterbodies of different depths and degrees of permanence.
- **The bigger the pond the better:** it was often thought that big ponds (because they often have more species) are automatically better habitats. In reality, small ponds may be very important habitats, and any pond from $1m^2$ upwards can support valuable species.
- **Ponds should not be shaded by trees:** gloomy shaded ponds often seem unattractive to human eyes; yet trees bring much to ponds, and many plants and animals are associated with wooded ponds.
- **Ponds should be dredged to prevent them from becoming choked with vegetation:** there is a long belief that ‘too much’ vegetation is in some way undesirable, choking ponds. In fact, there is no ‘right’ amount of vegetation for a pond; all stages of vegetation development form the sparse bare vegetation of new ponds, to the lush dense stands of a late succession pond are potentially valuable habitat. Perhaps the commonest pond management problem is too little vegetation, not too much.
- **Pond water-level fluctuations should be minimised:** alongside myths about drying out it was often thought that water levels should be stable all the year. In fact, water level fluctuation of 0.5 m or more is normal, and the drawdown zone created by this fluctuation is one of the richest areas of any pond.
- **Livestock should be prevented from having access to ponds:** the trampling of a small pond by a large herd of cattle in an intensive livestock operation is likely to be damaging. Yet ironically, gentle grazing pressure from a low density of livestock is one of the best ways of managing a pond, and should be encouraged.
- **Ponds are entirely self-contained systems, isolated ‘islands’ in a sea of dry land:** it has long appealed to biologists to think of ponds as isolated ‘islands’; in fact ponds are profoundly influenced by the land around them - their catchments - and constantly exchange plants and animals with neighbouring rivers, lochs, burns and wetlands.

A more detailed discussion of pond myths is given in Williams et al. (1999).

Figure 17. The drawdown zone - where water fluctuates between winter and summer - is one of the richest areas of any pond and is used in many different ways by plants and animals. Where possible, maximise the width of this area and take care that it is not damaged or destroyed during management. © *Pond Action*

Table 14.
Management of ponds: where to find information in this guide

Has the pond been surveyed? → **No.** Survey data is needed to guide pond management. See Section 3.

↓

Yes
Assess what type of management is needed (see Section 4.3 on planning pond management)

Is there evidence of pollution? → **Yes.** See Section 4.4 on techniques for controlling pollution.

↓

No
Is tree management required ? → **Yes.** Undertake gentle tree management. See Section 4.5.

↓

No

Is sediment management required ? → **Yes.** Implement sediment control or removal. See Section 4.5.

↓

No
Is vegetation management required? → **Yes.** Undertake gentle vegetation removal and monitor results. See Section 4.5.

↓

No
Keep a watching brief on the pond to maintain the status quo.

Figure 18. If you cannot do a detailed survey of a pond before management, maintain examples of all habitat types. For example, keep areas of leaf litter, fallen wood, different plant species and densities of plant stands. Don't manage ponds to fixed rules like 'dredge 1/3 of the pond at a time'; doing so may eliminate all examples of a particular habitat or vegetation type from the pond.
© *Pond Action*

4.3 Planning pond management

Box 1 summarises the main steps in planning and undertaking pond management. As this summary shows, pond management does not only involve invasive techniques such as dredging and removing vegetation. The best pond management is often based only on non-invasive methods such as survey, observation, protection of historical features or establishment of buffer zones.

Is it necessary to survey?

Without good survey information pond management will be undertaken blindfold and as much harm is likely to be done as good. Appropriate methods for gathering ecological and archaeological data are described in Sections 3, and these should be employed wherever possible.

Where survey information is not available this should severely limit the scope of any invasive management which is undertaken. In particular, there are many situations where the historical interest of ponds is most likely to be successfully maintained by doing nothing. If possible dig another new pond instead.

If pond management without supporting survey data is essential, useful rules of thumb in such cases are:

- Identify different habitat types: stands of emergent plants such as bulrush or bottle sedge; marginal grasses (especially the floating sweet-grasses *Glyceria* spp.); shaded areas; drawdown zones; areas of bare ground.
- Do not eliminate any of these existing habitats from a pond.
- If dredging, tree-felling or sediment removal are necessary (perhaps for amenity reasons), avoid drastic changes. In particular do not change more than about 25% of the existing site.
- Focus on protecting the pond from pollution as far as possible; in ponds fed by surface water, aim to install large buffer zones if they are not already present. Where possible re-route inflows draining roads or intensively farmed land.
- If managing more than one pond, consider the ponds as a group and try and maintain different types (deep, shallow and seasonal ponds, shaded and unshaded ponds, grazed and ungrazed). Avoid making all the ponds in an area look the same.

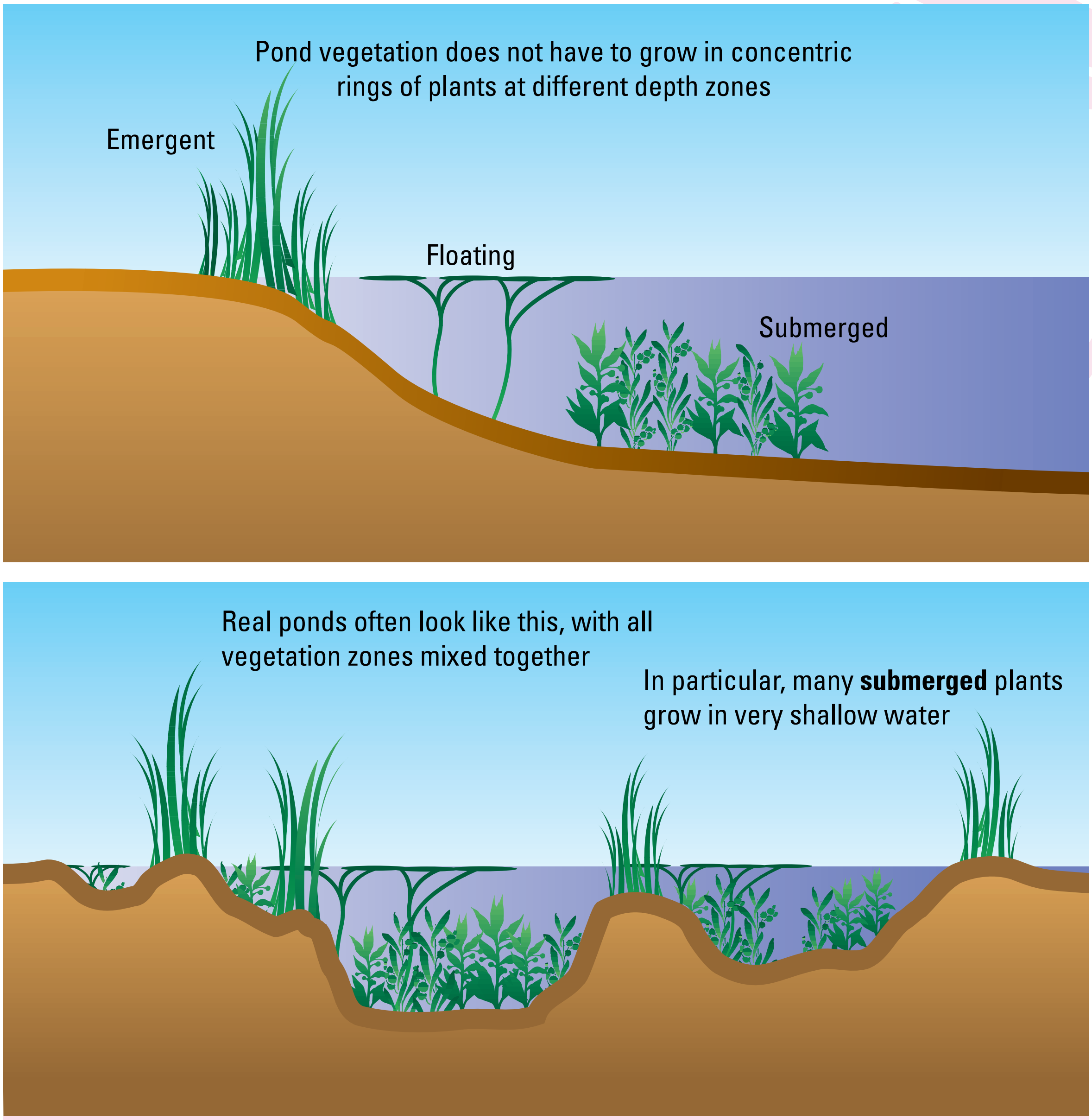


Figure 19. Encourage the development of rich plant mosaics. Rather than single concentric rings of emergent plants, floating-leaved plants and submerged plants, aim for complex mixtures growing at a variety of densities. It may be possible to encourage this by modifying the margins of ponds to make them broader and more undulating

Box 1. Planning and undertaking pond management

- Find out what is already known about the pond (conservation value, historical interest, archaeological importance). Discuss with local people what they think of the pond and how they use it.
- For most ponds, comparatively little or no information is usually available. This doesn't mean that the pond is of little interest, just that it hasn't been surveyed.
- If necessary, survey the pond using the standard methods recommended in this guide. Contract professional biologists or archaeologists to do this work if the group or organisation does not have the necessary expertise amongst its members. Management advice should normally be given in the light of detailed survey data.
- Prepare (or have prepared) a management plan for the site using the survey information collected and the objectives of the group responsible for the management of the site.
- If professional survey work is undertaken make sure that everyone is involved in discussing a draft version of the management plan before a final version is agreed.
- Some work may be carried out by carefully supervised volunteer groups; other work (such as rerouting road drains, herbiciding alien invasive aquatic plants) is likely to need professional contractors (if herbicides are being used, contractors must be licensed). All work should be carefully supervised, especially if any invasive management is planned (e.g. sediment or plant removal)
- Do management work a little at a time and monitor the results.

4.4 Pond management principles

Box 2 provides a summary of some of the key points to take into account when managing ponds.

In general, pond management can be divided into two different areas: catchment management and management of the pond. Traditionally, pond management has been almost entirely concerned with physical management of the pond itself - e.g. dredging out silt, removing plants, cutting down trees - with little attention paid to the catchment or its management.

In reality, the catchment profoundly influences pond type and quality, particularly the extent to which a pond becomes polluted. Ponds in non-intensively managed catchments will almost always be of high conservation interest whatever their physical state. In contrast, polluted ponds are almost always likely to be below their ecological potential - supporting fewer plant and animal species and few, if any, uncommon species.

Box 2. Key principles of pond management

- Wherever possible, undertake a survey before beginning any invasive management work such as dredging or extensive tree removal. Surveys are likely to be essential if (a) the pond is in a SSSI, or in an area of long established semi-natural habitat and is therefore likely to be of high quality (b) the pond is suspected of supporting protected species (c) it is likely to have archaeological interest with, for example, a continuous sediment record of 100 years or more (d) invasive management is likely to be required.
- Ponds in peatland systems, dune slack pools, dubh-lochans and other natural pools often need no more management than being protected from pollution and being allowed to go through the natural processes of succession.
- Water quality is critical to pond ecological quality: so reduce the intensity of land management in as much of the pond's catchment as possible. For example, install buffer zones around ponds, and along streams and ditches draining into ponds. The wider the buffer zone the better (10m or more) but buffer zones of 5m or less will give some benefits.
- Divert land drains from intensively managed farmland, roads and urban areas away from ponds, unless, of course, the ponds are specifically designed for water treatment.
- Avoid making all the ponds in an area look the same and avoid managing all ponds at the mid-succession stage - although often seen as the ideal (it is a rich environment), all stages of the pond succession from new ponds to seasonal late succession ponds provide valuable wildlife habitats for different species.
- In mature, late succession ponds more vegetation is likely to be better than less, and 75% or more cover of aquatic and emergent vegetation is fine.
- In general, don't remove marginal or aquatic vegetation from ponds unless it is clear what benefits will occur (e.g. maintaining areas of submerged and floating-leaved plants for dragonflies). Clearing ponds is often undertaken for amenity purposes, such as creating a better view over open water or increasing areas of open water for fish. Be aware, however, that where such management is extensive (i.e. covers more than one third of the pond) this may damage the pond's existing wildlife interest.
- When managing stands of vegetation (even single species stands of bulrushes or sedges) maintain variations in plant density - different densities of plants support different animal communities.
- Plant management is most effective where it encourages the development of complex plant mosaics. This may include locally thinning extensive stands of emergent plants to allow room for other plants to colonise and provide a greater variety of habitats for invertebrates and amphibians. However, take care not to destroy large stands of wetland plants completely. Management should never aim to eliminate a native plant species from a pond completely.
- Don't worry if shallow ponds dry out from time to time - the pond community is unlikely to suffer in the long term, and some species may benefit. In particular, don't panic and undertake extensive deep dredging which is likely to have much more damaging consequences.
- Don't make long established temporary ponds permanent.
- If dredging is required, go easy - try to remove no more than 1 m^3 (roughly three or four buckets of a JCB) a year for every $100m^2$ of pond area. So for a pond of $1000m^2$, remove no more than 10 m^3 sediment annually.
- Wherever possible allow natural colonisation; avoid planting countryside ponds with garden centre stock. With garden ponds, if planting is necessary introduce plants which grow wild locally and are not alien species.
- Where grazing is traditional, this is a very effective way of maintaining ponds; stocking densities should be low. There is no single ideal density, so obtain advice from FWAG, SWT or SAC for specific locations.
- Before removing any trees or shrubs from a pond consider what benefits they are bringing to the pond.
- Keep some areas of all existing habitats in a pond when managing it: fallen wood, areas of deep shade, leafy sediment, floating grasses at the pond margin, stands of bulrushes. This is especially important if biological surveys have not been undertaken.
- When in doubt, leave the pond alone. Create a new pond rather than managing an existing one.

4.5 Controlling pollution

The main pollutants affecting ponds

Pollution constrains the range of plant and animal species that can use a pond, and is the source of many of the most intractable pond management problems, including poor water clarity, algal blooms, duckweed cover and lack of submerged plants.

The main sources of pollution that impact ponds are summarised below. Table 15 summarises some of the effects of pollutants on pond wildlife. The use of ponds in Sustainable Urban Drainage Systems designed specifically to intercept and to control pollutants is described in Section 7.

Runoff from intensively farmed land. Runoff from intensively farmed land is likely to contain a variety of pollutants, particularly nutrients, various biocides (used in pest control and as veterinary medicines for grazing animals), sediments and organic matter. These may enter ponds by various routes, but ponds with ditch or stream inflows draining intensively farmed areas are particularly vulnerable. In fact, most ponds with an inflow in intensively farmed landscapes are likely to have unnaturally high nutrient concentrations and be exposed to intermittent or persistent biocide, sediment and organic matter pollution. Ponds near to farm buildings may also be contaminated by slurry from livestock, fuel spillages from machinery and leakages from chemical stores.

Urban runoff. Road runoff can contain a very wide range of pollutants including heavy metals (especially, lead, zinc and copper) together with oils and organic matter. In urban areas, where road run-off is supplemented by a cocktail of other pollutants surface water drainage can be as damaging to streams and rivers as untreated sewage (Gray, 1989).

The effects of diffuse urban pollution on the assemblages in ponds have not yet been systematically studied. However, evidence from surveys of urban balancing ponds in the National Pond Survey suggests that:

- open water habitats in balancing ponds are particularly badly affected by pollutants
- ponds with extensive areas of marginal vegetation (which is generally more resistant to pollutants) are likely to be richer habitats.

Because ponds trap pollutants contained in urban runoff they are often useful in Sustainable Urban Drainage Systems for retaining (and to some extent breaking down) pollutants.

Acid deposition ('acid rain'). For approximately 10% of the area of Scotland the deposition of acids is believed to exceed the threshold at which damage occurs to freshwater biota (SEPA, 1996).

Acidification can alter the structure of invertebrate assemblages and reduce salmonid (especially brown trout) biomass and abundance. It may also alter the vegetation composition of ponds, promoting increases in the abundance of acid tolerant plants.

Table 15.
The effect of pollutants on ponds

Nutrients. High levels of nutrients, causing eutrophication, exclude nutrient sensitive aquatic plants such as several of the *Potamogeton* species (e.g. long-stalked pondweed), and a variety of plants which require water with low nutrient concentrations (e.g. shoreweed, awlwort). Loss of plants is likely to have knock-on effects on animal populations. Nutrient pollution is also a common cause of dense growths of filamentous algae, duckweeds or water fern *(Azolla filiculoides)* and of algal blooms. Note that filamentous algae and duckweed are a natural part of the flora of many base-rich ponds and stands of filamentous algae, in particular, provide a rich habitat for invertebrates. In polluted ponds filamentous algae and floating-leaved plants may become dominant; when filamentous algae covers more than 50% of a pond, this is often evidence of nutrient pollution.

Organic matter. Still waters naturally accumulate organic matter. Many of the organisms found in ponds are well-adapted to an environment in which organic matter breakdown causes fluctuations in dissolved oxygen concentrations (for example, many pond invertebrates breath air at the surface). However, inputs of organic wastes from agricultural operations, septic tanks or other sources are likely to produce severe pollution owing to the small volumes of water available for dilution.

Biocides, micro-organics and heavy metals. The polluting effects of biocides, micro-organics and heavy metals are diverse, generally affecting both plant and animal assemblages. Toxicity data indicate that many chemicals have detrimental effects on aquatic organisms. Even approved chemicals, which have been licensed for use following standard laboratory-based test procedures, are generally tested on a very small range of organisms, making the ultimate effects of many unpredictable.

Acidification. Naturally acid waters in many areas of Scotland are vulnerable to acidification - the process by which rivers, lochs and ponds become more acid than they would be naturally, as a result of 'acid rain'. Although there are a wide range of plants and animals which prefer or require naturally acid water, many species of moderately acid waters cannot tolerate the increased acidity caused by acidification, or the toxic materials (especially aluminium) brought into solution as waters become more acid.

Silt (fine organic or inorganic particles). Ponds and pools naturally accumulate sediments and where these are derived from unpolluted streams and springs, trees or the breakdown of wetland plants this process is not harmful. Accumulating sediment is generally likely to be a problem where (i) it has an unnaturally high organic component and (ii) it carries silt-bound nutrients, heavy metals or other pollutants.

Oils. Oils can deoxygenate water as they are broken down, may inhibit diffusion of oxygen through the water surface and directly coat animals and plants causing injury or mortality. Oils also contain chemicals, such as polycyclic aromatic hydrocarbons, which are toxic to a range of aquatic organisms. Despite this, the precise effects of oils on natural waters are poorly understood as these chemicals are often present as part of a mixture of pollutants derived from surface water runoff.

Other pollution sources. Other potential sources of pollution for ponds include septic tank effluents, farmyard runoff into surface water drains and feeding of ducks and other waterfowl. Because of their small volumes and limited dilutions ponds are often more vulnerable to such small-scale pollutant sources than flowing waters or larger lakes.

Practical techniques for controlling pollution

The best way of preventing ponds from becoming polluted is to ensure that their catchments do not produce pollutants. Since most ponds have surface catchments that are relatively small, this is often quite feasible.

To minimise pollution impacts, ensure that as much as possible of the land that drains water into the pond (i.e. the land uphill of the pond) has semi-natural vegetation (e.g. extensive grassland, moorland) and is not intensively managed farmland or urbanised.

In ponds where it is not possible to maintain semi-natural vegetation cover over the whole catchment other useful options are:

- **Route any piped inflow from a potentially polluted source away from the pond**, unless the feature is intended to receive these flows as part of a Sustainable Urban Drainage System (e.g. detention basins, retention ponds and wetlands). Further details of the ecological design of sustainable urban drainage basins is given in Section 7.

- **Establish buffer zones around the pond**. It is difficult to recommend a single optimum size for a buffer zone to protect ponds from nutrients, biocides and other chemicals. However, in general, the wider the better.

  As a rough rule of thumb, a buffer zone of 30 m is likely to provide reasonable protection against many modern pesticides which become inert on contact with soils (e.g. synthetic pyrethroids) and pollutants transported in surface water (e.g. phosphates). Narrower buffer zones will also provide some protection, especially if the pond is surrounded by a barrier of tall vegetation and scrub. Even if a buffer zone of only 1 - 2 m can be created this will be better than having no buffer zone at all.

- **To eliminate phosphorus induced eutrophication**, it is normally necessary to reduce losses of phosphorus from the pond catchment to the point where the maximum soluble reactive phosphorus (SRP) concentration in the water is less than 0.10 mg/l[9]. On naturally acid and nutrient poor soils, soluble reactive phosphorous concentrations would naturally be below 0.01 mg/l.

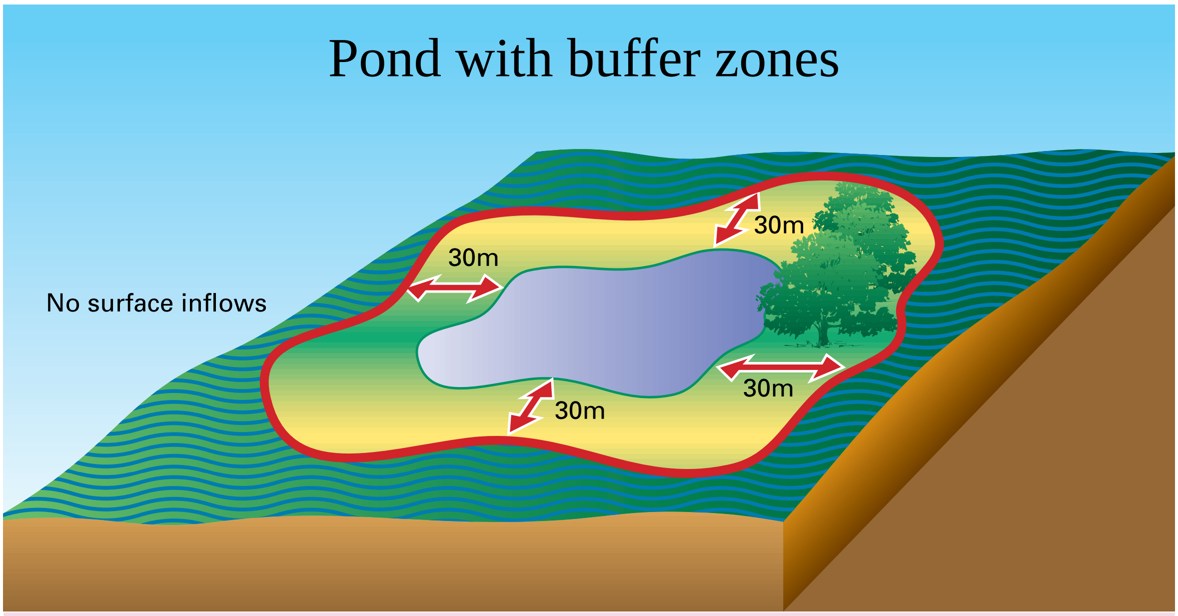


Figure 20. In intensive agricultural or urban areas make sure that each pond has a buffer zone around it to protect the pond from polluted surface water runoff.

[9] About 80% of 'minimally impaired' ponds in semi-natural landscapes in the National Pond Survey had SRP concentrations below 0.10mg/l in the spring (i.e. before plant growth takes up nutrients).

- **Remove sediments** where ponds have been receiving polluted sediments for some time, it may be necessary to remove completely those sediments to see any noticeable improvement in the quality of the pond.

- **Controlling filamentous algae is largely a matter of reducing nutrient levels**. This may require dredging-out of polluted sediments from the pond and removing nutrient sources from inflows to be effective.

  Alternatively filamentous algae may be treated using barley straw bales (Welch et al., 1990; Gibson et al., 1990). This method uses naturally occurring fungi which grow on the barley straw and release an algicide. Note that this method only treats the symptoms (acting in a similar way to a herbicide), and does not cure the original nutrient problem.

  When barley straw is used to suppress filamentous algal growth submerged water plants may sometimes return, although this cannot be guaranteed. If the physical structure provided by filamentous algae is only replaced with open water, a reduction in the abundance of invertebrate life in a pond is likely as filamentous algae is an excellent habitat for many small animals.

  Further information on the use and effects of barley straw are available from the Centre for Aquatic Plant Management (contact details given in Appendix 1).

- **To control planktonic algal blooms** it is preferable to reduce nutrient concentrations to levels at which blooms are no longer problematic. Where this is not possible, barley straw may also be used to reduce the abundance of planktonic algae (see above).

  Another alternative for controlling algal blooms in some ponds is to reduce fish abundance (a process known as 'biomanipulation'). Fish feed on the zooplankton (water fleas) that filter planktonic algae from the water. Where there are large fish populations the numbers of filtering water fleas are likely to be greatly reduced allowing algae to become more abundant. Removing fish reverses this process, leading to increased zooplankton abundance, more grazing of algae and clearer water. Very roughly, in nutrient rich ponds, fish biomasses above 100 kg per hectare may begin to have detrimental effects on the aquatic ecosystem through predation on zooplankton (and also on disturbance of water plants) (Martin Perrow, pers. comm.).

  There is currently no information available on the use or desirability of fish biomass manipulations on low productivity waters.

- **Preventing acidification by atmospheric deposition** is much more difficult and ultimately depends on national and international agreements to reduce air pollution. In Scotland some acidified lochs have been treated with lime to raise the pH for fisheries purposes. This is, however, unlikely to be a satisfactory solution for the management of acidification in the long term and has the potential to be damaging to other components of the aquatic flora and fauna.

Pond location and 'protective pond networks'

There is some evidence ponds located near to other wetlands (rivers, lakes, other ponds, wetlands) may recover from impacts more quickly than isolated sites.

Ponds in areas of long-established wetlands, or with other ponds around about, often have richer communities of plants and animals than those that are more isolated. It is probable that this is because, where other sites are close by, plants and animals are able to more quickly recolonise ponds temporarily damaged by physical management or intermittent pollution. Once the effects of these damaging episodes has passed, plants and animals can recolonise from adjacent waterbodies.

Where colonisation distances are larger, this is less likely to occur. In this context, 'close' proximity probably means less than 500m, perhaps less than 100m, from the neighbouring waterbodies.

This suggests that a pond's location can help to ameliorate some of the impacts of intermittent pollution or severe management (Williams et al., 1998a). Where ponds are near to other wetlands, or other ponds, they form a 'protective network' where some part of that network can become temporarily unsuitable for a species without it becoming completely extinct in the area.

Designers of Sustainable Urban Drainage Systems (SUDS) schemes may be able to exploit this phenomenon by creating habitat mosaics rather than single treatment basins (see Section 7).

Habitats to maintain in ponds

Figure 21. The surrounding land supplies part of the water supply for most ponds; if this is managed intensively the pond is likely to become polluted and it will never reach full potential. © *Pond Action*

Figure 22. All tall marginal plants have specific pond animal species associated with them; none are valueless, even vigorous and robust species like bur-reed (*sparganium*) and common reedmace *(Typha latifolia)*. © *Pond Action*

Figure 23. The drawdown zone shown here at low water level in a new pond is one of the most important areas of the pond; most management guides do not even mention its existence. © *Pond Action*

Figure 24. The edge and shallow water area of a pond is one of the richest parts; shallow water means 1 cm deep! © *Pond Action*

4.6 Physical habitat management

Is physical management needed?

Traditional pond management focuses on the physical management of ponds, mainly reversing successional processes, cutting down trees and deepening. However, before beginning physical management the first question to ask should be 'Is management needed?'.

Ponds do not automatically require physical management to retain their wildlife interest. The pond environment is an ancient and natural one and all stages of the pond succession are valuable, from new ponds through to late successional wooded or vegetated ponds. Consequently, it is easy to damage pond communities by poor or unnecessary management. Dredging out plants and sediments can, for example, destroy valuable animal and plant communities which have developed over many decades or even centuries.

Managing sediment

It is one of the most widespread myths about ponds that gradual silting up of ponds as succession proceeds is undesirable, and a large part of pond management has often focused on controlling and reversing this process.

The main effect of sediment accumulation is to reduce the depth of open water. As the pond becomes shallower, wildlife interest is likely to be less associated with open water and aquatic habitats, and more with marsh and swamp habitats. Since deep open water is a specialised habitat used by comparatively few species, removing sediment is not a crucial activity.

Silt traps

One of the best ways of managing silt in ponds is to reduce the amount that gets in to the pond in the first place.

Stream-fed ponds (whether on or off-line), fill up particularly quickly - often 10 to 20 times as fast as other pond types. Volumes of sediment carried by moving water can be surprisingly large. On entering a still water body, moving water will drop this sediment load as water movement slows down.

It has been estimated that the average sediment yield of a catchment in Scotland is 0.4 m^3 ha/year. Therefore a pond draining a catchment of 200 ha could expect to receive nearly 100 tonnes of sediment in one year. With sediment loads like this, typical infill rates in a stream-fed pond are often around 5-10 mm a year (although this will be less in grassland catchments with lower sediment loads).

An obvious way of avoiding such rapid infill rates is not to create stream-fed ponds. Alternatively, a silt trap can be installed to at least of slow down the rate at which sediment accumulates in the main pond.

Figure 25. There is no 'ideal' amount of vegetation for every pond. In many ponds a good rule of thumb would be 'the more the better'. Most reasons for removing plants are for purposes other than wildlife conservation (e.g. creating angling swims or providing views over open water for visual amenity).
© *Pond Action*

The design of silt traps should be longer than wide to allow water time to slow down; the suggested ratio of dimensions is length 3: width 1: depth 1. Vegetation at the downstream end can also help to trap sediment. Silt traps should be constructed to have fairly solid inlet and outlet sills so these are not eroded. Access for machinery is also valuable since the trap will need to be dug out periodically.

Note that SEPA has a general presumption against the construction of on-line stream-fed ponds because of the risk of downstream pollution (when ponds are desilted) and because of the risks associated with the construction of dams. This view is shared by a wide range of organisations concerned with the protection of wild fish stocks in Scotland generally because of the threat of interfering with fish migration, particularly when dams are involved.

Managing vegetation

One of the most persistent myths about ponds is that it is necessary to periodically remove plants to prevent them from becoming 'choked' by plants.

In reality, there is very little evidence that removing plants from ponds increases their overall value for wildlife - it just changes the community type. Conversely, it is clear that extensive removal of vegetation can certainly reduce the wildlife value of a pond. Indeed, one of the commonest problems with ponds is the absence of marginal and submerged water plants, often as a result of pollution or unnaturally high numbers of waterfowl or fish.

Some general principles for managing plants in ponds are included in Box 3. The general benefits of plants are described in Biggs et al. (1994) and in more detail in The Pond Book (Williams et al., 1999). In summary they are:

- Many wetland plant species are believed to be declining in Scotland; they often occur in small isolated populations and their removal from ponds will lead to the gradual erosion of biodiversity in many areas,
- Plants are vital for a wide range of animals and virtually every part of every aquatic plant species is used in some way by animals, from the flowers to the roots buried in muddy water,
- Aquatic and wetland plants are used by animals for egg laying, shelter, emergence sites, food, overwintering sites, pupation sites, nest sites and camouflage.

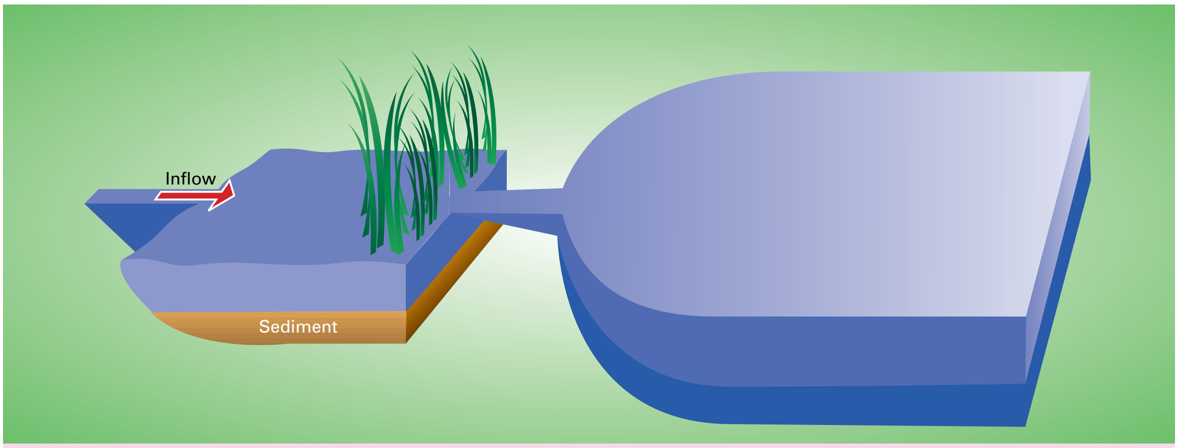


Figure 26. Silt traps are on-stream basins which slow down the water flow, allowing silt to be deposited and retained. If the basin is vegetated this can enhance the sediment entrapment process. Silt traps are a useful method for containing silt that would otherwise be carried into ponds by inflow streams. However, the traps still need to be dredged-out periodically.

It is obvious that the greater the surface area of a pond that is covered by plants, the more plant species there are likely to be found in the pond. The corollary of this, which is not so immediately apparent, is that removing vegetation from ponds is likely to result in loss of species. There are few instances where reducing the number of plant species in a pond is desirable (in contrast to reducing the abundance of some species - see below).

Figure 27. Well-vegetated ponds are usually rich in plant species; reducing plant cover may eliminate species from the pond. © *Pond Action*

Reducing plant abundance for nature conservation purposes is entirely justified in some specific cases including the management of ponds for great crested newts, dragonflies and uncommon marginal plants which may be outcompeted by other more robust species (e.g. pillwort, *Pilularia globulifera*).

- **Great crested newts:** where emergent vegetation in a pond eliminates all open water, which is used by great crested newts for breeding display, creating some clear areas may be beneficial. As a rough guide, the National Amphibian Survey showed that the highest occurrence of great crested newts was in ponds with emergent vegetation cover between 25% and 50% and submerged vegetation cover between 50% and 75% (Oldham, 1994).
- **Dragonflies:** many dragonflies hold territories and feed over open water fringed by emergent plants. Larval damselflies and some dragonflies are also common in submerged water plants. Thus, ponds completely covered by tall emergent plants may support fewer dragonfly species, and in smaller numbers, than more open ponds. However, note that dense stands of emergent plants are likely to be of value for other groups such as semi-aquatic invertebrates, water voles, and various wetland birds.

For further information on amphibians contact Froglife. Information on dragonflies is available from the British Dragonfly Society (for contact details see Appendix 1).

For advice on how to remove undesirable alien and nuisance plant species contact the Centre for Aquatic Plant Management. The Institute of Freshwater Ecology can also provide specific advice for the eradication of some highly invasive species such as New Zealand swamp-stonecrop *(Crassula helmsii)* (see Appendix 1 for contact details).

The value of grazing

Low-intensity grazing is generally one of the most benign, and natural, forms of physical management for plants in ponds. In many semi-natural landscapes high value ponds are maintained by gentle grazing - local FWAG, SWT or SAC staff can give advise on the ideal number of livestock units. Cattle are often regarded as the best type of animals for conservation grazing, but sheep and horses are often just as acceptable (at equivalent stocking densities). Note again that there is no detailed research information on the effects of grazing on ponds, so monitor the effects of grazing carefully when it is reintroduced to a site, or stocking densities altered.

Even in a landscape where there is intensive livestock husbandry, letting livestock have access for a few days a year may be a better form of management than permanently fencing animals out. Note that there may be a slight risk of pollution impacts from livestock treated with veterinary medicines to kill intestinal parasites, particularly chemicals of the avermectin group (including Ivermectin).

These chemicals have been shown to kill invertebrates in dung but their effects on small water bodies are unknown, especially when they get into the water via animal dung.

The impact of fish stocking

Fish are a natural component of the fauna of some permanent ponds, particularly those associated with river valleys and floodplains.

Roughly half of all freshwater plants and animals can co-exist with fish. This also means that there is a wide range of pond animals, including most amphibians (except toads), that survive better in ponds without fish. Consequently, fish stocking can be particularly damaging to small waterbodies, although the effects will vary depending on the species stocked.

Fish can be a particular problem in ponds when they are either:

- stocked in excess of the natural carrying capacity (e.g. in put-and-take trout fisheries), or
- added to permanent waterbodies where fish would not have occurred naturally. This includes many upland lochans and pools, from which fish would naturally have been absent since the last ice age.

In lowland, nutrient rich ponds, fish are generally likely to begin to have a marked impact on the physical environment of a pond when they reach numbers in excess of about 0.1 kg biomass per m^2 of pond area. This is often the situation in small garden ponds, where 20 or so fish in a pond of a couple of square metres are likely to eliminate all but microscopic plants and invertebrates.

In Scotland fish were, until added for angling purposes, absent from a large number of small upland lochans. There is little information on the impact of fish on the biota of these waters. However, in similar situations elsewhere, the introduction of fish has led to a profound decline in the abundance of dragonflies and other invertebrate groups.

Creating buffer zones

Ensure that as much as possible of the land that drains water into the pond (i.e. the land uphill of the pond) has semi-natural vegetation and is not intensively managed farmland or urbanised. This is not as difficult as it may sometimes seem, as ponds often (but not always) have small catchments.

Where parts of the pond catchment must be managed intensively aim to create buffer zones. See section 4.5 for more information on buffer zone widths.

Managing different types of pond

Management guidelines for different types of pond are given in Box 3.

Figure 28. Irresponsible releases of non-native fishes to ponds, pools and lochans in Scotland has caused considerable damage to native fauna and flora. Such activities damage the reputation of the vast majority of anglers who have done much to encourage the protection and wise management of freshwaters © *Lorne Gill/SNH*

Box 3. Managing the nature conservation interest of different types of ponds

Farm ponds, quarries, pits and other man-made ponds in lowland landscapes

Maximise the area of semi-natural vegetation cover in the pond catchments to reduce exposure to pollutants (e.g. from urban areas or intensive farmland); since pond catchments are often very small this is much more practical than is sometimes imagined. Where whole-catchment landuse cannot be altered, establish buffer zones to protect ponds from polluted runoff. In grassland systems, graze ponds at low density (seek advice from FWAG, SWT or SAC staff on appropriate grazing densities). Encourage the creation of new ponds to restart successional processes and replace lost ponds. Ensure that there is good semi-natural terrestrial habitat around the pond (scrub, grassland, woodland, moorland); the more extensive this area of terrestrial habitat the better.

Floodplain ponds

Maintain interactions with river systems (e.g. periodic flooding; groundwater flows). Maintain diversity of floodplain pond hydrological regimes (seasonal, semi-permanent and permanent ponds would naturally be present in many river floodplains). Protect from pollution: install buffer strips around groundwater fed ponds to intercept polluted surface runoff. Do not stock with fish at unnaturally high densities; floodplain ponds will naturally support fish populations. Allow natural river processes to create new ponds to provide a range of successional stages

Man-made and natural peat pools and dubh-lochans, upland pools and lochans

Maintain the natural hydrology of pools (see Conserving Bogs (Brooks and Stoneman, 1997)). Protect ponds from pollution: maintain catchments at low intensity, avoid application of fertilisers in catchments not normally fertilised. This includes soil disturbance, nutrient and biocide applications from intensive forestry in areas up-hill of ponds. Avoid fish stocking. Do not lime naturally acid ponds and pools. Do not dig out large areas of peat from late succession ponds unless this has recognised conservation benefits for specific species; late succession peatland habitats support a rich natural fauna and flora.

Temporary ponds

Maintain the hydrology of temporary ponds and protect ponds from pollution. Do not deepen temporary ponds to make them permanent.

Dune slack pools

Maintain the natural hydrology of dune slack pools (permanent, semi-permanent, seasonal). Protect ponds from pollution. Maintain low intensity grazing regime where appropriate. Prevent excessive groundwater abstraction where this threatens water levels in temporary ponds.

Ponds in semi-natural woodland (e.g. native pine forest)

Be aware of the range of small and temporary ponds often found in woodlands, for example: tree-throw pools in damp ground, stream-side pools, wooded flushes etc. Maintain the natural hydrology of forest ponds and pools. If necessary, manage some ponds to have varying degrees of shade from dense to light. Do not widely remove leaf litter and fallen wood from ponds.

New forestry plantation ponds

Establish pond complexes of varying size, permanence and with varying degrees of shade. Locate ponds near to other wetlands. Avoid routing runoff polluted by nutrients and biocides into all ponds. In highly acidic landscapes, some ponds may benefit from a limited amount of nutrient input - but try to avoid directing in polluted runoff from extensive plantation catchments. Allow wood and leaves to accumulate in some ponds.

Ponds created in Sustainable Urban Drainage Systems (SUDS)

See Section 7.

Figure 29. Man-made and natural pool in the uplands usually require nothing more than protection from pollution, drainage and fish stocking. © *RSPB*

4.7 The time and costs of pond management

Managing the pond catchment

Catchment management normally deals with large areas of land involving many different organisations and interests. For the ordinary pond enthusiast it can seem a daunting and technical process.

Fortunately, managing pond catchments is often much simpler because many ponds (although by no means all) have very small catchments. This means that a local group, or one landowner, may be able to influence and control the management of an entire pond catchment.

Typical catchment management activities that might be needed to protect or improve a pond include:

- getting highways authorities to route road drainage away from high quality ponds.
- tracing pollutant sources in the catchment of streams that feed into ponds and alerting environmental agencies of the need to control these pollutant sources.
- encouraging landowners and farmers to take up environmental grants which pay them to set up buffer zones around ponds.
- setting aside the whole of the pond catchment as a non-intensively managed zone - where fertilisers and biocides are not used, and semi-natural vegetation is allowed to develop. Since pond catchments are often tiny, this is wholly feasible.

Spend money on surveys, not physical management

It is often more cost-effective to spend money on good pond surveys than on dredging and or plant removal. Good surveys and effective advice can often reduce the cost of management work, through more effective targeting of effort. Obviously, they also provide information about the quality of a site which greatly refines the ability to manage it correctly.

Cost of management work

Examples of typical pond management work recently undertaken for the Ponds Conservation Trusts at demonstration sites around England, Wales and Scotland varied from £200 to £2500 per pond.

Work undertaken for the Trust included:

- Creating five small 1 m^2 pools in the drawdown zone of a large pond to provide additional habitat for a rare water beetle identified in a baseline survey: £100 or 5 volunteer person/days.
- Herbicide spraying by professional contractors to control invasive alien plants (e.g. *Crassula helmsii) :* about £5-10/m^2 of vegetation treated.
- Removing fish to improve water clarity and increase wildlife interest. This has the potential to earn income since angling clubs pay £1 to £2 per pound of fish they net from ponds. If fish are moved, ensure that transfers to another waterbody are licensed by SERAD.

- Removing small quantities (20 cubic metres) of sediment by hand from a marsh-filled curling pond to create local diversity: 50 person/days of volunteer labour.
- Selective coppicing of trees on 20 m of a pond margin: £500 (professional tree management).
- Installation of a dipping platform: £1000.
- Installation of interpretation boards: £1000+ per laminated noticeboard.
- Dredging. As a rough rule of thumb costs of dredging can be calculated assuming £1.50 per square metre of pond area for dredging, plus £1.50 per cubic metre of spoil taken off site. Note that excavators are normally hired by the day and many small ponds will need far less dredging than can be carried out in one day. Consequently, there is a temptation to over dredge sites in order to 'get ones money's worth'. When dredging small ponds mechanically identify several small jobs that can be done in one day.

If in doubt, think about creating a new pond instead. The costs are usually very similar and the advantage is that you end up with two ponds, helping to reverse the general decline in ponds numbers, maintaining the original pond in its late succession state and creating a new pond, which restarts the succession process.

Figure 30. Limited hand removal of emergent plants can often improve the visual amenity of ponds; it is also much less likely to cause damage to pond communities than dredging with machines. © *RSPB*

5. Pond creation

This section provides a summary of new information on the design and creation of ponds. More detailed information on all aspects of pond creation is given in The Pond Book (Williams et al., 1999).

Table 16.

Design of ponds: where to find information in this guide

- Summary of wildlife pond creation principles: Box 4
- Avoiding pollution: Section 5.3
- Pond shape and structure: Section 5.5
- Making fish ponds better for wildlife: Section 5.10 and Box 5
- Making wildfowl ponds better for wildlife: Section 5.10 and Box 6
- Designing SUDS ponds: Section 7

5.1 Introduction

The value of new ponds and wetlands in biodiversity conservation

Pond creation is a natural and effective method of managing ponds in the landscape. It is particularly valuable because it mimics the age-old processes of natural pond formation, creating new sites which can eventually pass through a range of successional stages, all of which will be exploited by freshwater life.
New ponds which are well-located and designed can rapidly become of considerable value for nature conservation. For example, a new pond complex at Pinkhill Meadow, Oxfordshire, supported approximately 20% of all the wetland plant and aquatic macroinvertebrate species found in Britain, only six years after its creation (Biggs et al. 1995, 1997). All of these species established by natural colonisation alone.

Different pond designs for different purposes

Ponds are created for many reasons: for wildlife conservation, for sporting activities such as fishing and shooting, and increasingly for a range of economic purposes such as irrigation and storage of urban runoff.

The sections below focus mainly on principles of pond design for nature conservation. However, appropriate designs for other functions are also outlined, together with information about how wildlife designs can still be incorporated into ponds where conservation is not the main objective. Special mention is made of the design of Sustainable Urban Drainage Systems (SUDS), (see Section 7), since these features are likely to become increasingly common in the next 5 to 10 years.

5.2 The three essential features of high quality wildlife ponds

Key principles of pond design are summarised in Box 4 and described in more detail in the remainder of this section.

There are three key factors which are critical to the creation of high quality wildlife ponds and all aspects of pond design can essentially be summarised under three headings:

- unpolluted water
- close proximity to other wetland or freshwater habitats[10]
- a varied design.

If a new pond can combine any two of these factors, it is likely to develop a good wildlife community. If all three can be incorporated, then the communities that develop are likely to be outstanding.

[10] It is essential that in the process of locating new ponds close to existing freshwater habitats, no damage is done to those wetlands. Don't dig up bogs, pools, springs or flushes to make new ponds, unless this is part of the traditional management of a site.

Box 4. Key principles for pond creation

- Locate new ponds to avoid or minimise exposure to water pollution. If possible create new ponds in areas where their catchments can be managed non-intensively - a good place to create a new pond is anywhere that unpolluted water can be guaranteed; a poor place might be (for example,) the corner of an arable field where the pond will drain nutrients and sediment from the field, and be exposed to biocide impacts. Box 10 provides special guidance on sustainable urban drainage system ponds which are designed to hold and treat contaminated surface water run-off.
- Dig trial holes before the pond is created to determine where water levels will be and what the substrate is like.
- Unless the pond is in a catchment with non-intensive landuse, avoid linking the pond to inflowing streams and ditches - these will create pollution problems in the long term by bringing in polluted water and sediment and may obstruct fish migration. Note that SEPA does not recommend the construction of on-line stream-fed ponds.
- Where possible, create new ponds close to existing wetland areas (streams, fens, ditches etc.) but don't dig up existing wetlands (e.g. flushes, wet meadows, springs, temporary ponds) to make new ponds.
- Design ponds with natural wetlands in mind: create pond mosaics and wetland complexes rather than single isolated waterbodies.
- Focus on the edge habitats and maximise the extent of the drawdown zone (the area between the winter high water level and the summer low water level).
- Most slopes at the edge of the pond should be very shallow; a gentle slope is 1 cm every 1m (i.e. 1:100). To maximise the extent of the drawdown zone dig down to just above the winter water level in dry ground (beyond the outer boundary of the pond) and then create very gently sloping drawdown area.
- Create 'hummocks and hollows' in the drawdown zone to maximise the hydrological diversity of this rich area.
- To maximise species diversity, vary the main factors influencing community type at any pond site i.e. water depth, water permanence, pond area.
- Make a particular effort to include (i) very shallow pools with a depth of no more than 5 cm (ii) temporary ponds as well as semi-permanent and permanent ponds.
- Keep shallow and deep water pools separate - they can be as little as 1-2 metres apart but should not all be permanently connected (except, perhaps in winter high water conditions).
- Vary the size of water bodies as much as possible - the smallest that you can easily create with a mechanical digger is about 0.5 metres diameter.
- Islands are valuable for birds, and where the margins of the pond are shaded, heavily trampled or grazed, they can provide a different kind of habitat for invertebrates and wetland plants. However, keep most low and wet, i.e. mostly submerged in winter. High islands block views for birds and people and quickly become wooded.
- Deep water (1 to 2 metres or more) is a specialised wildlife habitat most likely to be needed where fish or waterfowl are key objectives of the new pond. In the more remote areas of Scotland, where water quality is good, deep water bodies may also be valuable for some rare plant species.
- Planting up is rarely necessary for ecological reasons, as colonisation is usually rapid (especially when other wetland habitats are within 1-2 km, or less). The 'new' phase pond is also a particularly valuable habitat for specialist 'new pond' plant and invertebrate species.
- If planting-up of ponds is essential (e.g. in urban conservation schemes where it is important that something is seen to be happening very quickly), always use native species of local provenance.
- Expect to take time - pond creation is often best considered as at least a two-phase process, with fine-tuning of the structure made 1 to 2 years after the first construction phase.
- Ensure that some effort is allotted to pond management during critical early colonising stages, to ensure that one or two species of plant don't dominate the new site.

5.3 Water sources for new ponds

Getting good water quality

The best design feature to give any new pond is a location where its water quality is going to be protected in the long term. With good water quality any pond (whatever its shape and structure) will eventually develop a high-value wildlife community. A pond which receives polluted water is, in contrast, unlikely to ever achieve its full wildlife potential (although design can offset some of the impacts of pollutants).

If a pond is badly polluted then it will almost certainly give long-term management problems: a characteristic of ponds is that they accumulate pollutants with age, so non-degradable pollutants that enter ponds (phosphates, heavy metals, persistent biocides) gradually build up as the pond ages. This leads to a progressive deterioration in water and sediment quality, fewer species and the beginnings of difficult problems like nuisance levels of algae, water fern or duckweed caused by gradual enrichment by nutrients. Pollution problems like these can really only be solved if all polluted sediments are removed and external pollutant inputs reduced.

It is critical, therefore, that new ponds which are created mainly for wildlife conservation are located so that the quality of the water they receive is as high as possible. For ponds which are specifically created to treat contaminated surface water runoff, wildlife potential will be enhanced where specific measures are taken to maintain good water quality in at least some areas associated with the waterbody (e.g. marginal pools, series of ponds etc.) (see Section 7).

The main water sources for ponds, and methods for ensuring these water sources are clean, are discussed below.

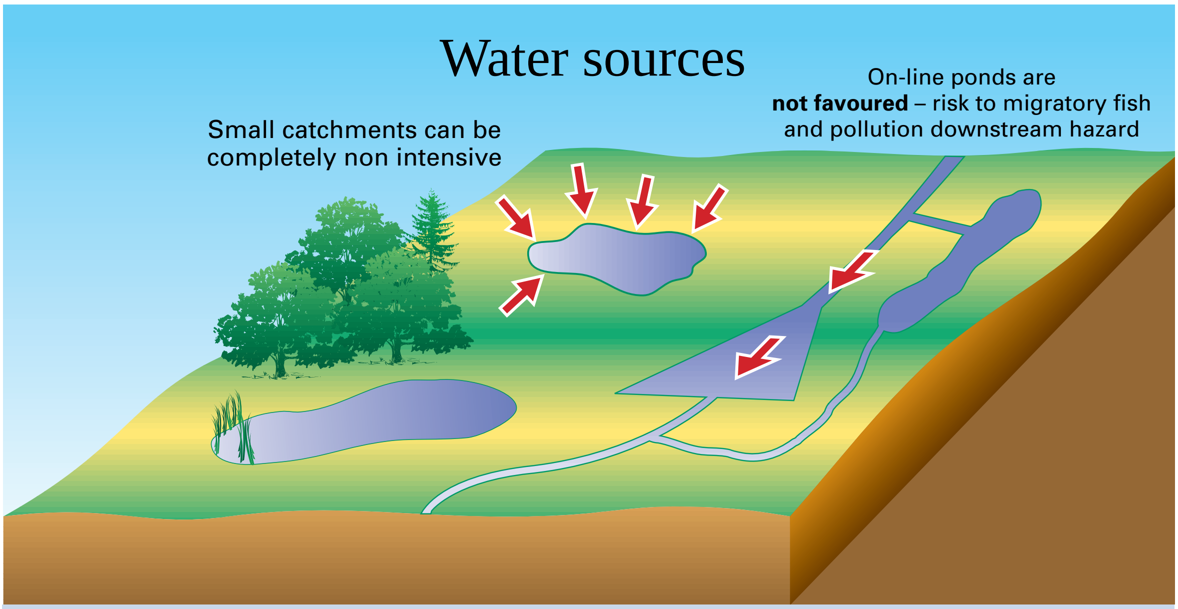


Figure 31. Ponds can be fed by a variety of water sources including surface water, groundwater and ditch or stream inflows.

Apart from rainwater, there are three main sources of water for ponds: (i) groundwater, (ii) surface runoff and (iii) inflows. Individual ponds may be fed by one or more of these water types and the importance of each may vary during the year.

Surface water

Surface run-off can provide some of the best, and some of the worst, quality water for new ponds, depending largely on the naturalness of the pond's catchment. In agricultural and urban areas, surface water quality is often highly degraded, with high levels of soluble pollutants (nitrate, biocides etc.), together with phosphate, organics, hydrocarbons, oils and sediment-bound toxins which are washed-in with soil particles. Because surrounding landuse exerts such a strong influence on the quality of run-off, surface water ponds are best located in semi-natural landscapes; where this is not feasible, the aim should be to control pollution sources in the drainage area around the pond (for example, by minimising pesticide usage) and to install buffer zones to intercept pollutants before they reach the pond.

The special case of SUDS ponds, which are designed to receive and treat contaminated surface water runoff from urban areas, is discussed in Section 7.

Groundwater

In intensively managed landscapes such as urban or arable areas, groundwater ponds are often less polluted than their surface water counterparts. Groundwater is, of course, not always pollutant-free, but it will at least have been pre-filtered subsurface before reaching a pond, removing sediment borne pollutants. In addition, since groundwaters move (albeit slowly), soluble pollutants entering a pond from surface runoff or inflows are continually diluted and carried away. For these reasons, groundwater ponds may sometimes support high quality wildlife communities even where their surroundings are degraded.

How to avoid pollution problems in new ponds

In designing ponds the best way to determine whether a new pond is likely to be polluted is to check the pond catchment for pollution sources.

Pollution sources include:

- streams, ditches or surface run-off draining arable farmland or intensive grassland (nutrients, biocides)
- spray drift from adjacent farmland (biocides)
- runoff from the farmyards of livestock enterprises
- streams, ditches or surface run-off draining forestry plantations (may be acidified, can produce very large sediment loads from clear felling operations and trackway erosion which carries nutrients from fertilisers used to promote tree growth)
- treated sewage effluent inputs
- leakage from diesel and oil stores
- drainage from road-runoff or urban areas (a wide range of pollutants)

Unpolluted waters supplies may be found in:

- non-intensively managed grassland (i.e. less than 50 units of nitrogen applied annually)
- groundwater (particularly in areas where it is not polluted by nutrients)
- water draining from extensive semi-natural woodland, scrub, moorland, heathland or bogs.

How big an area is needed for an unpolluted surface water supply to a pond?

Comparatively tiny areas of non-intensively managed land can supply enough water for a good sized pond.

For example, 1 ha of land receiving 1500 mm of rainfall annually (the Scottish average) will receive about 15000 m^3 of rainfall during the year. Assuming that half of this is lost through interception and evapotranspiration about 7500 m^3 of water remains.

A pond with a surface area of 500 m^2 and an average depth of 0.5 m holds 250 m^3 of water - i.e. 1/30th of the volume available from 1 hectare of land.

Calculations for dew ponds - i.e. clay-lined ponds fed by runoff from the surrounds - suggest that a pond will hold water during the summer if it has a surface catchment approximately twice the surface area of the pond. So, a circular pond with a surface area of 100 m^2 needs only a further 5 m all around it as collecting area to remain wet in most years.

Figure 32. Jeremy Biggs, Joanna Drewitt, Katherine Bradshaw and Baroness Hilton inspect pond animals at Pinkhill Meadow Experimental Wetland site (Oxfordshire). © *British Dragonfly Society*

Inflows and drains

Creating ponds that are linked to a temporary or permanent inflow always needs careful consideration because of its numerous disadvantages. In general, SEPA aims to discourage creation of on-stream ponds.

The quality of water in stream or ditch-fed ponds will reflect the quality of the inflow catchment and, in lowland Scotland (as elsewhere in Britain), most streams, rivers and ditches draining farmland and urban areas are polluted to a greater or lesser extent, especially by nutrients, and perhaps also by biocides. Overall, where a stream inflow is possibly polluted, it is best to avoid it. Note that a widespread myth in pond creation is the idea that ponds need an inflow to ensure that they do not become stagnant and unsuitable for wildlife. In fact, nothing could be further from the truth. Pond plants and animals are specifically adapted to live in still water. Ponds with inflows, will usually support a different biota but not a better community to ponds without.

In addition, on-stream ponds have a range of other problems associated with them. They often have significant construction costs and management requirements (e.g. flood spillways, fish passes). Ponds fed by streams or ditches draining all but the most pristine landscapes will quickly silt up - a pond with an inflow typically fills in 10 to 100 times as fast as one without. Consequently, these ponds need more frequent desilting than other pond types. This desilting can result in downstream pollution in any subsequent dredging operations.

5.4 Wetland locations for new ponds

Good places for ponds

There is evidence that siting new ponds near to existing waterbodies and wetlands is beneficial. In natural and semi-natural landscapes ponds rarely occur in isolation but are typically part of a wetland complex, in close proximity to wet habitats such as streams and their floodplains, wet woodlands, springs, seepages, mires or other ponds and pools. In these situations, water bodies may be no more than a few metres apart, and are often linked seasonally.

Increasingly, it is clear that designs for new ponds can be improved by simulating this natural connectedness of ponds and other wetlands. Even remote and isolated new sites will colonise with pond plants and animals. But new ponds will generally become richer if other wetlands are nearby.

In locating new ponds, it is also important to ensure that surrounding terrestrial habitat is of high quality; many pond animals spend part of their life cycle on land (e.g. amphibians, dragonflies) and have specific terrestrial habitat requirements. Again locating ponds near to existing high quality habitats is a good approach; alternatively, allow the pond surroundings to develop good natural vegetation (e.g. scrub, woodland, unfertilised tall grassland, heathland, moorland).

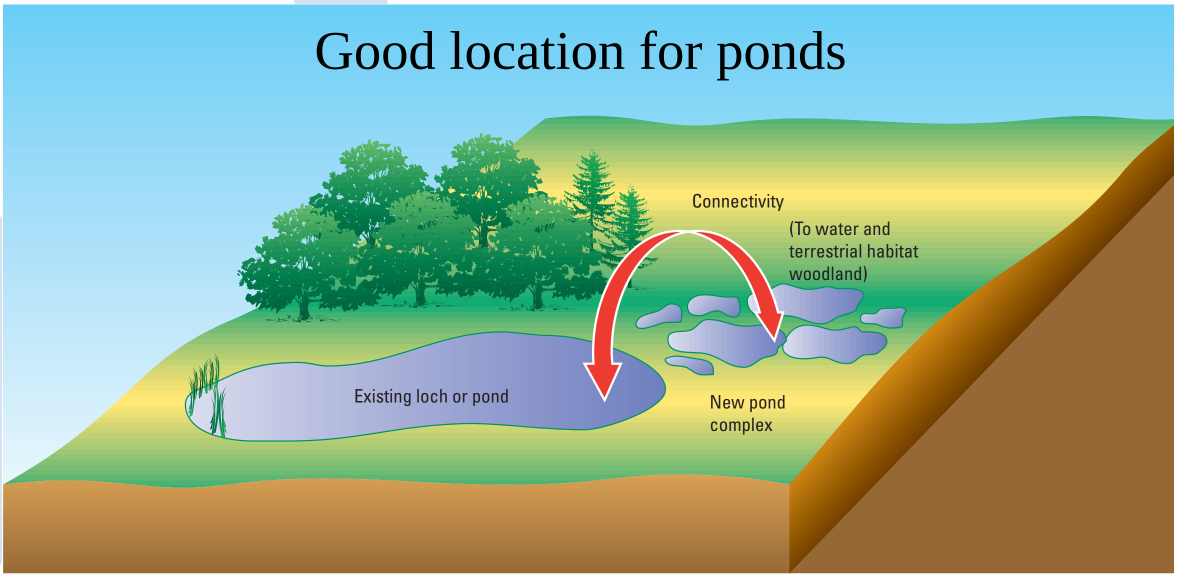
Normally the best ponds will be completely surrounded by high quality semi-natural vegetation but any semi-natural terrestrial habitat will be better than none. For a 1000 m^2 pond, aim to have as a very minimum 0.5 ha of non-intensively managed land within 500 m of the pond. For specific information about the terrestrial habitat requirements of great created newts and natterjack toads see the practical manuals by Froglife (2000) and Beebee and Denton (1996), respectively.

Poor places for ponds

It is essential to undertake sufficient survey work to ensure that the new pond does not replace a more valuable habitat, wet or dry. So do not dig up an existing wetland to make a pond.

Equally, care needs to be taken to ensure that the new pond does not alter the hydrology of an existing site by, for example, increasing evapotranspiration, or where groundwater is under hydrostatic pressure, by flooding adjacent areas. In general, it is usually safer to dig the new pond close to, but not directly linked with, the existing wet area.

Figure 33. Create new ponds in areas where they are protected from water pollution and close to other high quality terrestrial habitats such as woodland, scrub, unfertilised grasslands or other ponds. © *Pond Action*



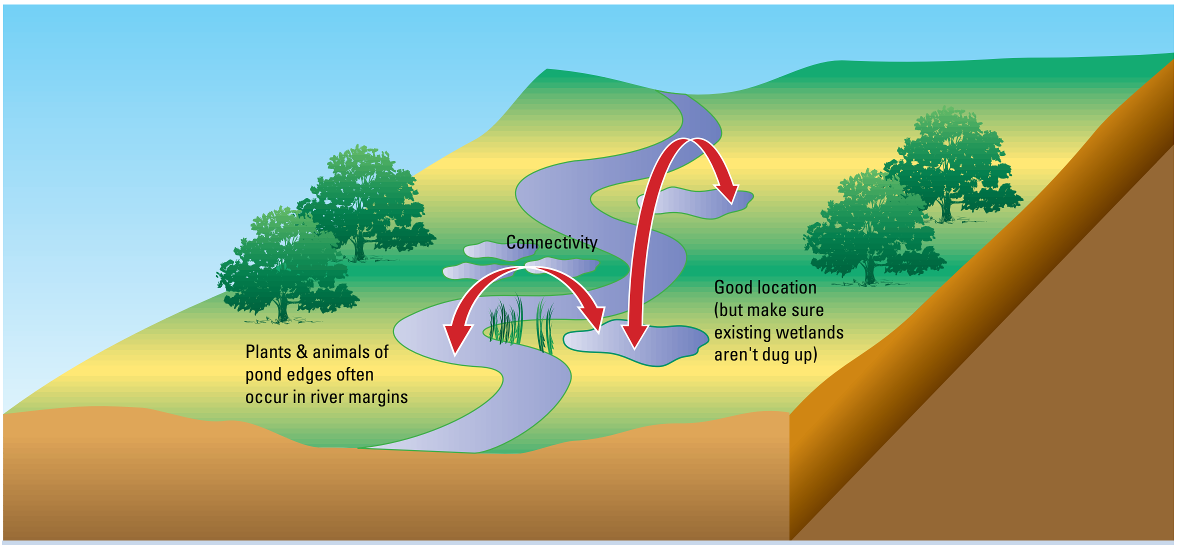


Figure 34. If possible locate new ponds in areas near to other wetland areas like rivers, marshes, wet woodland, ponds and ditches. This will help the pond to colonise rapidly with plants and animals. However, make sure that existing high quality habitats are not damaged in the process.

5.5 Good pond design

By looking at semi-natural wetlands and considering the preferred habitats of pond-dwelling species it is possible to improve some aspects of the detailed design of wildlife ponds. Some of the best ways of doing this are described below.

Make pond mosaics - creating new wetland complexes

Pond depth and permanence (and probably waterbody size) are major influences on pond community types. Varying these factors at a site, to create habitat mosaics with a mixture of permanent, semi-permanent and seasonal pools, makes it possible to provide habitats for a far greater variety of wildlife than could be accommodated in a single waterbody. Creating such mosaics is usually possible in all but the smallest pond creation schemes.

Include extensive areas of shallow water, undulating microtopography and drawdown

In most ponds, water rises and falls between winter and summer creating a drawdown zone of variable wetness. This land-water transition zone is an area of potentially high biological diversity in any pond (see Figure 17).

Lack of information about the importance of the drawdown zone has meant that, in most new ponds, it is rarely considered during the design process and it is therefore usually restricted to a narrow strip at the water's edge. Extending the drawdown zone, to give an extensive area of marshy or muddy habitat in summer, will considerably improve a pond's potential particularly for marginal, shallow water and semi-terrestrial plants and invertebrates.

Drawdown zones do not need to slope evenly down to deeper water. Centimetre scale variations in water levels and waterlogging, caused by subtle irregularities in the ground surface, should lead to major variations in plant community type.

In pond construction, there is an opportunity to simulate this small scale topographic variation by careful physical shaping of the drawdown zone. By extending the

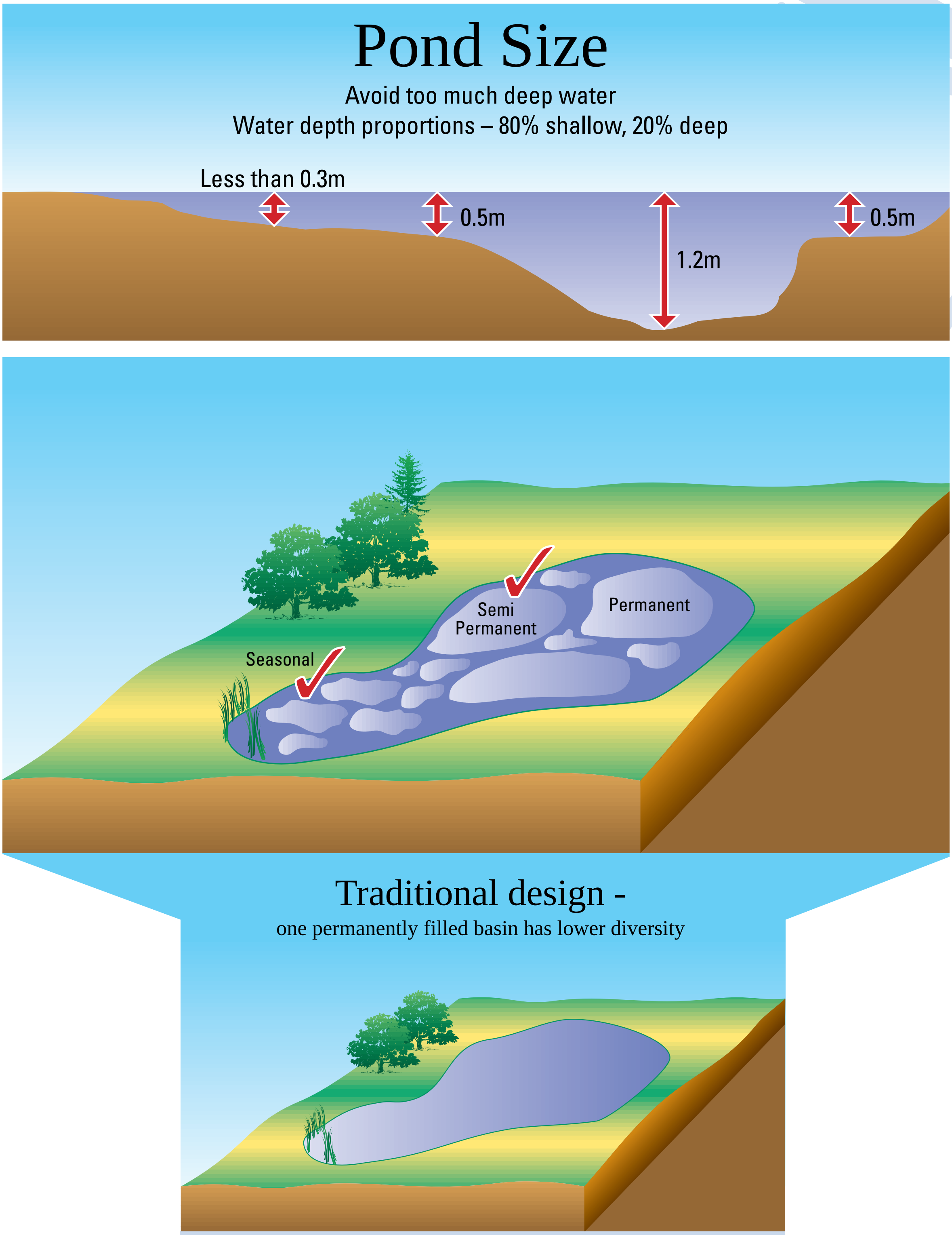


Figure 35. When designing ponds focus on creating pond complexes rather than a single pond. If possible include deep, shallow and temporary pools. This will help to maximise the number of plant, amphibian and invertebrate species that the site can support.

drawdown zone and areas of shallow water to include a patchwork of hummocks and pools of varying water regimes we can create a rich mosaic of small-scale habitats for plants and animals.

Use deep water sparingly

Deep water (1 to 2 metres or more) provides a relatively specialised wildlife habitat that typically supports relatively few species. From a wildlife perspective there is, therefore, no imperative to incorporate deeper water areas into pond creation schemes. The commonest exceptions to this are (i) projects where fish or wetland birds are the primary objective of pond creation, (ii) in some of the more remote parts of Scotland, where unpolluted, clear, deep water, could be created providing valuable habitat for a diverse and interesting range of submerged plant species (and associated invertebrates) including some of the rarer stoneworts and pondweed (i.e. *Potamogeton)* species (Stewart 1996).

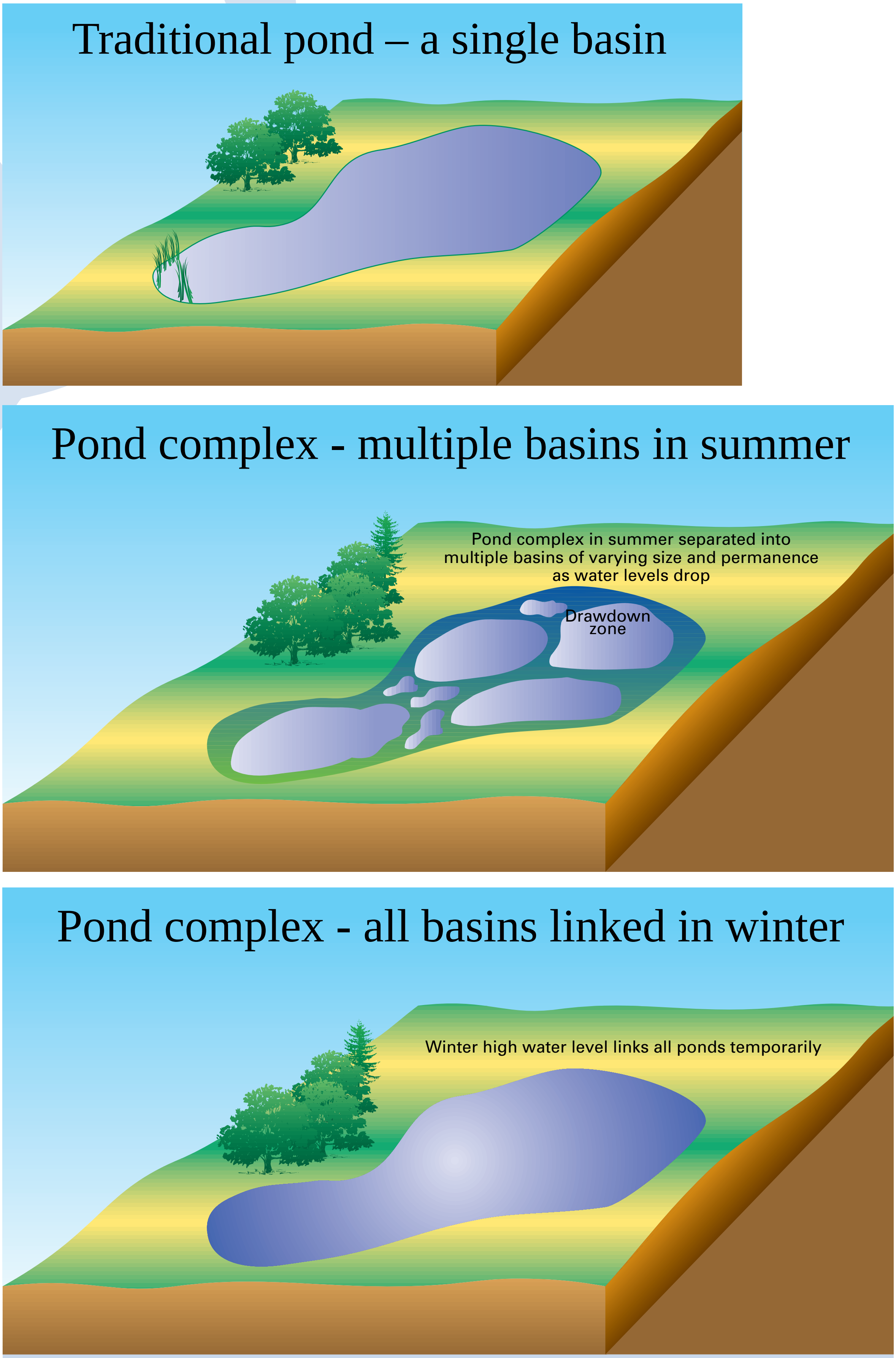


Figure 36. For individual ponds, create extensive undulating margins and complexes of sub-basins to maximise the diversity within each waterbody.

Introduce islands into large ponds

For plants and invertebrates, islands are most likely to be of value where the margin of the pond is shaded, grazed or trampled and the islands provide a different set of habitats.

For birds, islands are particularly important, providing safe areas for feeding, roosting and nesting in larger ponds. So, where wader or waterfowl conservation is the main purpose of pond creation, islands are certainly valuable.

Specific advice on island design for birds is given by Andrews and Kinsman (1990). More general points are:

- Height above water level will determine vegetation type: if islands are low they can also be a wetland habitat
- Gentle slopes near water level, and banks that are partly submerged, will give muddy areas for summer/autumn feeding
- Occasional islands with steep bank areas may provide additional habitat for water voles (Strachan 1998)
- Locating islands at least 4 to 5 m away from the bank and maintaining deep water around them, at least a metre or so, will provide birds with some protection from predators, but greater distances are better
- Islands near to the centre of water bodies will feel safest for most birds. Some wildfowl also prefer islands incorporated into reed beds.

Use wind direction

In larger ponds (i.e. waterbodies greater than about 30m x 30m), wind-blown waves can have quite a marked effect.

A potentially beneficial wind effect is that it blows seeds, spores and animal eggs across the pond and concentrates them. The prevailing wind direction in Britain is broadly from the SW, so this means that the NE margins are usually the best provided. The disadvantage of exposed shorelines is that wind-blown waves erode the bank, giving it a sharp edge which is often relatively inhospitable to wildlife.

A way round problems caused by wave action is to create a very undulating and embayed NE margin to the pond which will colonise-up from the good supply of seeds, but is protected from wave erosion. Very narrow-necked pools work particularly well, especially where their entrances to the main waterbody are off-set so that they do not face the prevailing wind.

Similarly, the front edge of islands can be protected from waves by creating a submerged bar (or reef) with a lagoon behind along the island's SW margin.

Retaining bare mud

Bare pond edges may look dull and lifeless, but are valuable for wading birds, many annual wetland plant species and a range of aquatic and semi-terrestrial invertebrates. There are, therefore, times when muddy areas need to be created, and more problematically, to be retained. Grazing or trampling (by stock, wetland birds or people) are obvious means of constantly creating muddy zones. But where this is not possible, design can help to encourage the retention of bare open ground.

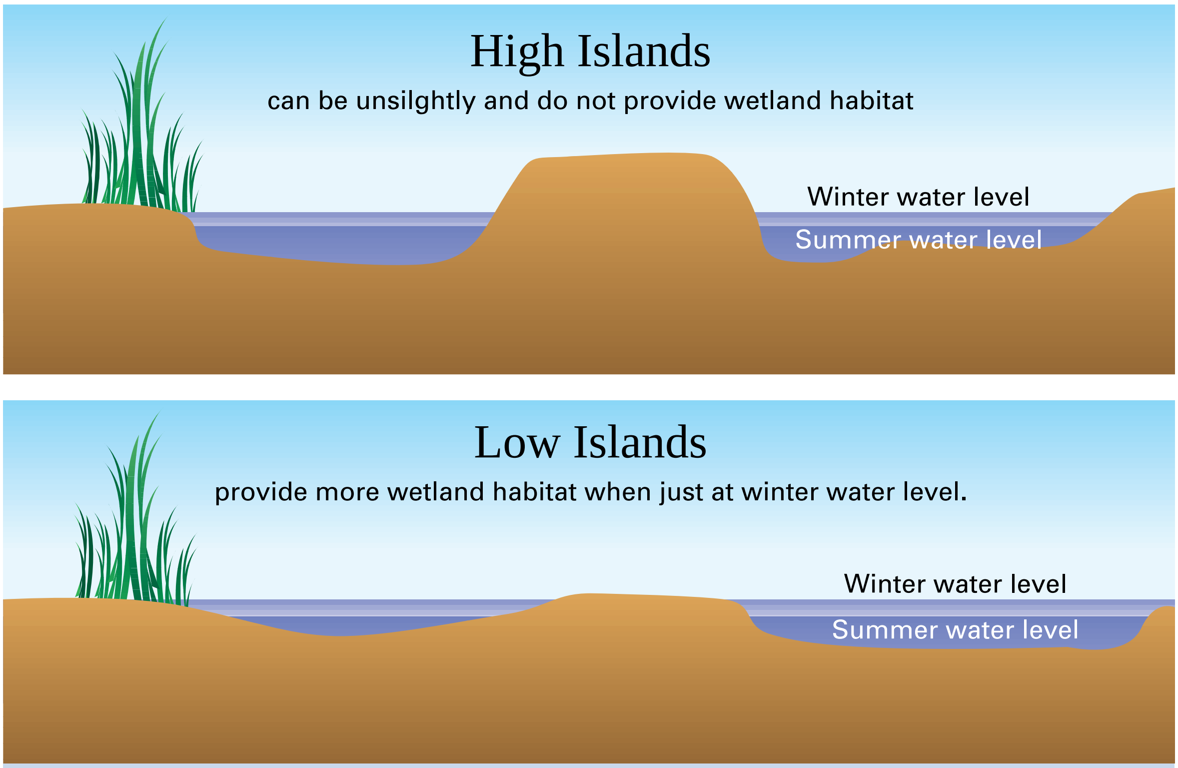


Figure 37. Low muddy islands can be valuable habitats and provide roosting, nesting and feeding sites for waterfowl and waders. Try to avoid high central islands which block the view for people and create terrestrial rather than wetland habitat.

Muddy areas appear to remain bare for longest in areas of very low topography which lie at and below water early in the growing season (late spring to early summer). This inhibits germination and increases the water stress and disturbance caused by fluctuating water levels. In these areas even very low undulations, which allow plants to gain a foothold and spread out over the bare mud, should be avoided.

5.6 Planning and undertaking pond creation

Water levels

Before beginning to create a pond it is highly desirable to create one or more trial holes to find out the extent to which water will stand in any area. Monitor the trial holes through at least one annual cycle. Alternatively, the pond can be roughly excavated first (perhaps half or two-thirds of the final size) to see how this behaves for a year or two before the job is completed. If water isn't retained by the natural soil and geology it will be necessary to line the pond.

Excavation techniques

Small ponds with a volume of 1 to 2 m^3 can be dug by hand by one or two people fairly easily; larger ponds usually require an excavator. Small excavators can be hired by anyone for the day or week. Larger ponds will need an experienced contractor.

SEPA does not recommend the construction of on-line ponds. See Section 5.3 about the risks of polluting downstream watercourses if ponds are created on-line and, if necessary, refer to SEPA's advice for contractors working in or near watercourses contained in Pollution Prevention Guidelines No. 5 (PPG5) (SEPA, 1999).

Spoil disposal

Spoil disposal is usually the most expensive part of the pond construction process, and to minimise handling costs it is an advantage if excavated spoil can be left relatively near the pond site. Note, however, that spoil may not be dumped in some areas such as floodplains. Spoil may need to be disposed of in licensed landfills, whether it is contaminated or not, unless a waste exemption has been registered. Contact the local SEPA office for advice on these matters.

5.7 Lining vs natural ponds

It is a very common misconception that most ponds in the countryside are lined - in fact, most ponds in the countryside are found in places where holes in the ground naturally hold water. Only in places where the underlying rocks are too permeable to hold water at the surface (e.g. in areas of limestone or chalk geology) are ponds likely to be lined.

Wherever possible, it is preferable to create ponds where they can be dug into substrates that naturally retain water (i.e. groundwater-bearing gravels or naturally impermeable substrates). Such ponds are generally much easier, cheaper and more flexible to create than those using artificial or natural liners. They are also likely to last longer and be easier to manage than lined ponds.

Most small garden ponds will, of course, need to be lined, since most gardens are too well drained to support ponds in natural soil. A wide range of flexible and pre-formed liners are available for this purpose. With larger ponds, however, (more than $100m^2$) only four main types of lining are available: butyl rubber, clay, bentonite and concrete. All can be tricky to install over large areas and large numbers of lined ponds fail within five years. Clay puddling, for example, though appealing in principle, is difficult to achieve successfully unless the lining is thick. Bentonite (either in the powdered form or as sheets of 'Rawmat') is fairly easy to work with but has often failed where it is installed over sandy soils or other substrates where minerals have interfered with the clay swelling process.

The best answer is to use skilled and fully experienced contractors.

5.8 Pond colonisation: is it necessary to plant up ponds?

It is sometimes thought that pond colonisation is a slow process and that adding plants and animals is necessary to speed up the process. Studies of pond colonisation have, in fact, shown that colonisation is usually a very rapid process, particularly where other wetland habitats (streams, ditches, lakes, ponds, bogs, fens) are reasonably close by (e.g. within 1 km).

Figure 38. It is sometimes thought that pond colonisation is a slow process which needs speeding-up. In fact, pond colonisation is rapid and many species quickly find new waterbodies such as this four-spotted chaser dragonfly, especially where other freshwater habitats are nearby (i.e. within 1 km). © *Laurie Campbell*

Not planting-up ponds can be particularly beneficial for wildlife. In its early years a new pond provides a distinctive environment when species that require inorganic sediments (such as stoneworts, darter dragonflies) can flourish, before being replaced by more competitive species or those that require organic sediments.

Planting-up ponds is not inevitably harmful in itself - indeed if material is collected locally its effect is probably not much different to the natural processes that move plants and animals around (large grazing animals, wind, floods etc.). It just means that, unfortunately, some of the valuable early pond stages may be shortened.

What is harmful however, is the planting of non-native, invasive species. Initial surveys of Sustainable Urban Drainage System ponds in Scotland in autumn 1999 by Pond Action indicate that planting schemes are spreading *Crassula helmsii* and introducing ornamental versions of water lilies, irises, variegated reed sweet-grass and reed canary-grass into ponds, as well as non-native plants such as Canadian pondweed *(Elodea nuttallii* and *E. canadensis)* and curly water-thyme *(Lagarosiphon major).*

Some of these plants have been added deliberately. Others, particularly *Crassula,* have come in accidentally with other plants.

The problem with these introductions are numerous:
- many non-native species are spreading into the countryside and out-competing native plants. The DETR lowland Pond Survey in 1996 showed, for example, that 1 in every 6 occurrences of a submerged aquatic plant in British lowland ponds was a non-native.
- even native species which are not of local provenance will have their natural genetic difference diluted
- most new ponds will colonise up naturally with entirely appropriate 'new pond species' - planting-up not only introduces troublesome plants, but takes out opportunities for distinctive native species to use the space
- in some cases where invasive plants are threatening remaining colonies of nationally protected species it is essential that they are removed. The price tag for clearing ponds has sometimes been upwards of £50,000! - an unnecessary waste of scarce conservation resources.

Rules for planting-up ponds

1. If only small quantities of plants for stocking are required, it is better to collect plants from the wild than use garden-centre stock. It is a requirement of the law that to do this you have permission from the land-owner (this applies to all plants, including common species) and that you do not collect any species which are uncommon or specially protected. SNH or SWT will provide information on specially protected species.

2. For large planting schemes consider:
   - collecting water plants which are being dredged from streams, ditches or rivers.
   - collecting seeds and growing the plants on from a known local source. For large pond creation schemes landscape architects should be able to source local stocks of native plant material. Community groups could set up their own nursery of local origin plants. For more information contact Plantlife, FWAG or SWT.

3. Don't buy plants from garden centres.

4. If planting-up of bought stock is essential:
   - use suppliers who only deal in native species (so that soil is not contaminated with seeds of non-native species) and who can supply ecologically appropriate plants for the area (see Appendix 2) including beneficial plants such as floating sweet-grasses *(Glyceria fluitans, G. notata, G. declinata)*
   - source plants that are of local provenance
   - get advice on the appropriate plants to introduce - e.g. do not add river or floodplain plants to upland ponds and vice versa.

Figure 39. Rules for planting up ponds: don't buy plants from garden centres; instead collect plants locally (making sure not to contravene the Wildlife & Countryside Act, 1981) © Lorne Gill/SNH

5.9 Planning issues

Pond creation may require planning permission where a significant change of land-use occurs. Consult your local authority planning department to confirm whether an application for planning permission is likely to be required. Generally garden ponds can be created without planning permission. If you wish to create a very large pond which occupies a significant proportion of a garden, consult the local planning authority first.

Contact addresses for local planning authorities are available from COSLA. If you are creating a large pond (holding more than 25,000 m^3 water) the Reservoirs Act applies. If you intend to stock with fish (except for garden ponds) contact SERAD in the first instance (see Box 10).

5.10 Health and safety

Pond construction schemes should be preceded by appropriate safety audits. For large organisations this is likely to be a standard practice supervised by the relevant health and safety staff.

Voluntary groups should carry out safety checks using the procedures developed by Scottish Conservation Projects (SCP) and the British Trust for Conservation Volunteers (BTCV). Further information can be obtained from these organisations (addresses are given in Appendix 1).

5.11 Designs for recreation

In lowland Britain (including Scotland) the DETR[11] Lowland Pond Survey indicated that the main recreational activities for which ponds are created are fishing and shooting.

Key features of the design of angling and wildfowling ponds are summarised in Boxes 5 and 6 below. However, in general, to maximise the value of such ponds for wildlife:

- if possible try to maintain natural densities of fish and birds
- establish natural population structures (for example, fish populations with mixtures of bottom feeders, predators, invertivores, planktivores)
- minimise the addition of nutrients to boost fish or duck biomass; if you want more fish and birds create more ponds!
- follow other design principles outlined above (create habitat mosaics, incorporate temporary and permanent water, vary pond basins sizes from tiny to large).

Ultimately it is important to recognise that some amenity uses (e.g. ponds intensively stocked for carp fishing, ponds used for rearing large numbers of waterfowl) are only likely to be able to support an impoverished fauna and flora consisting of common and pollution tolerant species.

In this situation a good alternative is to create several ponds - one for the main activity and then several smaller sites where, for example, waterfowl are not fed and fish are present in natural densities.

Do not stock fish which do not occur naturally in Scotland. Fish not native to Great Britain may not be released to the wild without a license issued under the Wildlife & Countryside Act 1981. Licenses are issued by SERAD. Certain fishes, such as zander (or pikeperch) and coho salmon, and certain species of non-native crayfish, are subject to Prohibition Orders issued under the Import of Live Fish (Scotland) Act 1978 (SERAD contact details are given in Appendix 1).

Figure 40. Fishponds can provide a valuable source of food for otters. © *Laurie Campbell*

[11] DETR: Department of the Environment, Transport and the Regions

Box 5. Designing ponds for fishing

This box lists features which will be useful in establishing a viable stillwater fishery and techniques for increasing their wildlife value. The recommendations generally apply to coarse fisheries but some of the wildlife enhancement techniques can also be applied to put-and-take trout fisheries.

Creating good conditions for fishing

Providing the right environment for fish

- Ensure that the pond is adequately oxygenated (dissolved oxygen concentrations need to be higher for salmonids than for coarse fish).
- Provide areas of deep water (1 to 3 m) to provide cool areas in summer and warmer water in winter.
- Create shallow edges to provide areas where dense plant stands can provide good habitat for coarse fish spawning and feeding.
- Create shallow marshy areas, which are inaccessible to adult fish, to provide good fry habitats.
- Encourage growth of submerged and floating-leaved plants (best done by maintaining clean water) to provide cover and natural food.
- Establish or retain bankside trees to provide shelter.
- Place large dead branches in shallow water to create deadwood 'reefs' to provide fish with shelter and protect them from predation. Make sure that branches are underwater so that they don't provide perches for fish-eating birds, if these are a problem.
- Desilt the pond at intervals as necessary to maintain open water for fishing.
- Establish no-go areas in the winter and spring to provide sanctuaries for fish spawning and/or respite from angling pressure.

Providing good facilities for anglers

- Provide access for vehicles, an attractive location and facilities for the disabled.
- Create spits, bays and islands to increase the amount of space available to each angler.
- Make or clear swims (if necessary) to improve angling enjoyment and create open water for casting.
- Maintain some deep water near to the bank to make landing fish easier; alternatively, create pontoons which run out to deep water allowing for more extensive shallow water edge habitats.
- Manage fish populations to reduce competition and produce bigger specimen fish. Ensure that the necessary permissions are obtained before moving surplus fish to another water.

Enhancing fisheries for wildlife

What to avoid:

- Avoid runoff from roads, car parking or other urban areas entering the pond.
- Avoid introducing non-natural substances which will add to pollutant levels as they degrade e.g. creation of 'reefs' from old tyres.
- Avoid stocking of fish beyond natural densities. Most fishing waters will be stocked to provide large numbers of fish for angling. Fish are a natural part of many permanent freshwater ponds: about 50% of all freshwater plants and animals co-exist with fish. The remainder prefer, or require, freedom from fish predation. Waters with a moderate fish density (up to about 100 kg per hectare) with a mixed population of fish, can be good wildlife habitats. Unnaturally high densities of fish, greater than 100 kg/ha, will have a strongly detrimental impact on the rest of the aquatic ecosystem (loss of submerged plants, increased turbidity) and will reduce diversity of 'fish compatible' wildlife. Note that it will rarely be feasible to simulate natural fish densities in put-and-take trout fisheries.
- Avoid fertilising or neutralising (raising the pH) of waters. In waters with naturally low nutrient status, or naturally acid (or acidified) waters, fishery managers sometimes fertilise water to increase fish productivity. This is likely to damage naturally acid and low nutrient status waters, which are a special feature of the Scottish landscape. Fertilising ponds and lochans is perhaps the single most undesirable activity that fishery managers could undertake.

Box 5 continued. Designing ponds for fishing

- Do not release fish in Scotland which are not part of the natural fauna. In upland Scotland fish have been introduced to many small, permanent upland lochans comparatively recently. Deliberate and accidental release of fish that don't occur naturally in Scotland is highly undesirable.
- Avoid adding any non-native plants. Plant only native species of local provenance. Avoid garden centre plants which are often contaminated with alien plant seeds. This is vital to avoid non-native plants from being released into the wild and decreasing the conservation value of some of our most beautiful and valuable waterbodies and wetlands.

What to encourage

- Areas of very shallow water with very dense plant cover where even young fish find it difficult to penetrate. These will provide sanctuaries for invertebrate animals and amphibians. In the long term the fish will also benefit from the increased food supply as invertebrates move out into other areas more accessible to fish.
- Isolated shallow pools, some seasonal, around the edge of ponds which are completely separated from the main waterbody. These provide completely fish-free areas where a wider range of dragonflies, water beetles and other wildlife can thrive.
- Ponds with a mosaic of habitats that will encourage a range of species. This could include: stands of different densities of emergent plants, trees growing in and near the water (providing leaf litter, rotting dead wood for dragonflies, tree roots growing into the water for invertebrate habitat), mosaics of groundwater and surface water fed pools.

Box 6. Designing ponds for wildfowling

Key features of ponds for wildfowling

- Isolated and undisturbed position.
- Open flight lines into the prevailing wind.
- Low horizons for shooting butts.
- Shallow areas for wildfowl to feed in.
- Marginal and aquatic plants to provide food (including seeds) and cover.
- Low cover in the surroundings (perhaps maintained by grazing).

What to avoid

- Too much corn. Corn is often supplied to ponds to attract wildfowl. Avoid adding any more than will be quickly eaten. Large quantities of corn dumped into water is a source of organic pollution which will reduce the wildlife interest of a pond. It is also likely to increase the nutrient status which may lead to turbidity and eutrophication problems such as extensive cover of duckweed.
- Planting-up. Wildfowling guides often make the assumption that planting is necessary; whilst careful planting of local, native species, is not harmful, natural colonisation is more likely to be successful and reduces the risk of introducing alien plants.

What to encourage

- Creation of a mosaic of marginal wetland areas with shallow and temporary pools which can support a wide range of plants and animals (as well as seed-bearing plants and invertebrate food for wildfowl).
- Extensive shallow water areas which are generally the richest area of a pond for wildlife. See Section 5.5 on the design of ponds.
- Low density grazing, maintaining low cover which creates excellent wildlife habitat in ponds.

Box 7. Initial steps in pond design and creation

- **Decide what the main and secondary uses of the pond will be** (e.g. wildlife conservation, angling, landscape, shooting wildfowl or water treatment). Information on designing fishing ponds is given in Box 5; advice on designing wildfowl ponds is given in Box 6.

- **Identify a site**. The features of good sites for wildlife ponds are summarised in Section 5.2. A key feature of a good location is the availability of an unpolluted water supply. Where possible avoid future pollution or design constraints by avoiding sites which will need a stream inflow or basins which will need an artificial liner. Check there is access for excavating machinery if appropriate.

- **Make sure the selected site has no existing wildlife or archaeological interest**. If the site is already of value, don't dig it up; put new ponds near to existing wetlands (bogs, wet patches, other pools, streams, springs) but don't replace them.

- **Create a clean water supply if necessary.** If no supply of unpolluted water is available, check whether one can be created by reducing the intensity of land management in the pond catchment (e.g. converting intensive grassland to extensive management, or planting woodland).

- **Check that the project is not constrained by services (gas, electricity, water)**. Before getting too far down the route of planning a pond it is VITAL to check whether there are any private or public services crossing the site. Moving services is generally far too expensive to be feasible in pond creation projects so essentially schemes have to be designed around services. Check for electricity (above and below ground), telephone (above and below ground), gas, oil and sewage.

- **Prepare a preliminary design for the pond**. Do a rough 'back-of-the envelope' sketch, including ideas about the size and profiles to be excavated. As a general rule, on stream ponds are regarded by SEPA as undesirable; if it is essential to create a dammed pond, seek professional advice.

- **Dig trial holes**. Dig a set of trial holes to establish the geology and water supply for the pond and monitor them through at least one winter to see whether the planned pond will hold water. In the light of monitoring, prepare a set of rough sketches to pass through the legal checking process.

- **Legal check**. Follow through the checklist of legal requirements in Box 9 to ensure that the pond does not contravene any laws, or need further work to ensure legality.

- **Go ahead with pond creation**. For small ponds, go ahead and excavate the pond. For larger ponds, prepare a detailed design and finalise it with the local planning authority and other agencies (see Appendix 1 for addresses).

- **Lined ponds**. For ponds which involve linings (clay, butyl or bentonite) it is most likely to be successful if a skilled, experienced, contractor is engaged.

- **Think of pond creation as a two stage process**. Dig a rough version of the site and then refine that shape when more knowledge of the way water levels will behave is available.

- **Let the pond fill with water before finishing it off**. It is much easier to sculpt the edges when you know where water levels are.

- **Future management**. Ensure that the design includes plans for management once the pond is constructed.

Box 8. The main steps in pond construction

Initial work

Before beginning any excavation or construction the following work should be done:

- For all but the smallest ponds, undertake a survey of the site with particular attention to levels. Many contractors provide leveling as a service in a construction contract.
- Mark out the intended shoreline, including islands, with posts or aerosol line-marking paint.
- Calculate the quantity of spoil to be removed and identify location(s) for tipping. Spoil should not be dumped on floodplains or in any area where it will damage existing habitats. Contact SEPA if in doubt.
- Remove topsoil and if necessary store it - it may be useful for landscaping at the end. However, bear in mind that nutrient enriched topsoil should be removed from the surface water catchment of a new pond to prevent nutrient pollution.
- Make allowances for bad weather when assessing: (i) the estimated time for the project to be completed, (ii) suitability of machinery, (iii) the approach route for vehicles to the site, (iv) possible cost (due to time over-runs).
- Plan spoil removal for maximum efficiency. Normally a dumper or tractor and trailer will be used to take spoil from an excavator working at the pond side. It is important to keep the transport system working efficiently as the speed of the job will normally be determined by the rate at which spoil can be removed (not by the rate of digging).
- Spoil should be transferred directly from the excavator to a dumper or trailer to avoid double handling (double-handling is dumping the spoil on the ground and then picking it up again to put it in a truck for disposal off-site).

Spoil disposal

Before beginning a project consider carefully how spoil will be disposed of. Spoil disposal has a major influence on the cost of pond construction. Check how much there will be, where it is to be put, the method for transporting it, how the heap of spoil will be shaped once it is tipped and the cost.

Options for disposal of spoil are:

- Spread thinly a little way back from the pond margin. Be careful not to create steep banks next to the pond edge. Remember spoil cannot be dumped on river floodplains (it reduces the storage available for flood water).
- Use the spoil to create a clean catchment for the pond. For example where new groundwater ponds are created in agricultural landscapes, piles of spoil can be used to block polluted surface runoff from arable fields which would otherwise reach the pond.
- Landscape a mound near to the pond for planting with trees and shrubs; effective landscaping requires that mounds are in keeping with the scale of the landscape.
- Create carefully landscaped spoil mounds to provide habitats for basking reptiles; mounds with vertical edges can provide nesting sites for sand martins and kingfishers.
- Tip spoil in a mound to screen unsightly buildings or to create a buffer against intensively managed land or busy roads.
- If the spoil is suitable (i.e. has a high clay content), use it to create a lined pond in an area with otherwise permeable substrates.
- Remember that waste disposal regulations require that excavated material may only be spread if it is of agricultural quality. Otherwise it will need to be removed to a licensed waste disposal site.

Don't dispose of spoil by:

- putting topsoil into the pond (this will usually pollute the pond with nutrients).
- making large tall islands, unless dense vegetation is wanted on those islands.
- building-up spoil into high banks right next to the pond.

Box 9. Ponds and the law

Work through the questions to avoid falling-foul of the law when constructing a new pond. Note that these rules do not apply to garden ponds.

Question 1. *Is the pond for non-agricultural purposes (e.g. wildlife, landscape, fishing, shooting)?*

- If Yes, check with the local planning authority if planning permission is needed for a change of land-use. The creation of a pond for purposes other than agriculture is defined as an engineering operation and will generally require planning consent. All applications for planning consent, with a few specific exceptions, are subject to a planning fee which is set nationally by the Scottish Executive. If approval is obtained go to Question 2.
- If No, go to Question 2.

Question 2. *Is the site designated for its nature conservation or archaeological interest (e.g. SSSI, Scheduled Ancient Monument)? This information can often be most quickly obtained from the local planning authority.*

- *If No, go to Question 3.*
- If Yes, consult Scottish Natural Heritage or Historic Scotland. If approval is obtained go to Question 3.

Question 3. *Is the pond likely to be (a) filled with water taken from a stream, river or groundwater (b) a source of pollution during or after construction (e.g. from sediments washed into adjacent streams) or (c) a source of licensable waste?*

- If No, go to Question 4.
- If Yes, consult SEPA. If approval is obtained go to Question 4.

Question 4. *If the pond is fed by a stream or river, does the supplying water course have any migratory salmon or trout. This may need to be checked by professional electric fishing or other survey work (particularly to distinguish juvenile sea trout, which are accorded the same protection as salmon, but are indistinguishable from juvenile trout).*

- If Yes, consult the District Salmon Fisheries Board and/or the Scottish Executive Rural Affairs Department (SERAD). If approval to construct a pond is obtained go to Question 5.
- If No, go to Question 5.

Question 5. *Does the proposed pond exceed 25,000 cubic metres in volume (equivalent to five and half million gallons)?*

- If Yes, the pond falls under the provisions of the Reservoirs Act 1975. It must be constructed under the supervision of a qualified civil engineer and regularly checked. Ensure that provision for a professional engineer is made and go to Question 6.
- If No, go to Question 6.

Question 6. *If the pond is stream fed, have you informed downstream riparian owners, and others who might be affected, about your plans?*

- If Yes, go to Question 7.
- If No, inform your neighbours of your plans and go to Question 7.

Question 7. *Have you informed SEPA of your plans? Asking SEPAs advice and keeping them informed of your plans from an early stage will prevent any unexpected problems from occurring and may save money.*

- If Yes go to Question 8.
- If no, inform SEPA of your plans, then go to Question 8.

Question 8. *Are there plans to introduce salmon or non-native fish?*

- If Yes, consult with the District Salmon Fisheries Board (salmon only) and SERAD (salmon and non-native fish). Non-native fish may not be released to the wild except under a license issued under the Wildlife & Countryside Act 1981 (contact SERAD for further information). If permissions are given, go to Question 9.
- If No, go to Question 9.

Question 9. *Are there any plans to introduce wildfowl?*

- If Yes, it is illegal to release non-native waterfowl into the wild unless they are pinioned or clipped (i.e. flightless). Make sure that plans are in place to pinion any introduced waterfowl then go to Question 10.
- If No, go to Question 10.

Question 10. *Do you intend to introduce plants and animals from another pond in the area?*

- If Yes, it is a provision of the Wildlife & Countryside Act 1981 that no plant may be dug up without the permission of the landowner. Certain rare plants are completely protected and may not be dug up even by the landowner. Ensure that you have permission to collect any plants that you use from neighbouring ponds and streams. Note that protected animals (e.g. great crested newts) can only be moved if licensed by SNH.

If you have successfully completed the questions the planned pond creation will be a legal operation.

6. Safety

6.1 Introduction

The safety of ponds is an important concern especially in urban areas. To keep safe near water, follow the advice given by the Royal Society for the Prevention of Accidents (RoSPA). The following information on water safety is reproduced from advice given by RoSPA.

Any project involving the creation of ponds and other wetlands should clearly involve discussion and consultation with local people most likely to be affected. However, many of the risks associated with urban ponds can be greatly reduced by careful design (see Section 7.7.).

6.2 'The Drowning Chain'

Not everyone is equally at risk from drowning. Unfortunately, males are four times more likely to drown as females and the greatest risk is for young men between 16 and 34.

RoSPA has identified a chain of possible events which can lead to drowning, 'The Drowning Chain'. Countering these events will greatly reduce the risk of fatal accidents.

The chain of events that can lead to drowning are:
1. Ignorance, disregard or misjudgment of danger.
2. Unrestricted access to hazards.
3. Absence of adequate supervision
4. Inability to save yourself, or be rescued

Ignorance, disregard or misjudgment of danger. Any plan to prevent drowning must aim to break one of the links in the chain of events and so avoid the ultimate fate. Such an intervention is most successful if it breaks the first link in the drowning chain. Through education comes recognition and therefore avoidance of danger. The danger is then recognized, respected and avoided.

The most positive way of countering drowning is to prevent entry into the water in the first place.

Unrestricted access to hazards. The counter to the second link in the 'drowning chain' is to deny access to the hazard. This may be done by warning of danger or by otherwise preventing potential casualties from entering into danger.

RoSPA encourages safe public use of waterbodies through the creation of principal access points, clearly defined footpaths and formalised viewing areas where water safety information can be targeted at specific areas. This is particularly important for children's educational activities. Generally areas which encourage entry into the water (e.g. gently shelving beaches) should be avoided since these expose people to the dangers inherent in entering the water (e.g. misjudging how cold water can be on a warm day).

Table 17.
Numbers of accidental deaths in different environments in the UK

Environment (year)	No. of deaths
Home (1995)	4,066
Road (1996)	3,598
Water (1997)	440
Work (1994-1995)	376

Source: Royal Society for the Prevention of Accidents (RoSPA).

Table 18.
Drownings in the UK in 1998 by location

• Rivers, streams	239	42%
• Coastal	129	23%
• Lakes and reservoirs	55	10%
• Home baths	53	9%
• Canals	47	8%
• Docks and harbours	19	3%
• Swimming pools	17	3%
• Garden ponds	9	2%

Source: Royal Society for the Prevention of Accidents (RoSPA).

In the specific case of new SUDS ponds, access to hazards can be prevented by careful design (shallow maximum depths, gentle slopes, dense planting of vegetation) although sometimes local residents may prefer to see fencing (but note that fencing may create a challenge to the adventurous).

Absence of adequate supervision. Absence of adequate supervision can only be countered by more competent training and application. Those who guard the lives of others can only ever be totally vigilant.

Inability to save yourself, or be rescued. If the 'drowning chain' is still intact, and the victim has not been 'saved' while still out of the water, only the fourth and final link remains! Now only self rescue, or rescue by another person, can avoid the worst consequences.

Although rescue is a poor option in any preventative plan, this does not mean that it should not be considered and encouraged where appropriate. Other options should have greater priority because they have more chance of success. Based on the RoSPA water safety code, Table 19 summaries the main ways of staying safe near water. The main principle is don't get into the position to need rescuing.

Table 19.

Safety near water - based on the RoSPA water safety code

SPOT THE DANGERS. Water may look safe, but it can be dangerous. Learn to spot and keep away from dangers. You may swim well in a warm indoor pool, but that does not mean that you will be able to swim in cold outdoor water. Beware especially of ICE.

TAKE SAFETY ADVICE. Special flags and notices may warn you of danger. Know what the signs mean and do what they tell you.

CHILDREN - DON'T GO ALONE. Children should always go to ponds with an adult, not by themselves. An adult can point out dangers or help if somebody gets into trouble.

LEARN HOW TO HELP. You may be able to help yourself and others if you know what to do in an emergency.

RESCUE METHODS. You may be able to help somebody if you understand the rescue methods listed below. Don't go into the water unless the four methods below have failed and you are a strong swimmer. Always call for help at the same time. The four ways to help people are:

Reach
With a long stick, a scarf, clothes or anything else. Crouch or lie down to avoid being pulled into the water.

Throw
A rope is best - you can then pull in the person. Otherwise throw something that will float - a ball, a plastic bottle, a lifebuoy....this will keep the person afloat until help comes.

Wade
Only enter the water yourself if none of these methods work and you are a very strong swimmer. Use a towel or item of clothing to tow the person without touching them. A drowning person may be very strong and pull you under the water as well. Test the depth with a long stick before wading in and then use the stick to reach out. Hold onto someone else or the bank.

Row
Use a boat if there is one nearby and if you can use it safely. Do not try to pull the person on board in case they panic and capsize the boat. Instead throw them a rope or flotation device or reach out to them with clothing or a stick.

7. Maximising the ecological value of Sustainable Urban Drainage Systems (SUDS)

Sustainable urban drainage systems (SUDS) are increasingly being used to store and treat the surface runoff from urban areas. These systems very often include either intermittently or permanently wet ponds.

In Scotland, SEPA has identified three main objectives for SUDS schemes:

- the prevention of damage to streams and rivers by holding and treating urban surface water run-off at or near to the source
- the provision of additional nature conservation benefits
- the provision of additional amenity benefits.

The general principles of the engineering design of constructed wetlands and retention ponds in Scotland are given in manuals on sustainable urban drainage systems produced by SEPA (SEPA, 1998a, b, 1999 and 2000) and CIRIA (CIRIA, 2000).

The sections below provide additional, complementary, information on the design of retention ponds and constructed wetlands which will help to maximise their value for nature conservation and improve their amenity value.

7.1 New data about the wildlife value of SUDS schemes

Advice given in the following sections is backed up by data from a recent pilot survey of Scottish SUDS ponds carried out for SEPA by Pond Action. The survey results show that:

- SUDS ponds can, at their best, support quite rich wildlife communities largely dominated by common species.
- Most SUDS ponds do not currently fulfil their ecological potential.
- There are many simple design features which could be added to new SUDS schemes, or retro-fitted into existing schemes, to improve their ecological value without compromising their function (e.g. see Box 10).
- There is a considerable worry about the number of non-native plant species currently being introduced into SUDS sites. This includes:
    - deliberate introduction of non-native species.
    - plant suppliers who do not adequately fulfil required specifications for providing native species of local provenance.
    - accidental introduction of invasive aliens via seeds in contaminated soil from other bought-in plants. Introduction of the highly invasive New Zealand swamp stonecrop *Crassula helmsii* is particularly common.

[12] See Section 5 for further information on these factors

Recommendations for appropriate planting of SUDS ponds are given in Section 7.5.

More specific findings from the survey are discussed in the relevant text sections below.

7.2 Ecological design principles to maximise the nature conservation value of constructed retention ponds and wetlands

As in all pond design, there are three key factors[12] which influence the quality of SUDS ponds for nature conservation purposes:

- water quality
- proximity to existing wetlands and freshwater habitats and
- physical shape and structure.

Clearly, since most SUDS schemes are primarily created to deal with contaminated surface water runoff, maintaining good water quality in SUDS ponds is a key issue. It is not, however, an insoluble problem. Much can be done to ensure that at least parts of a waterbody or series of waterbodies have good water quality. In addition, good design and location can be used to partly mitigate water quality impacts.

SUDS ponds and wetlands incorporating the full range of new pond design techniques have considerable biodiversity potential, including the ability to provide habitats for species of high nature conservation importance (e.g. Biodiversity Action Plan species). Experience indicates that relatively small refinements to traditional pond designs, based on new understanding of pond ecosystems, can lead to big improvements in the ecological quality of ponds.

A list of 20 suggestions for improving the ecological design of ponds incorporated into SUDS schemes are given in Box 10. The main principles behind these suggestions are discussed in more detail below.

7.3 Two principles for working with contaminated surface water runoff

There are two main ways of maximising the value of constructed wetlands for aquatic wildlife:

- design the waterbody or wetland to maximise water quality in some or all areas;
- ensure that there are large areas of well vegetated shallows, to maximise the habitat for aquatic species which are most tolerant of contaminated water.

Maximising water quality in ponds

Although a variety of common and robust aquatic organisms tolerate mildly polluted water, many do not. This means that all design features which can minimise pollution in retention ponds will benefit wildlife.

The employment of Best Management Practice features in SUDS schemes will do much to minimise pollutants reaching open waterbodies, and these measures should always be implemented to the full (see SEPA 1998a,b, 1999, 2000). Specifically:

- Implement a full range of source control techniques (e.g. buffer strips, swales, porous pavements).
- Design the SUDS treatment sequence to include structures which intercept and reduce the silt and pollutant loads in runoff water before it reaches pond or wetland habitats.
- Establish a series of linked, vegetated pond basins, which progressively filter and clean the contaminated runoff, creating waterbodies which can sustain progressively higher quality wildlife communities.
- Route cleaner sources of water (such as roof water) into separate isolated basins which provide a less contaminated habitat.

In addition to these standard methods, a fifth way of improving water quality in retention ponds is to use run-off from the slopes around the pond basin itself to provide a high quality water source for small surface runoff pools at the edge of the waterbody.

It is important that these small runoff pools are not directly connected to the main series of SUDS treatment waterbodies to ensure that they remain unpolluted, contributing a high water quality environment to the complex as a whole.

To do this, clean-water pools ideally need to be located above the water level of the main pond. The quality of the surface runoff will depend on the quality of the catchment area around the pond - so to be effective the pond banks need to be under semi-natural vegetation such as untreated grassland or scrub.

Maximising the availability of habitat for pollution tolerant species

Some common amphibians, fish, invertebrates and waterfowl appear to be quite tolerant of pollutants. For example, smooth newts and some water beetles may sometimes be seen in quite remarkably contaminated conditions. Similarly waterfowl are commonly present on quite degraded ponds and lakes, and even water voles can tolerate some levels of water pollution.

The plants and animals that suffer most from pollution tend to be species that live entirely below the water surface. Thus submerged plants often do badly in polluted ponds, whereas many tall emergents, herbs and grasses at the edges can thrive. Similarly, many of the species of mayflies, dragonflies and caddisflies which respire underwater, do not tolerate heavily polluted waters.

Other groups, particularly the air breathing invertebrate groups such as water beetles, bugs and water snails, appear to be far less affected by water quality - what they mainly need is good habitat structure (Williams et al., 1998b).

A key to designing wildlife-rich SUDS ponds and wetlands is, therefore, to incorporate extensive areas of marsh and very shallow water where diverse communities can survive under most water quality conditions.

Where this is done, urban run-off ponds can support comparatively uncommon animals. For example, in Wokingham (Berkshire) the water beetle *Peltodytes ceasus*, an indicator of high quality wetland habitats, was found in an urban drainage pond where well-developed mixed marginal vegetation provided a habitat which compensated for the poor water quality in the main basin.

Other groups such as mammals, birds and semi-terrestrial insects would also be likely to benefit from extensive marsh zones (e.g. water vole, scrub wetland birds such as reed buntings and reed warblers).

Box 10. Twenty ways to maximise the nature conservation value of SUDS ponds

This box describes ways to maximise the nature conservation value of new ponds in Sustainable Urban Drainage Systems (SUDS). Clearly SUDS schemes vary considerably in terms of their functions and constraints and not all of the features will be viable in all schemes. However, include as many as possible.

- Maximise water quality reaching pond basins by fully implementing SUDS treatment sequences to prevent or ameliorate the export of pollutants into pond basins.
- Where possible locate SUDS basins in, or adjacent to, non-intensively managed landscapes where natural sources of native species are likely to be good.
- In particular, locate water treatment ponds near to (but not directly connected to) other wetland areas e.g. natural ponds, lakes and river floodplains. Plants and animals from these environments will be able to colonise the new ponds, and potentially recolonise after pollutant influx events.
- Create habitat mosaics with sub-basins of permanent, temporary and semi-permanent ponds; vary these in size (from 1 ha down to 1m^2) and depth (1m down to 5 cm).
- Ensure that some ponds, or parts of basins, are not exposed to the main pollutant burden allowing many more sensitive animals and plants to exploit some parts of the site.
- Create small pools around the margins of larger ponds which are fed by clean surface runoff from non-intensively managed grassland, scrub or woodland on the basin sides.
- Create shallow grassy ponds along swales and floodways, particularly towards their cleanest ends - pools just 1 or 2 metres across and only 10 cm deep will be valuable for wildlife.
- Maximise the area of shallow and seasonally inundated ground dominated by emergent plants - these are generally more tolerant of pollutants than submerged aquatic plants. To do this, create very low slopes at the water's edge (e.g. 1:50) and try to avoid fixing pond levels at a predetermined height.
- Create undulating 'hummocky margins' in shallow water; these mimic the natural physical diversity of semi-natural habitats.
- Avoid smoothly finished surfaces as traditionally used in ditch, drain and river engineering; although giving an impression of tidiness, they provide less physical habitat diversity for plants and animals.
- Plant trees scrub and wet woodland around ponds: these provide a valuable habitat for amphibians, a food source for invertebrates and tannins from decaying bark which will help to suppress algal blooms.
- Encourage development of open, lightly shaded and densely shaded areas or pools; this will add to the diversity of habitats available.
- Encourage or install dead wood in ponds (anchor securely where necessary). Dead wood provides firm substrates for pond animals and can provide egg laying sites for dragonflies and other animals.
- Encourage the development of mosaics of marginal plants (rather than single species stands) to maximise habitat structural diversity.
- Avoid planting-up ponds (other than the plants needed for the water treatment function of the pond or the creation of safety barriers). This will allow native plants more opportunity to colonise.
- Don't plant non-native water plants, trees, shrubs or grass mixes; take special care to avoid invasive alien plants such as *Crassula helmsii* by dealing with nurseries that only deal in native stock.
- If planting is essential, stick to native plants of local origin. Include species which are wildlife friendly e.g. grasses such as *Glyceria fluitans* (floating sweet-grass) and *Agrostis stolonifera* (creeping bent).
- Check planting schemes 1 and 2 years after establishment to ensure that specifications have been carried out and undertake immediate remedial action if invasive alien species are found.
- Consider whether grazing livestock can be given access to ponds; grazing has been shown to be a viable and effective way of managing some SUDS schemes in agreement with conservation organisations or farmers.
- Wherever possible include a brief post-implementation stage about 1 year after SUDS creation. Use this to (i) undertake fine-tuning of the pond design and (ii) capitalise on new opportunities that have arisen (e.g. pooling of natural areas of standing waters or natural seepage areas etc.). Fine tuning of this sort costs very little but will often greatly increase the biodiversity value of a SUDS scheme.

7.4 Adding value with two-phase designs

Pond creation is usually best undertaken as a two stage process and SUDS schemes are no exception. Thus, just as landscaping and tree-planting needs after-care to ensure successful establishment, the ecological value of pond systems can be considerably improved by a short follow-up phase. Such works can often double the value of SUDS sites for wildlife.

This short second phase, can be used to:

- Undertake fine-tuning of the pond designs after a period of observing how the scheme behaves e.g. re-profiling margin areas, adding-in small topographic variation such as marginal pools.
- Maximise the potential of new opportunities that have arisen during construction (e.g. use of excess runoff water or natural seepages to create new pools etc.).

At present, standard planning conditions indicate that new ponds in SUDS schemes should be completed as a one-off operation in the year following building completion. So, in small or short-term schemes, create the main SUDS works so as to be a fully functioning structure, but budget an extra 1% - 5% for the short aftercare programme in the following year. Larger schemes, such as development parks, are often completed over a number of years, so here a second phase can usually be incorporated within the overall development plan.

Such follow-up measures would typically involve one day's work on site and utilise a small excavator moving around minor amounts of spoil. The necessity for dumper trucks or net production of spoil (which would need additional piling, profiling and seeding) should be avoided.

7.5 Planting-up SUDS ponds

Should SUDS ponds be planted-up?

SUDS ponds will normally be planted up with tall emergents for two main reasons (i) to aid their functioning and (ii) to provide safety screening. In addition, planting may be appropriate in some urban areas to provide a visual interest and give a 'finished' look to a scheme. However, for nature conservation purposes planting-up is not necessary and wherever possible (within the constraints given above) should be avoided.

New ponds usually show a very rapid rate of natural colonisation. Assessment of ponds in the pilot survey of Scottish SUDS schemes by Pond Action, for example, showed that within a year or two of their creation most SUDS ponds supported 15 - 20 species of native plant which had arrived purely by natural means. These species were always more appropriate to the pond habitat, landscape and water quality than plants which had been deliberately introduced as part of planting schemes.

In urban landscapes, where it may be necessary to install a reasonable level of landscaping around new waterbodies, any planting should focus on:

- The careful use of native species of local provenance.
- Inclusion of at least some plant species which are particularly wildlife friendly e.g. grasses such as *Glyceria fluitans* (floating sweet-grass) and *Agrostis stolonifera* (creeping bent) which provide a good habitat for newts and other invertebrate animals.

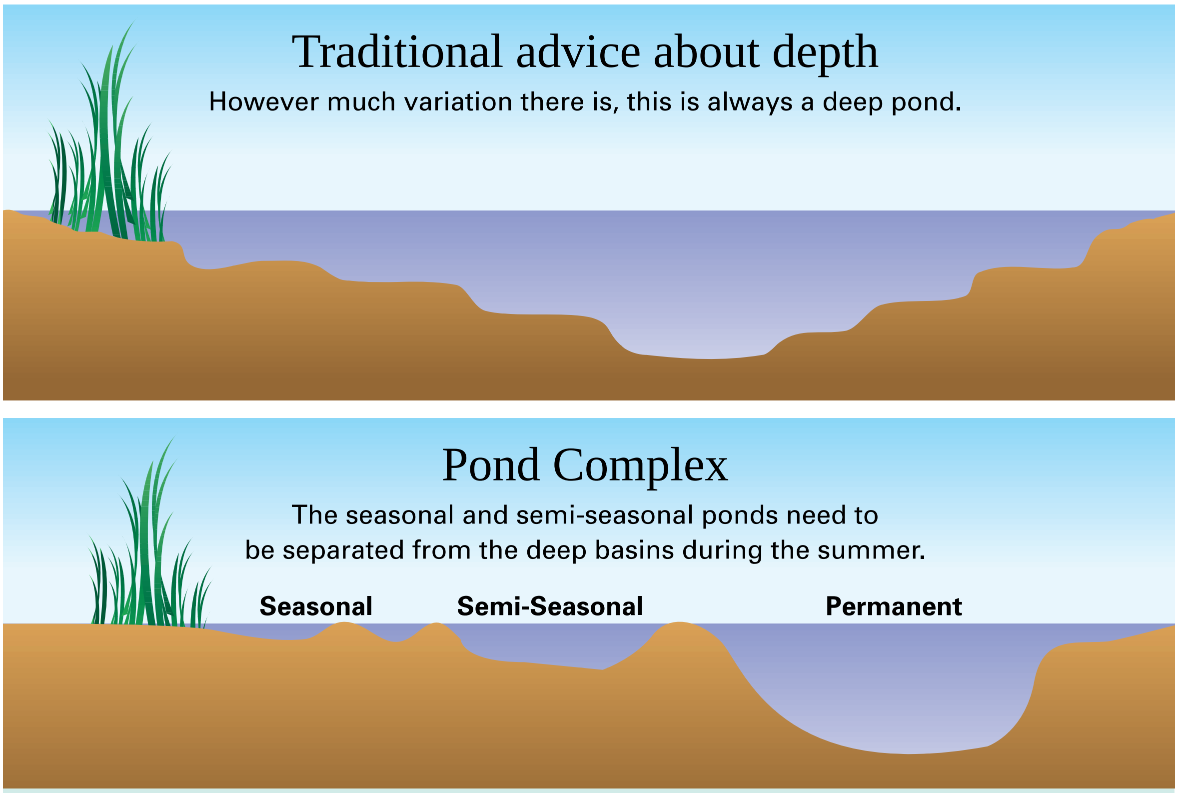


Figure 41. Where possible in SUDS schemes, create habitat complexes with pools that vary in their depth and permanence. Try to include small marginal pools which are fed by clean runoff water from the slopes of the SUDS basin.

In addition, be aware that planting schemes can also add to pollutant levels in SUDS ponds. Topsoil addition, fertiliser use and regular soil disturbance in the pond surrounds will all increase runoff of nitrates and phosphates into ponds, and increase nutrient-caused pond problems such as blooms of algae and duckweed. To stop such problems:

- Follow good practice guidance for slopes above waterbodies to minimise nutrient run-off e.g. (i) ensure slopes are rapidly vegetated to minimise soil erosion, (ii) create trenches near slope bases to hold eroded sediment above water level.
- Minimise, and preferably avoid, the application of topsoil in areas next to water bodies. Almost all native wetland species, for example, develop well when planted directly into subsoil.
- Create low maintenance landscapes around SUDS water features (e.g. grassland, perennial shrubs). Avoid gardened areas which require digging, weeding or application of fertilisers and pesticides since these will continually add to waterbody pollutants.
- Try and locate terrestrial planting beds (e.g. ornamental shrubs) so as to minimise nutrient-rich runoff into waterbodies, i.e. plant so that run-off from bare soils is directed away from ponds or filtered through a grassland buffer.

Sources of wetland plants for SUDS schemes.

As noted above, ensure that wherever possible, plants introduced to SUDS schemes are native species of local provenance.

As a possible source of plants it is worth noting that large quantities of wetland plants are commonly removed from streams, ditches, drains and other wetlands in the course of legitimate countryside management activities. In some cases the re-use of this local plant material may be a possible source of appropriate plants. Organisations such as British Waterways, the Scottish Wildlife Trust and Scottish Conservation Projects may know of suitable sources.

The most practical alternative source of plant stock for SUDS ponds is provision of stock from plant nurseries which fulfill the general requirements given in Section 5.8, Rules for Planting up Ponds.

It was noted in the survey of Scottish SUDS schemes described in Section 7.1 that a very high proportion (about one third) of all SUDS ponds contained the highly invasive alien plant *Crassula helmsii.* In most or all of these cases the *Crassula* appeared to come from seed contamination in the soil of other planted stock.

Such findings are very worrying. There is increasing concern about the effects of highly invasive alien plants in the UK. Three species pose a particular threat: *Crassula helmsii, Hydrocotyle ranunculoides and Myriophyllum aquaticum.*

Because of the problems associated with alien plants, every effort should be made to take a strong line in Scotland in resisting their spread. To do this, it is important to ensure that plant stocks are bought from nurseries which grow only native species so that cross-contamination is unlikely.

Another experience from Scottish SUDS schemes is that there was often a considerable difference between the landscape architect's original planting specification (e.g. for native wetland species of northern origin) and what was actually delivered by the nurseries (which was often a high proportion of non-native aliens). This clearly points to the need for detailed post-implementation appraisals of planting schemes as well as the potential for inclusion of corrective measures if species such as *Crassula* are found.

Species which can be planted

In practice, most common native marginal wetland plants are likely to establish well in SUDS schemes, unless pollution levels are excessive. There is, however, rarely likely to be any point in planting submerged plants: introductions are often unsuccessful, and submerged species are more likely to colonise by natural means if the pond is suitable for them. In the survey of Scottish SUDS ponds, for example, all ponds had naturally colonised with between one and four submerged plants; few, if any, of the native planted aquatics appeared to have survived.

Lists of desirable plants given in pond management guides often give the impression that a standard list of plants is desirable and appropriate in every pond. In reality, planting schemes should be (a) restricted to the plants which are already growing in the locality (e.g. within 10 km of the site) (b) appropriate to the physical and chemical conditions. Do not, for example, plant up a pond in a acid water area with the plants of base-rich soils.

The lists given in Appendix 2 show species which are widespread and common in Scotland and which may be suitable for planting. Do not treat this list as a recipe but get local information about what are the common water plants for a given county or district. This information is usually available in floras (contact the Scottish Wildlife Trust or SNH).

A typical semi-natural pond in Scotland could be expected to support 20-30 species of wetland plants (it could be as many as 50 species on a large site - say 1.5 ha).

Most planting lists make little mention of the plants of acid waters which are highly characteristic of many areas of Scotland. In appropriate locations, there is no reason why these plants should not be incorporated into planting schemes.

7.6 Amenity benefits of ponds (including SUDS schemes)

People find water in the landscape intrinsically attractive and ponds offer the opportunity to use many classical landscaping techniques which work with water.

Water creates a natural focal point in any landscape; it reflects the sky, or buildings or night lights. It is animated and the birds of ponds and lakes, such as coots, mallards and mute swans, are highly valued by people.

In designing ponds, including basins used in SUDS schemes, the opportunities to add to the amenity value of sites include:

- creation of views over water from buildings and from roads and path approaching ponds and lakes
- designing in reflection pools - careful siting of ponds so that reflections of interesting landscape features (trees, landmark buildings) are created
- the creation of 'visual surprises', where unexpected views are created by landscaping or careful location of trees and shrubs, or the creation of gaps in marginal vegetation
- provision of walks or picnic facilities near to water features.

To improve the appearance of ponds, avoid unsightly concrete structures; use soft engineering techniques (e.g. live and dead willows, wood, vegetation palettes).

To combine the requirements of visual amenity (clear views unobstructed by wetland plants, trees or scrub), with nature conservation (vegetation, trees, shelter), create viewpoints with dense cover off to the sides of these main viewpoints.

Make provision for regular litter removal; accumulated litter gives the impression that a site is uncared for. If litter is likely to be a problem, consider reducing the amount of tall vegetation and scrub in any planting schemes; it is harder to remove rubbish from these areas.

In more formal settings, such as business parks and other prestige locations where style and design are important, the impression of formality can be created by careful location of short grass close to longer less intensively managed vegetation. Note that because of the overriding importance of unpolluted water for good pond habitats, even ponds with a completely regular shape will inevitably provide a good wildlife habitat; indeed as a rough rule of thumb, the more formal the setting, the cleaner the water needs to be to provide good wildlife habitat.

7.7 Designing safe SUDS ponds

The main techniques for keeping permanently wet SUDS ponds safe are:

- carry out a risk assesment/safety audit of the ponds to be created
- provide safety equipment (grab rails, ladders) and rescue equipment if necessary.
- design ponds with slopes no more than 1 in 4 (good ecological design should normally give much gentler slopes than this anyway).
- if a safety audit suggests that it is necessary, establish barrier planting schemes to prevent entry into the water
- if necessary consider the use of low fencing to prevent access to the water for young children.

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Glossary

Acidification	The term acidification is applied to the process by which naturally acid waterbodies become more acidic, usually as a result of human activity. Acidification is mainly caused by the deposition of acids from the atmosphere ('acid rain') derived from the burning of fossil fuels (mainly by power stations and vehicles). Acidification can also be caused by runoff from conifer plantations.
Algal blooms	Proliferation of microscopic planktonic algae, often exacerbated by nutrient pollution, but sometimes occurring naturally.
Amphibians	Frogs, toads and newts.
Aquatic plants	A group combining both submerged and floating-leaved species (and excluding marginal plants).
Assemblage	A group of plants or animals recorded together. The term is used in preference to 'community' because the latter implies an interaction between species.
Base-poor soils	Soils which have little capacity to neutralise acids (especially from acidified rain) making waterbodies that drain from these soils more vulnerable to acidification.
Biodiversity	The variability among living organisms including diversity within species, between species and of ecosystems.
Biomass	The total mass of living matter within a given unit of area (e.g. per square metre).
Biota	The plant and animal life of a region or ecosystem, as in a pond or other body of water.
BMP	Best Management Practice, a shorthand term for urban drainage best management practice, a set of techniques used to control and manage urban runoff, particularly as part of SUDS schemes.
BTCV	British Trust for Conservation Volunteers.
Buffer zone	A protective, neutral area between distinct environments (e.g. a grass strip, scrub or wet organic soil between farmland and a pond).
Catchment	The total area of land from which water drains into any given pond, loch, river, or other body of water.
Charophytes	A distinctive group of green algae (Characeae), known as stoneworts, which superficially resemble vascular plants in their size and the complexity of their structure. They are particularly associated with unpolluted waters rich in calcium.
Common Agricultural Policy (CAP)	The CAP is a central element in the European Union's institutional system and has been the forerunner of the single market (which ensures free movement of goods, services, capital and people, in the 15 Member States of the Union). The objectives of the CAP are (i) to increase productivity, (ii) to ensure a fair standard of living for the agricultural Community, (iii) to stabilise markets, (iv) to assure food supplies, and (v) to provide consumers with food at reasonable prices.
DETR	Department of the Environment, Transport and the Regions.
DETR Lowland Pond Survey.	A survey of the ecological quality and numbers of ponds in lowland Britain (England, Wales and Scotland) undertaken in 1996 for the DETR by Pond Action and the Institute of Terrestrial Ecology.
Drawdown zone	Zone at the margin of ponds and lochs which is flooded in winter but which dries out in summer and autumn as water levels drop naturally during drier weather. In reservoirs large and unnaturally rapid drawdowns may occur causing extensive damage to marginal ecosystems.

Duckweeds	General name for a group of six species of small free-floating plants which often form a complete cover on the water surface. Abundant growths of Common and Least Duckweed often occur on polluted or shaded ponds. The other species are generally indicative of higher quality water, or occur only in high quality habitats. The species that occur in Britain are: Common, Least, Ivy-leaved, Greater, Fat and Rootless Duckweeds. The respective scientific names for these plants are *Lemna minor*, *L. minuta, L. trisulca, Spirodela polyrhiza, L. gibba* and *Wolffia arhiza.*
Ecology	The study of the relationships between living organisms and their environment.
Ecosystem	A community of interdependent organisms together with the environment they inhabit and with which they interact (e.g. a pond, an oakwood).
Emergent plants	Wetland plants which typically have most of their leaves above water level, e.g., tall emergent species such as bulrush *(Typha latifolia)* and soft rush *(Juncus effusus);* wetland herbs such as water forget-me-not *(Myosotis scorpioides)* and low-growing grasses such as creeping bent *(Agrostis stolonifera).*
Environmentally Sensitive Area (ESA)	ESAs are parts of the country of particularly high landscape, wildlife or historic value which are threatened by changes in farming practices. Incentives are offered to farmers to adopt agricultural practices which will safeguard and enhance the rural environment and create improvements in public access. There are now 22 ESAs in England and Scotland covering some 10% of agricultural land. They are administered by the Scottish Executive Rural Affairs Department or the Ministry of Agriculture, Fisheries and Food (England and Wales only).
Eutrophic	High nutrient status e.g. typically Total Phosphorus concentration 0.03 - 0.10 mg l^{-1}, Inorganic Nitrogen concentration 0.5 - 1.5 mg l^{-1}, pH greater than 7.4.
Eutrophication	Eutrophication is the term applied to the physical, chemical and biological changes which occur when nutrient concentrations in ponds, lakes and rivers are increased as a result of natural or anthropogenic processes. Eutrophication is mainly of concern where it results from pollution caused by the release of nutrients from point or diffuse sources (e.g. runoff from farmland and urban areas, sewage treatment works effluents). In all cases eutrophication leads to increased algal growth but effects on other biota depend on the initial starting condition of the waterbody; in oligotrophic and mesotrophic waterbodies, eutrophication leads to loss of species dependent on low nutrient status in favour of species associated with higher nutrient concentrations. In eutrophic waters, further enrichment (hypertrophy) can lead to complete elimination of submerged aquatic plants and consequent damage to animal assemblages through loss of habitat.
Eutrophic Standing Waters Habitat Action Plan	Part of the UK Biodiversity Action Plan process to identify actions for the conservation of eutrophic standing waters.
Evapotranspiration	The combined evaporation from the soil surface and the transpiration from plants.
Filamentous algae	Aggregations of single-celled algae that grow in long strings or mats in water and are either attached or free floating. Dense growths of filamentous algae are often associated with nutrient enriched waters but also occur naturally in lower abundances. They provide habitat for a wide range of invertebrate animals.
Floating-leaved plants	Aquatic plants with most of their leaves floating on the water surface, e.g., Common Duckweed *(Lemna minor)*, water lilies *(Nuphar* and *Nymphaea).*

FWAG	The Farming and Wildlife Advisory Group (FWAG) is the foremost UK based organisation providing conservation advice to the farming community, and promotes environmentally responsible farming. FWAG provides advice on conservation in the widest sense, including wildlife, landscape and public access.
Geology	The study of the physical nature and history of the earth.
GIS	Geographical Information System, computer-based systems for mapping and analysing data.
Groundwater	Water that occupies pores and crevices in soils and rocks, below the surface and above a layer of impermeable materials (as opposed to surface water which remains at or close to the land surface).
Habitat	The native environment or specific surroundings where a plant or animal naturally grows or lives. The surroundings include physical factors such as temperature, moisture, and light together with biological factors such as the presence of food or predator organisms.
Herpetofauna	A collective terms for reptiles (snakes, lizards) and amphibians (frogs, toads, newts).
Hydrology	The study of water and water movement above, upon and beneath the ground.
Hypereutrophic	Very high nutrient status e.g. typically Total Phosphorous concentration greater than 0.10 mg l^{-1}, Inorganic Nitrogen concentration greater than 1.5 mg l^{-1}.
Hydrostatic pressure	The pressure in a fluid in equilibrium which is due solely to the weight of fluid above.
Insectivores	Insect eating animals (may sometimes be applied to insectivorous plants such as sundews).
ITE	Institute of Terrestrial Ecology.
JNCC	Joint Nature Conservation Committee.
LBAP	Local Biodiversity Action Plan.
Macroinvertebrates	Larger invertebrate animals, easily visible to the naked eye, such as snails, beetles, dragonflies.
Mesotrophic Lakes Habitat Action Plan	Part of the UK Biodiversity Action Plan process to identify actions for the conservation of mesotrophic standing waters.
Microinvertebrates	Smaller invertebrate animals, difficult to see with the naked eye.
Macrophyte	Larger wetland plants typically referring to vascular wetland plants, mosses, liverworts and charophyte species.
MAFF	Ministry of Agriculture, Fisheries and Food.
Marginal plants	Wetland plants growing at or near to the margin of waterbodies in shallow water or seasonally flooded soils.
Meander	Freely developed bend in a river.
Mesotrophic	Moderate nutrient status e.g. typically Total Phosphorus concentration 0.01 - 0.03 mg l^{-1}, Inorganic Nitrogen concentration 0.3 - 0.65 mg l^{-1}, pH around 7.
Nationally uncommon plant	A species designated as Nationally Scarce or recorded from 100 or fewer 10 km squares in Britain.
NPPG	National Planning Policy Guidance.
NNR	National Nature Reserve.
NPS	National Pond Survey.
Oligotrophic	Low nutrient status e.g. typically Total Phosphorus concentration 0.005 - 0.010 mg l^{-1}, Inorganic Nitrogen concentration 0.02 - 0.4 mg l^{-1}, pH 6-7.
Operation Brightwater	Pond conservation project undertaken between 1990 and 1993 by Scottish Conservation Projects.

PCG	Pond Conservation Group.
pH	A measure of the acidity or alkalinity of a substance based on the number of hydrogen ions in a litre of solution. pH 7 represents neutrality, smaller values are acid, larger values are alkaline.
Planktivores	Animals (usually fish) that feed on plankton.
Red Data Book (RDB)	Red Data Books of Britain and Ireland list species of plants or animals in danger of extinction in the British Isles (they many be widespread elsewhere in Europe). Species are categorised according to the degree of threat they face. For plants, RDB categories follow the new IUCN guidelines (IUCN, 1994). For invertebrates, the earlier nationally defined standards set by JNCC are followed.
RoSPA	Royal Society for the Prevention of Accidents.
RSS	Rare Species Score. Value representing sum of numerical scores given to uncommon species in order to reflect their rarity value i.e. 2= locally common species, 64 = RDB1.
RSPB	Royal Society for the Protection of Birds.
Salmonid	A member of the fish family Salmonidae which includes salmon, trout and sea trout.
SCP	Scottish Conservation Projects.
Second-tier sites	Sites which are important for nature conservation but not of high enough quality or importance to be designated as SSSIs.
SEPA	Scottish Environment Protection Agency.
SNH	Scottish Natural Heritage.
Species	A group of organisms which resemble each other and which will not normally breed with members of another group.
Species richness	The number of plant or animal species recorded in a particular habitat or sample.
Species Rarity Index (SRI)	A numerical assessment of the average species rarity of a particular assemblage or sample.
SSSI	Site of Special Scientific Interest.
Submerged plants	Aquatic plants which are generally submerged for most of the year (except for flowers), e.g., hornworts (*Ceratophyllum* spp.), water milfoils (*Myriophyllum* spp.).
SUDS	See Sustainable Urban Drainage Systems.
Surface water	Water which occurs on or near to the ground surface.
Sustainable Urban Drainage Systems (SUDS)	SUDS schemes are a group of techniques designed to control the damaging impacts of urban runoff. They combine pollution control measures with techniques for reducing the rate at which water runs off of paved surfaces into surrounding streams and rivers. SUDS schemes also aim to provide new wetland habitats and to improve the landscape and environment for people living in urban areas. SUDS schemes are made up of four main elements: (i) permeable pavements, (ii) filter strips and swales, (iii) infiltration devices and (iv) basins and wetlands.
TRS	Trophic Ranking Score. The Trophic Ranking Score system is based on the presence of indicator plant species, weighted (on a 1 to 10 scale) according to the mean nutrient status of the waterbodies in which they typically occur (from dystrophic to highly eutrophic). The average Trophic Ranking Score from each site therefore gives an approximate assessment of the nutrient status of the waterbody.
Wetland plants	All wetland plant species, including those which are emergent, floating-leaved, and submerged. A standard list of wetland plants is given in the Guide to the methods of the National Pond Survey (Pond Action, 1998).

Appendix 1.
Specialist advisors

Organisation	Contact	Area of expertise
Balfour-Browne Club	Honorary Secretary - Prof. Garth N. Foster 3 Eglinton Terrace Ayr KA7 1JJ, Scotland, UK g.foster@au.sac.ac.uk	Conservation of water beetles including surveys and site assessment. Extensive database of Scottish site records.
British Herpetological Society Conservation Committee	BHSCC, 28 Old Fort Road Shoreham by Sea BN43 5RJ	The BHSCC promotes the conservation and welfare of amphibians and reptiles.
British Waterways	British Waterways Canal House 1 Applecross Street Glasgow G4 9SP Tel: 0141 332 6936 Contact: Dr. Olivia Lassiere	Specialist advisor Dr. Lassiere has extensive experience of lake and pond management in Scotland.
BTCV (British Trust for Conservation Volunteers)	Head Office: BTCV 36 St Mary's Street Wallingford Oxfordshire OX10 0EU Tel: 01491 839766 Fax: 01491 839646 Web site: www.btcv.org.uk	BTCV and its affiliated groups undertake practical nature conservation work, including work on ponds and wetlands. In Scotland BTCV is represented by Scottish Conservation Projects (see below). BTCV produces 'Waterways and wetlands: a practical handbook' by Elizabeth Agate and Alan Brooks (2nd Edition 1997) which is a comprehensive guide to many of the practical techniques of managing wetlands, including ponds.
British Dragonfly Society	Secretary of the Society: Bill Wain, The Haywain Hollywater Road, Bordon, Hampshire, GU35 0AD.	Provides information and advice on the conservation of dragonflies. Undertakes survey work throughout Scotland (and the rest of Britain) with special reference to rare and scarce species.
Centre for Aquatic Plant Management (CAPM)	CAPM, Broadmoor Lane Sonning, Reading Berkshire, RG4 0TH Tel: 0118 9690072 Fax 0118 944 1730	Provides advice on techniques for managing aquatic plants, with special expertise in the use of barley straw to control algal growth.
CETCO Europe Ltd	Cetco Europe Ltd, Birch House Scotts Quays, Birkenhead Merseyside, L412 1FB Tel: 0151 606 5206 Fax: 0151 638 5330.	CETCO manufactures and supplies geosynthetic clay liners 'Claymax' and 'Bentomat'. The company is an alternative supplier to 'Rawmat'.
Convention of Scottish Local Authorities (COSLA)	COSLA, Rosebery House, 9 Haymarket Terrace Rosebery House Edinburgh, EH12 5XZ Tel: 0131 474 9200 Fax: 0131 4749292 Web site: www.cosla.gov.uk	Local government in Scotland is represented collectively by the Convention of Scottish Local Authorities (COSLA). Formed in 1975, COSLA exists to promote and protect the interests of councils in Scotland by providing a forum for discussion of matters of common concern. COSLA ascertains the views of member councils and communicates these to central government, other bodies and the public. All councils in Scotland are members of COSLA.

Organisation	Contact	Area of expertise
Farming and Wildlife Advisory Group (FWAG)	FWAG Scotland, The Rural Centre, Ingliston, Midlothian EH28 8NZ Tel: 0131 472 4080; Fax: 0131 472 4083 The FWAG national centre is based at the National Agricultural Centre Stoneleigh, Kenilworth Warwickshire, CV8 2RX Tel: 01203 696699.	FWAG works with farmers and landowners to promote nature conservation in the farm environment. Advisors provide confidential advice and guidance on a range of topics including: the protection, management and creation of wildlife and landscape features such as woodlands, ponds, watercourses and hedgerows, and various agri-environment and grant-aid schemes including ESAs.
Fish Conservation Centre	Fish Conservation Centre Nether Sunnyside Haddington East Lothian, EH41 4NR Contact: Prof. Peter Maitland	The Fish Conservation Centre was established to initiate and develop work related to fish conservation problems in Scotland and elsewhere in the world. The work is mainly done under contract but there are some voluntary activities. One of the primary objectives is to raise public awareness of the plight of many fish species and gain support for their conservation.
Freshwater Biological Association	Freshwater Biological Association (FBA), The Ferry House Far Sawrey, Ambleside Cumbria, LA22 0LP. Web site: www.fba.org.uk	The FBA promotes scientific research on the freshwater ecosystems. It publishes a series of standard guides to the identification of aquatic invertebrates, fish and other freshwater organisms.
Freshwater Fisheries Laboratory	Freshwater Fisheries Laboratory Pitlochry Perthshire, PH16 5LB Tel: 01796 472060; Fax: 01796 473523 Web site: www.marlab.ac.uk	The Freshwater Fisheries Laboratory is the only government research laboratory in Great Britain which is wholly devoted to freshwater fisheries. Together with its field stations at Almondbank, Deeside and Montrose, and a specialist unit in Aberdeen it is the leading scientific authority on Scottish freshwater fisheries.
Froglife	Froglife, Triton House Bramfield, Halesworth Suffolk, IP19 9AE Tel: 01986 784518; Fax: 01986 784579.	Froglife is a non-profit making organisation which publishes information and promotes amphibian conservation projects, especially the Toads on Roads campaign. Froglife also co-ordinates the activities of the Herpetofauna Groups of Britain and Ireland. Froglife provides training on amphibian survey techniques.
Glasgow City Council	Glasgow City Council 37 High Street Glasgow G1 1LX Tel: 0141 287 5064; Fax: 0141 287 5151 Web site: www.glasgow.gov.uk	Manages sites of nature conservation interest in the City of Glasgow, including a number of ponds and lakes. Practical advice and assistance is available.
Herpetofauna Groups of Britain and Ireland	Contact details for the Herpetofauna Groups of Britain and Ireland are contained in the Herpetofuana Workers Guide 2000 (Gibb and Foster, 2000).	HGBI is a consortium of local Herpetofauna Groups which undertakes practical conservation work to protect amphibians and reptiles.
Herpetological Conservation Trust	Herpetological Conservation Trust 655A Christchurch Road Boscombe, Bournemouth Dorset, BH1 4AP Tel: 01202 391319.	The Herpetological Conservation Trust aims to advance the conservation of amphibians and reptiles in the UK and Europe. HCT manages sites of importance for reptiles and amphibians, especially lowland heathland, with special emphasis of rare species such as the natterjack toad.
Historic Scotland	Historic Scotland Longmore House Salisbury Place Edinburgh, EH9 1SH Tel: 0131 668 8600	Historic Scotland safeguards Scotland's built heritage by scheduling monuments of national importance and by listing historic buildings of special architectural or historic interest.

Organisation	Contact	Area of expertise
Institute of Freshwater Ecology	Institute of Freshwater Ecology Windermere Laboratory The Ferry House Far Sawrey, Ambleside Cumbria, LA22 0LP Tel: 015394 42468; Fax: 015394 46914 Web site: www.ife.ac.uk.	The Institute of Freshwater Ecology undertakes research on the ecology of freshwater ecosystems.
JNCC	JNCC Monkstone House, City Road Peterborough, PE1 1JY Telephone: 01733-562626; Fax: 01733-555948 Web site: www.jncc.gov.uk	JNCC is the Government's wildlife adviser undertaking national and international conservation work on behalf of Scottish Natural Heritage, English Nature and the Countryside Council for Wales. JNCC provides information about Biodiversity Action Plan species and habitats.
Local authority archaeologists	Local authority archaeologists provide information and advice on all aspects of archaeology. Contact details are given for all regions in Scotland (based on information given in the Historic Scotland leaflet on 'Archaeology on the Farm'): Aberdeenshire, Moray: Aberdeenshire Angus Archaeology Service 01244 664723 Aberdeen City: 01224 646333 Argyl & Bute, City of Glasgow, East Ayrshire, East Renfrewshire, Inverclyde, North Ayrshire, North Lanarkshire, Renfrewshire, South Ayrshire, South Lanarkshire, West Dunbartonshire: West of Scotland Archaeology Service 0141 287 8332/3. Borders: Scottish Borders Archaeology Service 01835 824000 Clackmannan, Stirling: 01786 442752 Dumfries and Galloway: 01387 260154 Edinburgh, East Lothian: 0131 5581040 Fife: Fife Archaeology Service 01592 416153 Falkirk: 01324 503783 Highland: Highland Archaeology Service 01463 702250 Orkney: 01856 850285 Perth & Kinross: 01738 632488 Shetland: 01595 694688 Western Isles: 01851 703564 Dundee, East Dunbartonshire, Midlothian, West Lothian: 0131 662 1456.	
Pond Action	Pond Action c/o Oxford Brookes University Gipsy Lane, Headington Oxford OX3 0BP Tel: 01865 483249; Fax: 01865 483282 Web: www.brookes.ac.uk/pondaction	Pond Action is a national centre for information and advice on pond conservation. Pond Action initiated and runs the National Pond Survey and in 1999 established the National Ponds Database. Pond Action provides information on pond management, design and construction.
Ponds Conservation Trust	Ponds Conservation Trust c/o Oxford Brookes University Gipsy Lane, Headington Oxford OX3 0BP Tel: 01865 483199; Fax: 01865 483282.	The Ponds Conservation Trust promotes the conservation of ponds by working with local community groups to carry out practical pond conservation projects. The Trust is made up of a consortium of 22 environmental archaeological and community organisations.
RoSPA	Royal Society for the Prevention of Accidents Slateford House, Lanark Road Edinburgh EH14 1TL Occupational enquiries: 0131 444 1155 Home & Road enquiries: 0131 455 7457 Fax: 0131 443 9442. Web: www.rospa.org.uk	RoSPA is a registered charity which was established over 80 years ago. Providing information, advice, resources and training, RoSPA is actively involved in the promotion of safety in all areas of life - at work, in the home, and on the roads, in schools, at leisure and on (or near) water.
RSPB	RSPB Scotland Headquarters Dunedin House, 25 Ravelston Terrace Edinburgh EH4 3TP Tel: 0131 311 6500; Fax: 0131 311 6569 Web: www.rspb.org.uk	The RSPB's objectives include: conserving the most endangered bird species and their habitats, safeguarding Scotland's most important sites for birds through nature reserves and other mechanisms, providing a range of information and fundraising materials to support this work, campaigning to inform members and the public about conservation and the countryside.

Organisation	Contact	Area of expertise
Scottish Agricultural College	SAC Edinburgh SAC West Mains Road Edinburgh, EH9 3JG Tel: 0131 535 4000; Fax: 0131 535 4246 Web: www.sac.ac.uk	The Scottish Agricultural College provides advice to farmers and landowners on land management issues including various aspects of nature conservation. (e.g. ESA schemes, Countryside Premium Scheme).
Scottish Conservation Projects	Scottish Conservation Projects Balallan House, 24 Allan Park Stirling, FK8 2QG. Tel: 01786 79697.	Scottish Conservation Projects organises practical conservation activities, including pond conservation work. SCP is the only body in Scotland established specifically to promote the involvement of people in practical nature conservation work.
Scottish Executive Rural Affairs Division (Fisheries Group)	Scottish Executive Rural Affairs Department SERAD) Fisheries Group, Pentland House 17 Robb's Lane Edinburgh, EH14 1TY	SERAD Fisheries Group administers Scottish fishery legislation, particularly with regard to migratory fisheries.
Scottish Natural Heritage	Headquarters: 12 Hope Terrace Edinburgh EH9 2AS Tel: 0131 447 4784; Fax: 0131 446 2277 Web: www.snh.org.uk.	SNH aims to help people enjoy Scotland's natural heritage responsibly, understand it more fully and use it wisely so that it can be sustained for future generations. SNH provides technical advice about the management of freshwater ecosystems including ponds. SNH also holds a national database of botanical survey data on lochs (including many smaller lochans) throughout Scotland).
Scottish Wildlife Trust	Scottish Wildlife Trust Cramond House Cramond Glebe Road Edinburgh, EH6 6BT Tel: 0131 312 7765; Fax: 0131 312 8705.	The Scottish Wildlife Trusts is Scotland's leading voluntary body promoting wildlife conservation. The Trust manages over 100 nature reserves including a number of sites with ponds. The Trust can provide advice on various aspects of pond conservation, management and construction.
Scottish Environment Protection Agency (SEPA)	SEPA Head Office Erskine Court Castle Business Park Stirling, FK9 4TR Tel: 01786 457700; Fax: 01786 446885. Web: www.sepa.org.uk. SEPA East Region Headquarters Clearwater House Heriot Watt Research Park Avenue North, Riccarton Edinburgh, EH14 4AP. Tel: 0131 449 7296; Fax: 0131 449 7277 SEPA North Region Headquarters Graesser House, Fodderty Way Dingwall Business Park Dingwall, IV15 9XB Tel: 01349 862021; Fax: 01349 863987. SEPA West Region Headquarters SEPA West, 5 Redwood Crescent Peel Park East Kilbride, G74 5PP Tel: 01355 574200; Fax: 01355 574688	SEPA's task is to protect the land, the air and the water of Scotland. It does this in partnership with others and in a way which enables Scotland to sustain a strong and diverse economy. SEPA initiated the Habitat Enhancement Initiative of which the Ponds Handbook is a part.
WWF Scotland	WWF Scotland 8 The Square Aberfeldy Perthshire PH15 2DD.	WWF Scotland works to protect the wildlife and landscapes of Scotland.

Appendix 2.

Appropriate plants for adding to new ponds

This appendix lists plants that are common and widespread throughout the British Isles (including Scotland), and that can be transplanted to new ponds.

Submerged and floating-leaved plants of base-rich ponds

Submerged plants do not always survive transplantation to a new pond, particularly where water quality is different to that of the original site, and it is often best just to let them colonise naturally. The following submerged plants are fairly tolerant of conditions in at least moderately unpolluted base-rich ponds:

- *Curled pondweed (Potamogeton crispus)*
- *Various species of water-starworts (Callitriche* species*)*
- *Rigid hornwort (Ceratophyllum demersum)*
- *Various species of water-crowfoot (Ranunculus* species*)*
- *Spiked Water-milfoil (Myriophyllum spicatum)*
- *Marestail (Hippuris vulgaris)*

Three common floating-leaved plants are tolerant of a wide range of conditions:

- *Broad-leaved pondweed (Potamogeton natans)*
- *White water-lily (Nymphaea alba)*
- *Yellow water-lily (Nuphar lutea)*

Plants for the drawdown zone and shallow water:

Most marginal water plants are tolerant of natural water level fluctuations and will grow both in shallow water and on damp marshy ground. When planting up the pond edge, encourage a mix of tall emergents and, just as important, low grasses and herbs. Plant in small mixed clumps - they will soon spread. Perennial species planted into damp ground at the water's edge generally 'take' well regardless of the time of year in which they are planted.

Suitable taller marginal plants include:

- Yellow Iris *(Iris pseudacorus)*
- Marsh Woundwort *(Stachys palustris)*
- Gipsywort *(Lycopus europaeus)*
- Purple Loosestrife *(Lythrum salicaria)*
- Various species of rush *(Juncus species)*
- Great Water-dock *(Rumex hydrolapathum)*
- Great Pond-sedge *(Carex riparia)*
- Reed Canary-grass *(Phalaris arundinacea)*
- Reed Sweet-grass *(Glyceria maxima)*
- Branched Bur-reed *(Sparganium erectum)*
- Bulrush *(Typha latifolia)*

Note that the last five of these species are usually very vigorous. It is inadvisable to plant them at the edge of small shallow ponds, unless a marshland pond dominated by tall emergents is required, or continuous plant management is to be undertaken.

Lower-growing herbs and grasses that can be added to ponds on base-rich soils include:

- Amphibious Bistort *(Persicaria amphibia)*
- The floating sweet-grasses *(Glyceria* species*)*
- Creeping Bent *(Agrostis stolonifera)*
- Common Water-plantain *(Alisma plantago-aquatica)*
- Watercress *(Nasturtium officinale)*
- Marsh-marigold *(Caltha palustris)*
- Marsh Pennywort *(Hydrocotyle vulgaris)*
- Water Forget-me-not *(Myosotis scorpioides)*
- Water Mint *(Mentha aquatica)*
- Creeping Bent *(Agrostis stolonifera)*
- Marsh Foxtail *(Alopecurus geniculatus)*
- Fool's Water-cress *(Apium nodiflorum)*
- Common Spike-rush *(Eleocharis palustris)*

Marginal plants appropriate for acid conditions

- Star Sedge *(Carex echinata)*
- Common Sedge *(Carex nigra)*
- Bottle Sedge *(Carex rostrata)*
- Marsh Thistle *(Cirsium palustre)*
- Tufted Hair-grass *(Deschampsia caespitosa)*
- Common Spike-rush *(Eleocharis palustris)*
- Marsh Willowherb *(Epilobium palustre)*
- Floating Sweet-grass *(Glyceria fluitans)*
- Yellow Iris *(Iris pseudacorus)*
- Articulated Rush *(Juncus articulatus)*
- Sharp-flowered Rush *(Juncus acutiflorus)*
- Bulbous Rush *(Juncus bulbosus)*
- Soft Rush *(Juncus effusus)*
- Hard Rush *(Juncus inflexus)*
- Ragged-robin *(Lychnis flos-cuculi)*
- Creeping Forget-me-not *(Myosotis secunda)*
- Bog-myrtle *(Myrica gale)*
- Tormentil *(Potentilla erecta)*
- Lesser Spearwort *(Ranunculus flammula)*
- Marsh Violet *(Viola palustris)*
- Marsh Speedwell *(Veronica scutellata)*
- Deergrass *(Trichophorum caespitosum)*
- Bog Stitchwort *(Stellaria uliginosa)*

Aquatic plants appropriate for acid conditions

- White Water-lily *(Nymphaea alba)*
- Bog Pondweed *(Potamogeton polygonifolius)*
- Intermediate Water-starwort *(Callitriche hamulata)*
- Alternate Water-milfoil *(Myriophyllum alterniflorum)*

Plants to avoid

Avoid introducing non-native plants, especially into ponds in the wider countryside. It is particularly important not to introduce some of the very vigorous alien plants that can take over ponds and exclude native species. These include:

- Canadian Pondweed *(Elodea canadensis)*
- Nuttall's Pondweed *(Elodea nuttallii)*
- Curly Waterweed *(Lagarosiphon major)*
- Parrot's-feather *(Myriophyllum aquaticum)*
- Water Fern *(Azolla filiculoides)*
- New Zealand Swamp-stonecrop *(Crassula helmsii)*
- Floating Pennywort *(Hydrocotyle ranunculoides)*

This guide has been prepared for the Scottish Environment Protection Agency by Pond Action following consultation and discussion with Scottish conservation and environmental protection organisations.

AUTHORS

Jeremy Biggs, Penny Williams, Mericia Whitfield, Gill Fox, Pascale Nicolet

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Members of Pond Task Group

Stuart Brooks (Scottish Wildlife Trust), Jim Davis (Glasgow City Council), Mike Devlin (SEPA), Ian Dickson (SAC), Willie Duncan (Scottish Natural Heritage), Ian Fozzard (SEPA), Chris Jeffries (University of Abertay), Gaye McKissock (SEPA), Neil McLean (SEPA), Huw Thomas (SEPA).

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