Common Standards Monitoring Guidance

for

Canals

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1. Introduction

1.1 This guidance describes a monitoring methodology for judging the condition of canals that are notified habitat features forming the whole or part of designated sites. The method described here focuses on monitoring the aquatic and marginal plant communities, but there is a range of abiotic and habitat attributes which contribute to the overall condition assessment. Details of these attributes and associated targets are described in Table 1. Where a canal also supports a particular species of interest, for example floating water plantain (*Luronium natans*), reference should be made to any species specific monitoring guidance.

1.2 The guidance has been developed from Eaton and Willby (2003), which contains further detail on associated methods suitable for other purposes. Some general discussion of both the basic principles and the practical constraints involved in surveying artificial linear waterways such as canals are given by Hatcher *et al.* (1999). The need for standardised survey procedures is emphasised, to allow valid comparisons between waterways and on the same waterway over time. Issues of vegetation heterogeneity and random sampling along linear systems are considered and the key points from the study are incorporated into the methods specified here.

2. Definition

1.3 Canals are defined for the purpose of these guidelines as artificial waterways. This definition excludes rivers that form part of the navigable waterway system, even if they have been substantially modified to accommodate boat traffic. (CSM guidance for rivers should be used for these.) Canals occur throughout the UK and form an extensive network in parts of England, particularly the Midlands, linking navigable river systems. Most canals were constructed during the late eighteenth and early nineteenth centuries. They vary in width, with the locks of 'narrow' canals being only 7 ft. wide, although in the pounds between locks the channel may be much broader, especially at winding holes (boat turning points). Canals need a reliable supply of water in order for locks to function and this is taken either from rivers or from specially created reservoirs. Many canals have remained navigable since construction or have recently been restored, but part of the network is semi-derelict. The majority of boat traffic is now recreational and consequently more seasonal than it would have been in the past.

2.2 Within a site designated for canal flora and fauna there will be a variety of structures (locks, tunnels, bridges) and semi-natural habitats. In addition to the main channel there will be towpaths and possibly hedgerows, scrub, woodland, reservoirs, feeder streams, side arms, swamp or fen. This guidance covers only the vegetation of the channel, so where there are other interest features within the site the relevant habitat or species guidance (grassland, woodland, wetland, river, standing water, bats etc.) should also be used.

2.3 Despite being artificial, canals may receive water and plant propagules from a variety of sources and are somewhat analogous to a range of natural habitats and can be very rich in wildlife. For instance, at the time of SSSI designation the Basingstoke Canal, which receives water from a variety of sources including chalk and heathland streams, supported half the UK's native aquatic vascular plant species. It is also very important for its dragonfly fauna and (in the Greywell Tunnel) its bat fauna. Species-richness depends not only on water quality but also on the intensity of boat traffic and channel management. In the absence of management unused and derelict canals become overgrown with emergent vegetation and lose the open water element of their flora. Heavily used canals lose much of their submerged and floating-leaved vegetation because the water column becomes turbid and plants are chewed up by propellers and uprooted by the passage of boats. Wash can erode banks and destroy emergent vegetation, so artificial bank

re-inforcement is frequently needed where boat traffic is heavy. A number of novel techniques for constructing protected soft canal banks have been developed but these have not yet been widely adopted.

2.4 There is no recognised classification of canal flora, but a simple system for use in monitoring is described in Section 7.1. British canals are mainly lowland, mesotrophic to eutrophic, base rich waterbodies and, as such, do not show the wide range of characteristic communities exhibited by, for example, lakes and rivers. The particular assemblage found in an individual canal may show limited regional influences, but otherwise seems to be some local combination drawn from the relatively large national pool of lowland species. There are a few exceptions, such as locally brackish waterways and Pennine lengths which show local oligotrophic, base poor and/or acidic influences; many of these canals have particularly high wildlife interest reflecting the nature of the water chemistry. Appendix 2 lists species likely to be found in these special conditions. There are, however, many species overlaps between these (rather ill-defined) groups. Nevertheless the following generalities provide useful guidance on what may be expected in various geographical locations.

2.5 Lightly trafficked or untrafficked canals with base-poor feeders draining moorland, woodland or rough grassland-dominated catchments overlying sandy or peaty soils tend to contain a diverse range of aquatic plants. Species seemingly naturally found in these canals include: *Potamogeton alpinus, P. compressus, P. perfoliatus, P. obtusifolius, P. berchtoldii* and (rarely) *P. gramineus and P. praelongus.* Such canals are also distinguished by the occasional presence of species such as *Callitriche hamulata, C. hermaphroditica* and *Luronium natans.* Canals with base- and nutrient-rich water sources draining catchments dominated by intensive agriculture are more likely to contain the following: *Potamogeton pusillus, P. trichoides, P. perfoliatus, P. lucens, P. friesii, P. pectinatus, Myriophyllum spicatum, Callitriche stagnalis, C. platycarpa, Persicaria amphibia* and *Zannichellia palustris.* A further set of species comprising *Sparganium emersum, Sagittaria sagittifolia, Potamogeton natans, Elodea canadensis, E. nuttallii, Ceratophyllum demersum, Lemna minor* and *L. trisulca* is widely distributed across both the above groups but, together with filamentous algae, tends to become dominant in the more productive sites.

2.6 The main deviations from the above pattern are presented by

- canals, mostly in the south of England, with a strong riverine influence (e.g. the Kennet & Avon Canal in Berkshire and the South Oxford Canal). Here there may be locally increased presence of Batrachian *Ranunculus spp., Callitriche spp., Sparganium emersum, Schoenoplectus lacustris* and occasionally *Oenanthe fluviatilis,*
- lengths with slightly brackish waters, resulting from saline groundwater sources (especially in the Worcester-Droitwich area) or a coastal location (e.g. the Glasson Branch of the Lancaster Canal). There species such as *Zannichellia palustris* and *Potamogeton pectinatus* may occur with increased frequency, sometimes with species not otherwise typical of canals, such as *Ranunculus baudotii* or *Ceratophyllum submersum* (see Appendix 2).

2.7 The high diversity of plant communities is a central feature of lightly trafficked canals and those untrafficked ones in which succession processes are retarded or arrested, usually by periodic management. There is also a number of uncommon species that depend heavily on these habitats for their UK population status. These include *Nitella mucronata, Callitriche truncata, Luronium natans* (listed on Annex II and Annex IV of the Habitats Directive), *Potamogeton compressus, P. friesii, P. trichoides* and the hybrids *P. x bennettii, P. x cooperi* and *P. x lintonii*. As disturbance by boats increases there is a convergence of the various above assemblages towards communities typical of lowland clay-based rivers, with species such as *Nuphar lutea, Potamogeton perfoliatus, P. lucens, P. pectinatus, Sparganium emersum and Sagittaria sagittifolia.* Such sites may still be of value in regions where natural watercourses have been extensively degraded.

3. Attributes and targets

3.1 A series of broad habitat attributes has been defined, which should be monitored in order to assess whether the canal feature is in favourable condition. At least one target is specified for each attribute. The targets set out here are for guidance only and may need to be modified in the light of the local characteristics and history of the site. Decisions to adopt more or less stringent targets for a particular attribute should be made in discussion with the appropriate national specialist. Assessment of most of the attributes is mandatory, but one (salinity) is not relevant to all sites and another (biological quality and water chemistry) need only be assessed where the relevant data exist or where a pollution problem is suspected, in which case, investigative monitoring should be considered. Indicators of local distinctiveness should be monitored wherever they are significant elements of the feature.

3.2 The attributes used for monitoring canals are listed below. Most have two or more constituent elements. Those marked * are discretionary or site-specific

- Extent:
  - characteristic vegetation
- Habitat functioning:
  - water availability
  - water transparency
  - water quality (indirect method): cover of algae/*Lemna*/*Azolla*
  - biological quality and water chemistry [assessed where data exist]
- Habitat structure:
  - sediment depth and texture
  - channel shading
- Aquatic plant community:
  - quantity of vegetation
  - species richness
- Indicators of negative change:
  - introduced plant species
- * Indicators of local distinctiveness
  - rare species and quality indicators
  - unusual plant communities

3.3 Targets for each of the attributes and the relevant assessment methods are summarised in Table 1. The failure of any one attribute to meet its target condition generally dictates that the condition of the whole canal feature should be classed as unfavourable. Further advice on target setting and assessment is given in Section 7.

4. Monitoring

4.1. Terminology

4.1.1 Canal vegetation is here divided into the following categories, partly because each is a distinct architectural type that interacts as an entity with the other types (thus emergent vegetation displaces the other two, the floating-leaved group shades the submerged group). For the purposes of this method emergent vegetation is assessed separately from floating-leaved and submerged vegetation in the quantitative section and site surveys.

- Emergent: species with most or all foliage above water level, growing at or out from the water's edge (e.g. reeds, sedges, rushes, broad-leaved marsh species).
- Floating-leaved: rooted and free-floating species (e.g. lilies, *Potamogeton natans*, *Sparganium emersum*, *Lemna minor*, *Hydrocharis morsus-ranae*, *Stratiotes aloides*).
- Submerged: species with foliage wholly underwater, mostly rooted (e.g.

Potamogeton pectinatus, Myriophyllum spicatum) but a few free-floating (e.g. *Lemna trisulca, Ceratophyllum demersum).*

A few species may be recorded in more than one category. For example *Nuphar lutea* may have both floating and submerged leaves at the same locality. As submerged and floating leaved species are grouped together to assess the aquatic plant community attribute such species may be recorded to either category. However, species such as *Sagittaria sagittifolia,* which may display emergent, floating and submerged foliage all together will prove more difficult to categorise. In such situations it is most appropriate to record as floating-leaved and/or submerged, depending on its growth form(s) at the particular location, as the emergent form is not comparable with reeds in its displacement capabilities.

4.1.2 Bank vegetation above the normal waterline is not included in the formal method, but notes should be made of it and especially of any notable species or features. During periods of drawn-down or heavy boat use, the water level of a canal length may be below the 'normal' level. In such cases the normal waterline should be evident from water marks on canal structures, exposed muds and 'stranded' marginal vegetation. There is often a little overlap between the emergent aquatic and terrestrial floras. *Phragmites australis* is one of a small number of species that occasionally grows well up the bank, away from the water and amongst wholly terrestrial species.

4.1.3 Checklists of native and non-native aquatic plants associated with canals are given in Appendices 1 and 2. Each species is categorised according to its growth form (emergent, floating, submerged).

4.2. Skills required

Ability to identify aquatic plants is required. Some of the most important species found in canals are difficult to identify, especially *Callitriche spp.,* some *Potamogeton* and charophyte species and the various growth forms of *Luronium natans.* Samples of all critical and uncertain material should be retained, checked in the laboratory and, if necessary, sent to specialist referees for verification. Voucher specimens of such material should be retained, preserved in 5 % ethyl alcohol or pressed on herbarium sheets. For submerged vegetation, direct visual observation is unreliable as a way of detecting species and even in very clear water a grapnel with cord at least half the width of the channel should be used to collect samples for bankside checking. The standard grapnel design shown in Figure 1 should be used.

Note: Where the Schedule 8 (Wildlife and Countryside Act, 1981) species *Luronium natans* is known to be present a licence to handle or uproot *L. natans* must be obtained from English Nature, Countryside Council for Wales or Scottish Natural Heritage in advance of carried out fieldwork.

4.3. Recommended visiting period and frequency of visits

To allow for seasonal development of species, surveys should not be started before early July and should be completed by mid-September at the latest (Appendix 4). Surveys should not be undertaken after dredging until one complete growing season has elapsed after the end of the works. Condition assessment on a six-year monitoring cycle will be based on walking the whole canal and detailed sampling at intervals (see Section 5).

4.4. Recording field locations

It is essential that canal sections and sampling sites are identified unambiguously, both by map co-ordinates and by reference to local named structures along the canal. For co-ordinates, Ordnance Survey six figure grid references are the minimum requirement. GPS records are preferable. Where

bridges and locks are numbered or named, these identifiers should also be recorded. Useful sources of canal maps are the regional set of *Nicholson/Ordnance Survey Guide to the Waterways*, stocked by most large bookshops. An increasing number of canals are covered by the *GEOprojects* series of maps. The standard reference work is L. A. Edwards' *Inland Waterways of Great Britain*, the Sixth (1985) Edition of which is a valuable source of information on distances between locks and some bridges. The Seventh (1997) Edition contains fewer distance data.

4.5. Limitations when only towing path access is used

Surveys rely on working from the towing path, this being much the quickest way to collect data. The offside of canals is usually difficult to access and use of a boat greatly extends working time. However, it is the offside which usually supports the largest stands of emergent vegetation. Inevitably therefore there is scope for under-recording any species which are mainly on the offside. In practice, simple tests show that few such species are missed. The larger offside emergents are usually readily identifiable from the towing path, especially if close focusing binoculars are used to check any uncertainties. There is no significant qualitative difference in submerged vegetation between the nearside and offside shallows. The only species liable to be under-recorded are small broad-leaved marginal, amphibious and marsh plants (e.g. *Mentha aquatica, Myosotis scorpioides, Veronica beccabunga*) where these are hidden behind reeds on the offside and there is no comparable emergent fringe for them to contribute to on the nearside. Also, lightly cattle-poached offside margins sometimes develop low-growing, discontinuous swards of broad-leaved, graminaceous and rush vegetation that is difficult to identify from the towing path side of the channel, yet may be comparatively species rich. The surveyor should examine the offside at points where access is feasible, concentrating observations especially on the rear of the emergent fringe and on cattle-poached areas.

4.6. Recommended survey procedure - refer to Appendix 1

Please refer to **Appendix 1** for general procedure and details of the section and site walking survey

4.7. Desk studies

Desk studies should be undertaken where necessary to provide supporting information for condition assessment.

- Obtain Environment Agency chemical and biological GQA class for site and phosphorus data where available.
- Obtain boat traffic density estimate (boat movement per year) for site from navigation authority.

5. Condition assessment

This section should be read in conjunction with Table 1.

5.1. Extent

This attribute relates to the botanical reasons for which the canal was notified (other than for species such as *Luronium natans* that are features notified in their own right). Extent is assessed during the section surveys. Some canals or sections of canal, usually unnavigated waterways, were designated because their swamp/fen vegetation is outstanding, some because of their abundant open water vegetation, and others for a combination of the two. The lengths with greatest overall

species richness are often those with about 25 % emergent cover, as this provides enough fringe area for a wide range of species to occur, while leaving extensive open water to support a good assemblage of floating-leaved and submersed species. Most canal SSSIs contain good examples of the vegetation of eutrophic, base-rich watercourses, but others are important for their oligo-mesotrophic, mesotrophic or base-poor characteristics. Some of the best canals, such as the Montgomery and Basingstoke, have a range of trophic types, reflecting a range of water inflows (e.g. water from upland reservoirs, calcareous river water, drainage from heathland,). A few canals are notable for their brackish water flora (this is covered in Section 7.6.2). Targets must be set on a site-by-site basis, within the framework of the following simple classification.

- Type the canal, using one of the three target vegetation categories A to C, to indicate the balance of vegetation expected in the designated site. Previous survey information (baseline data) or the SSSI citation should indicate which target community is likely to be appropriate. Category A is likely to be unusual, except in unnavigated canals with very thick vegetation. Category B represents canals where the aquatic flora is more extensive than the emergent flora, such as situation might arise where there has been a history of dredging throughout the entire canal cross-section and boat traffic levels are relatively low. Category C is representative of canals where a marginal shelf has been retained during dredging but where levels of boat traffic may be too high to allow extensive aquatic flora to develop. Very low cover of both vegetation elements is unacceptable, hence the blank cells in the table indicate unfavourable condition. Low cover is often associated with intensive boat traffic or frequent intensive management

- A range of vegetation categories may be present along the length of the canal, so a separate target should be set for each section.

<table>
<tr><td rowspan="2">Submerged + floating-leaved vegetation cover*</td><td colspan="5">Emergent vegetation cover*</td></tr>
<tr><td>Dominant
>70%</td><td>Abundant
30-70%</td><td>Frequent
10-30%</td><td>Occasional
3-10%</td><td>Rare
<3%</td></tr>
<tr><td>Dominant
>70%</td><td colspan="2" rowspan="2">A</td><td colspan="2" rowspan="2">B</td><td rowspan="2"></td></tr>
<tr><td>Abundant
30-70%</td></tr>
<tr><td>Frequent
10-30%</td><td colspan="2" rowspan="2">C</td><td colspan="2" rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Occasional
3-10%</td></tr>
<tr><td>Rare
<3%</td><td colspan="5"></td></tr>
</table>

* When assessing cover, the four most invasive alien aquatic taxa (*Azolla* spp., *Crassula helmsii*, *Hydrocotyle ranunculoides* and *Myriophyllum aquaticum*) should be excluded from the DAFOR rating.

- Overlay on this classification a target trophic category for each section: eutrophic or oligo-mesotrophic/mesotrophic (e.g. A/eu, B/meso). Hence there are potentially six different canal categories. Trophic status will be determined by the source of water for the canal, canals fed from upland feeders may be expected to be moderately nutrient poor and support oligotrophic or mesotrophic species. In contrast many canals have lowland sources of water being fed by lowland rivers, these canals will be more eutrophic. Further clues to the trophic status of a canal include the information provided in the citation or the information in Appendix 2. If three or more species

marked 'Meso' in Appendix 2 occur in a section, this indicates that the canal water is mesotrophic or oligo-mesotrophic. Such waters also lack species most typical of eutrophic conditions (*Potamogeton pectinatus, P. pusillus, Myriophyllum spicatum,* and *Zannichellia palustris*).

- Canals notified because of a range of trophic conditions would only be considered to be in favourable condition if the extent of these community types, as established by baseline survey or in the citation, was maintained.

- A canal section should not display a change between either vegetation category or trophic category over time to maintain favourable condition.

5.2. Habitat functioning

5.2.1. Water availability

Canals have small flows of water due to leakage and boat movements through locks. These flows can be essential elements in maintaining good water quality. Consistently low water levels may stress emergent and aquatic vegetation. In non-navigable canals water supply may be a problem and aquatic species may be lost through drying out. High levels of lock usage on navigated canals can result in large fluctuations in water levels and associated scouring of bed sediments and aquatic vegetation. In a navigated canal, condition assessment must take account of changes in level caused by the use of locks. Where pound lengths (sections between locks) are particularly short these fluctuations in water level may be considerable. However, a drop in overall depth of more than 10% throughout the canal would cause condition to be considered unfavourable.

5.2.2. Water quality

- **Water clarity** is an indicator of light availability for submerged plants. Turbidity can be caused by suspended solids resulting from disturbance by boats, though other factors such as phytoplankton and inputs of silt-laden drainage water after rain can also cause loss of clarity. Some discretion is needed in using the water clarity criterion. Occasional algal plankton blooms can discolour normally clear waters. Similarly, turbidity from entry of silt-laden storm water after heavy rainfall can cause temporary loss of clarity. If such causes are suspected for an unexpectedly poor clarity, a brief revisit 1-2 weeks later will often resolve the uncertainty.

- **Filamentous algae, *Lemna* spp. and *Azolla* spp.** in large quantities are usually indicative of nutrient enrichment which, at least in the long term, may lead to loss of native species richness. Their prominence is used as an indirect, measure to indicate the need for a more reliable assessment of likely eutrophication. Duckweeds and *Azolla* are mobile on canals and as wind-induced movements often override the direction of mass flow, so floating mats of these plants may move up and down a length unpredictably. For this reason, the overall measure of their abundance by the extensive survey is to be preferred to the instantaneous local measures at the intensively surveyed 150 m sites. Targets are set for percentage cover of filamentous algae and *Lemna* and *Azolla.* Their prominence is used as an additional, though indirect, measure to indicate the need for a more reliable assessment of likely eutrophication.

- **Chemical and biological water quality** targets are assessed by reference to existing data collected by the environment agencies. This attribute is discretionary only where water quality data are not available; in practice most navigable canals are included within wider water sampling programmes. Where no data on water chemistry is collected within a SSSI length the merits of initiating a routine sampling programme should be discussed with the navigation authority and environment agency. It should be noted that where water quality data are collected less frequently than monthly,

such data will not necessarily reflect actual conditions. However, the analysis of water quality information with reference to other information obtained during field surveys should indicate any water quality problems.
The GQA chemistry and biology modules (or equivalent) have been developed with reference to running waters and, although widely used for canal monitoring, may occasionally give poor GQA classes for canal waters. This is frequently a result of lower dissolved oxygen levels in canals due to their static nature. As such, where a canal fails on the GQA attributes alone it may be necessary investigate the reasons for failing to achieve the target classes and review the target if the failure can be attributed to the static nature of the canal or other locally driven factors.

5.3. Habitat structure

5.3.1. Substrate

Substrate suitability for aquatic plants is related to boat traffic intensity. Soft sediments may support diverse vegetation provided boat traffic is low or absent. When boat traffic increases, fine unconsolidated sediments become unsuitable as a rooting medium and plants may be easily uprooted. Under high boat traffic levels fine sediments are readily re-suspended, leading to high turbidity levels and smothering of plant surfaces. Large quantities of leaf litter may lead to highly anoxic conditions unsuitable for plants and other organisms.

5.3.2. Shading

Shading by trees is an indicator of light availability to the vegetation. As well as creating shade, overhanging trees may deposit significant quantities of leaf litter to the channel bed, creating poor rooting conditions for plants in the canal. A subjective assessment of sediment texture during grapnel sampling should indicate problems with sedimentation or leaf litter build-up. The low threshold set for tree shading recognises that by the time branches are starting to overhang, the main tree is already curtailing light to the channel and that once overhang starts it quickly extends to higher percentages of the relatively narrow channel. However, in assessing the degree of tree shading in may be necessary to consider the needs of other species (e.g. invertebrates or bats) that may depend on the canal corridor and the historical landscape characteristics of some canals.

5.4. Aquatic plant community

5.4.1. Quantity

The amount of submerged and floating vegetation is assessed in terms of frequency of catch for random grapnel throws during the section surveys. The amount of aquatic vegetation present will depend upon disturbance, including boat traffic and management (e.g. dredging). Filamentous algae, *Enteromorpha* and the four most invasive non-natives (*Azolla* spp., *Crassula helmsii*, *Hydrocotyle ranunculoides* and *Myriophyllum aquaticum*) are disregarded in the assessment.

5.4.2. Species richness

Species richness of submerged + floating-leaved vegetation and emergent vegetation are assessed at each 150 m site, using grapnel throws and observation. Presence only is recorded; DAFOR value is not recorded unless this is considered useful as supplementary information. Appendix 2 must be used as a checklist. Hybrids should be counted as additional species, even if not identified. If a plant occurs in different growth forms in both the open water and the emergent zone, both occurrences should be recorded and counted when assessing species richness. An example might be *Schoenoplectus lacustris* growing as a floating-leaved plant and in the emergent vegetation.

Filamentous algae, *Enteromorpha* and the four most invasive non-natives (*Azolla* spp., *Crassula helmsii*, *Hydrocotyle ranunculoides* and *Myriophyllum aquaticum*) are disregarded in the assessment.

5.4.3. Targets

Targets are given separately for aquatic (i.e. submerged and floating-leaved) and emergent vegetation. In many cases there is considerable interaction between these two groups. Thus a canal dredged deep to hard vertical edges will commonly have little or no emergent vegetation, but may support a diverse aquatic flora. Conversely, where shallow soft edges permit marginal vegetation to proliferate and spread out substantially into the channel, the emergent group may achieve considerable species richness, especially if the competitive exclusion capacity of some of the more aggressive reed species is curbed by disturbance (for example by boat traffic or maintenance works). This may, however, be achieved at the expense of depriving the aquatic group of habitat. Submerged and floating-leaved vegetation will predominate in some canal vegetation categories (see section 7.1) and emergent vegetation in others. The choice of which target to apply will depend on the vegetation category, but both species richness targets may be attained in all three categories. As a general rule the submerged and floating leaved species target should be adopted for sections with vegetation type A or B and emergent species target for sections A or C i.e. sections of type A should meet both targets.

5.4.4. Native and alien species

Only native species are included in the assessment of species richness. *Elodea canadensis* and *Elodea nuttallii* are now widely established in canals and their scope for invasive competitive exclusion of native species must be regarded as reducing. However, where there are no previous records for these two species in a canal there is a risk that sudden population explosions may result in the loss of other species. As such it may be desirable to treat such colonisations in the same way as the most aggressive invasive species listed below (7.5.1), this should be included during target setting for any canals not yet colonised by these two species. Other alien species are listed in Appendix 3, most of these species have the potential to cause problems but their impact will vary according to characteristics of the site and factors such as canal management. The impact of these species should be picked up through the assessment of other attributes but their presence should be noted in the supporting information sections to inform management and to explain any future changes in canal floristic composition.

Several aquatic species that are nationally scarce as natives have been introduced into canals outside their native range. *Stratiotes aloides* and *Nymphoides peltata* are major examples and may impose threats to the status of some canal SSSIs where their growth is uncontrolled (e.g. Hollinwood, Rochdale, Basingstoke and Royal Military Canals). *Hydrocharis morsus-ranae* has also been extensively introduced, (e.g. Forth & Clyde Canal and Manchester canals), but is seemingly native in the Montgomery Canal and in the Royal Military Canal and other waterways associated with grazing marshes. One nationally rare species, *Potamogeton epihydrus*, is also well established in the Rochdale Canal and the connecting Calder & Hebble Navigation as a historic introduction.

5.5. Indicators of negative change

5.5.1. Invasive alien species

Invasive alien species are used as the primary indicators of negative change. Although competitive exclusion of native plant species should be picked up during the assessment of species richness, a

number of non-natives have such invasive potential that they should be assessed separately. Invasive species of major concern are *Azolla* spp., *Crassula helmsii*, *Hydrocotyle ranunculoides* and *Myriophyllum aquaticum*. If any of these species is present, even as scattered plants, in 50 m length or more of the whole designated site, the condition of the feature should be considered unfavourable. If any of these plants is present at DAFOR cover greater than Rare in any of the 150 m sites surveyed, the condition of the section should be considered unfavourable. This target should also be applied to the two *Elodea* species in situations where there have been no previous records for the canal (see 7.4.3).

5.6. Indicators of local distinctiveness

Indicators of local distinctiveness are features that form part of the reason for notification but which are not covered by the attributes already described or by separate guidance e.g. for notified species features. They should be apparent from the SSSI citations or past surveys. This is a discretionary attribute in that it may not be applicable to every site; but where local distinctiveness has contributed to the selection of a site it should be mandatory. A detailed species monitoring target is not required, rather to provide a rapid indication of presence/absence and or approximate extent, allowing for natural fluctuations in population size.

Populations of rare plants, invertebrates or other species should persist for condition to be regarded as favourable. Rare plants and macrophytes indicative of high quality canal systems are listed in Appendix 2. Targets must be set on a site-by-site basis prior to survey visits. This attribute and the attribute for unusual plant communities (7.6.2) are intended to assess whether the special scientific interest of the canal SSSI is still present. The attribute is site-specific and covers only those plant species that are not features to be monitored in their own right. Any species that are notified features (such as *Luronium natans*, which is listed in Annexes II and IV of the EC Habitats Directive) should not be included in this assessment as they will be monitored separately.

Each site will have its own characteristic aquatic plant flora, determined by geographical location, history and management regime. The flora may include Schedule 8, Red List, Nationally Rare or Nationally Scarce species and other species indicative of good water quality or species rich aquatic habitats (e.g. *Hottonia palustris*, *Potamogeton friesii*, *Groenlandia densa*, charophytes). All these species are indicated in Appendix 2. Other plants mentioned on the SSSI citation may also be included. A suite of species should be selected and searched for during section surveys so that populations can be checked and recorded as present where appropriate. If a species cannot be found in its usual location on the route of the walk it should be searched for elsewhere, to confirm its loss from the site as a whole.

5.6.1. Unusual plant communities

Plant communities of particular interest (other than those covered by the categories in Section 7.1) include

- vegetation more typical of chalk streams than canals (e.g. at the upstream end of the Basingstoke Canal) that is distinguished by high cover of *Ranunculus penicillatus* ssp. *pseudofluitans.*
- brackish water vegetation.

Generally, only brackish communities mentioned as of interest on the citation should be included as indicators of local distinctiveness, because saline conditions may occur as a result of pollution. Brackish communities can be identified by using Appendix 2. If any of the species marked ‘Brack’ in Table 1 are present, the site is probably saline. However, many of the species typical of eutrophic waters (e.g. *Potamogeton pectinatus*, *P. pusillus*, *Zannichellia palustris*, *Myriophyllum spicatum*, *Phragmites australis*) are also tolerant of brackish conditions and may occur along with

the indicator species. The presence of salinity can be confirmed by measuring conductivity. If this exceeds 2000 µ siemens (*s)* cm^{-3} (equivalent to a salinity of >500 mgL^{-1} NaCl) the water is probably brackish. However, care must be taken because conductivity measurements do not distinguish between NaCl and other ions that might be present as a result of gross pollution.

5.7. Aspects of environmental disturbance noted as an accompaniment to condition assessment

Characteristics not covered by the attributes and targets in this guidance may be of significance for maintaining site quality, despite not being used in condition assessment. Incidental points of interest should be noted during section surveys to help in the interpretation of the outcome of monitoring and to assist with subsequent management planning.

5.7.1. Introduced animals

The impact of introduced plant species may be readily assessed but the impact of introduced fauna may be indirect and difficult to identify. Known problems with introduced species should be addressed through management action. The removal of piscivorous fish or the introduction of benthic-feeding species, such as carp both have the potential to cause switches to phytoplankton-dominated states in water bodies with moderate nutrient loads. Other introduced species may have a direct impact on native fauna (e.g. mink on water vole) or effects on ecosystem functioning through the food web or via direct effects on the plant community (e.g. large waterfowl populations). If introduced animal species are suspected of causing damage or impairing the capacity of the canal to support characteristic flora and fauna, specialists should be called in to investigate and quantify the problem and to suggest remedial measures.

5.7.2. Recreational use

In addition to the effects of high levels of boat traffic upon plant communities there are a range of other possible negative impacts associated with recreational use of canals (e.g. ground-baiting for angling, pollution from boat marinas, disturbance by towpath users).

5.7.3. Channel morphology

Canals are typically fairly uniform habitats and therefore habitat heterogeneity is limited. Channel dredging and bank re-inforcement undertaken unsympathetically will further limit the range of potential habitats by removing shallower, marginal areas within the channel. Dredging should be undertaken so that only the central channel is deepened for boat passage, gently shelving margins close to the canal banks should be retained to provide sufficient shallow water habitat.

5.8. Overall condition assessment

Biological and non-biological attributes must be examined for condition assessment of both vascular plant and habitat features. A site should be classed as being in unfavourable condition if any individual attribute fails to meet its targets. However, careful consideration must be given to the confidence in the data collected. The absence of a species when habitat conditions are favourable could be a false negative due to the ecology of the species, or the timing of the survey. Failure of a particular attribute from low confidence data should trigger further investigation and monitoring.

6. Generic attributes table

The following table lists the generic attributes that should be used to define the condition of canals.

Table 1. UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Canals

May support many aquatic NVC communities (Rodwell, 1995) including:

A3 *Spirodela polyrhiza-Hydrocharis morsus-ranae*; A4 *Hydrocharis morsus-ranae-Stratiotes aloides*; A6 *Ceratophyllum submersum*; A11 *Potamogeton pectinatus-Myriophyllum spicatum*; A13 *Potamogeton perfoliatus-Myriophyllum alterniflorum*; A15 *Elodea canadensis*; A19 *Ranunculus aquatilis*; A21 *Ranunculus baudotii*.

The following NVC swamp communities (Rodwell, 1995) may be represented:

S1 *Carex elata*; S2 *Cladium mariscus*; S3 *Carex paniculata*; S4 *Phragmites australis*; S5 *Glyceria maxima*; S6 *Carex riparia*; S7 *Carex acutiformis*; S8 *Scirpus lacustris* ssp *lacustris*; S9 *Carex rostrata*; S10 *Equisetum fluviatile*; S11 *Carex vesicaria*; S12 *Typha latifolia*; S13 *Typha angustifolia*; S14 *Sparganium erectum*; S15 *Acorus calamus*; S16 *Sagittaria sagittifolia*; S17 *Carex pseudocyperus*; S18 *Carex otrubae*; S19 *Eleocharis palustris*; S20 *Scirpus lacustris* ssp *tabernaemontani*; S21 *Scirpus maritimus*; S22 *Glyceria fluitans*; S23 Other water-margin vegetation.

Equivalent Phase 1 category: G1 Standing water (part)

Annex 1 types: None

Reporting category: Standing open water and canals

All attributes listed are mandatory unless indicated as discretionary or site specific by *.

Attribute	Targets	Method of assessment	Comments
Extent	No reduction in the extent of vegetation types for which the canal was designated.	Observations on the balance between cover of emergent and submerged + floating-leaved vegetation and on the aquatic species present, during section surveys. Application of method described in Section 7.1.	This attribute relates to the botanical reasons for which the canal was notified. In some canals the swamp/fen vegetation is outstanding, in some there is extensive open water vegetation, and others have a combination of the two. Characteristic species assemblages are closely related to water chemistry, with intensity of use (e.g. boat traffic density) influencing deviation from these patterns. Most canal SSSIs contain good examples of the vegetation of eutrophic, base-rich watercourses, but others are important for their oligo-mesotrophic, mesotrophic or base-poor characteristics. Some of the best canals have a range of trophic types, reflecting the source of the inflows. Targets must be set on a site-by-site basis, within the framework of the simple classification given in Section 7.1 ***The important vegetation types for which the canal was designated (e.g. extensive emergent vegetation and submerged/floating-leaved communities typical of mesotrophic conditions) should be present at least to the same extent as when designation occurred.***
Habitat functioning: Water availability	A drop in overall depth of less than 10% throughout the canal	Observation during section survey	Canals have small flows of water due to leakage and boat movements through locks. These flows can be essential elements in maintaining good water quality. Consistently low water levels may stress emergent and aquatic vegetation. In non-navigable canals water supply may be a problem and aquatic species may be lost through drying out. High levels of lock usage on navigated canals can result in large fluctuations in water levels and associated scouring of bed sediments and aquatic vegetation. In a navigated canal, condition assessment must take account of changes in

Attribute	Targets	Method of assessment	Comments
			level caused by the use of locks.
Habitat functioning: water quality - transparency	In at least 90% of observations, the canal bed is clearly visible in water 1m deep in summer	Secchi disk measurement or visual observation during section and site surveys.	Elevated turbidity levels as a result of high boat traffic densities, high phytoplankton densities, or the presence of benthic-feeding fish will have adverse impacts on submerged plant communities. Temporal and spatial variability of turbidity in canals makes direct measurement difficult hence a subjective measure of water clarity is utilised here. Where the maximum depth is less than 1m, the bed should be visible at the deepest point in the channel.
Habitat functioning: water quality - cover of algae/*Lemna*/ *Azolla*	Filamentous algae and combined *Lemna*/*Azolla* cover, each less than 10% cover on average (no more than Occasional on the DAFOR scale)	Assessment of cover in section surveys	Excessive growths of filamentous algae or Lemna spp and Azolla can result in the competitive exclusion of submerged aquatic species and can indicate nutrient enrichment. Monitoring growths of these taxa may serve as an indirect and integrated measure of eutrophication.
*** Habitat functioning: biological quality and water chemistry**	Biological GQA Class 'a' or 'b' depending on reach type. In addition, no drop in class from existing situation.	Desk study following tests by Environment Agency or other competent body National river quality classification - biological class or equivalent. Assess every 6 years.	This is a discretionary attribute. If water sampling and analysis are carried out routinely on the site these results should be assessed. Additional sampling or new baseline chemical analysis are needed only if water clarity or aquatic vegetation composition indicate poor water quality. A wide range of water quality parameters can affect the status of canal flora and fauna. Canal water quality is commonly assessed using the Environment Agency's General Quality Assessment scheme or an equivalent approach. The biological module of the GQA scheme is based on assessment of the macro-invertebrate community.
	Chemical GQA Class 'A' or 'B' depending on reach type. In addition, no drop in class from existing situation	National river quality classification - chemical class or equivalent. Assess every 6 years.	The chemical module of the GQA scheme sets standards for dissolved oxygen, biochemical oxygen demand and total ammonia, It therefore covers a number of water quality parameters that commonly cause problems within freshwater systems.
	Phosphorus concentrations should be consistent with natural trophic status of source water (and no deterioration)	Total phosphorus concentrations (annual mean)	Elevated phosphorus levels may lead to dominance by attached or planktonic algae and a loss of characteristic plant species. Functionally canals are closely aligned to shallow lake ecosystems but some canals may have significant flows of water. Appropriate phosphorus levels will depend on the source of canal water and flow rates within the canal. As a guide, interim total phosphorus targets are: • mesotrophic canals (upland, hard-rock water sources) <20µg L^{-1} TP • eutrophic canals (lowland, soft-rock geology) <60µg L^{-1} TP There should be no deterioration from existing levels where less than the target.
Habitat structure: sediment depth and texture	Extent of fine and unconsolidated sediments limited: passage of grapnel should not result in excessive re-suspension of sediments or leaf litter in at	Record any resuspension caused by the use of the grapnel during site surveys	Soft mineral sediments may support diverse vegetation provided boat traffic is low or absent. When boat traffic increases, fine unconsolidated sediments are an unsuitable rooting medium and plants may be subject to uprooting. Furthermore, under high boat traffic levels fine sediments are readily re-suspended leading to high turbidity levels and smothering of plant surfaces. Large quantities of leaf litter may lead to highly anoxic

Attribute	Targets	Method of assessment	Comments
	least 90% of throws		conditions unsuitable for plants and other organisms.
Habitat structure: channel shading	On average no more than 5% of the channel surface be shaded by overhanging vegetation in each section length.	Visual assessment during section surveys (estimate of vertical projection)	Excessive overhanging vegetation results both in shading of aquatic vegetation and large inputs of organic matter in the form of leaf litter. Because of the narrow nature of most canals overhanging trees can quickly shade the entire water surface. Regular management of trees is frequently required to protect the integrity of channel structure and on navigable canals may be required to ensure safe boat passage. Where canals are notified for certain animal interests a higher cover of overhanging vegetation may be desirable and this target should be adjusted accordingly.
Aquatic plant community: quantity of vegetation	In at least 90% of sample sites, at least 8 out of 10 grapnel throws retrieve aquatic vegetation.	During section surveys record the mean number of random grapnel throws bringing up vegetation.	Canals that are recovering from or are experiencing increasing disturbance may support a characteristic contingent of species but only in very small quantities. A reasonable quantity of vegetation is necessary for population stability and to provide habitat for other organisms. Filamentous algae, *Enteromorpha* and the four most invasive non-natives (*Azolla* spp., *Crassula helmsii*, *Hydrocotyle ranunculoides* and *Myriophyllum aquaticum*) are not counted in the assessment.
Aquatic plant community: species richness	Mean number of 7 native submerged and floating species in 150m sampling sites >7. **AND/OR** Mean number of 7 native emergent species in 150m sampling sites >7.	Record species numbers in 150m sampling sites, using a grapnel and through observation.	Analysis of a range of SSSI and non-SSSI canals indicates that, in terms of species richness, the top 25% of canals have at least seven submerged and floating-leaved species per 150m length (mean 4.5). Alien species and algae should not be included in the total. The median number in the top 25% of canals is seven emergent species per 150m site. A higher target may be appropriate for particular SSSIs where the emergent plant community is an interest feature. The main determinants of emergent plant composition are the degree of cattle poaching, tree shade and bank profile. Intensity of boat traffic also exerts a strong influence with boat wash adversely affecting marginal vegetation. Conversely, at low densities of boat traffic and in the absence of management, emergents may encroach into the open water habitat or a single species (usually Glyceria maxima) may become dominant. A marginal fringe should be present on both sides of the canal and should comprise a variety of species ranging from those growing as emergents in canal margins to those associated with the drier conditions higher up the canal bank. A checklist of native aquatic plants is given as Appendix 2. This should be used as the standard when numbers of species are counted.
Indicators of negative change: introduced plant species	The four most invasive species (*Azolla* spp., *Crassula helmsii*, *Hydrocotyle ranunculoides*, *Myriophyllum aquaticum*): these should be absent from the canal or at the most	Presence of all alien and introduced aquatic plants should be noted during section surveys. They should be recorded on the DAFOR scale for every site survey.	Although competitive exclusion of plant species should be identified during fixed point plant sampling, a number of non-natives have such invasive potential that they should be assessed separately. Invasive species of major concern at present are : *Azolla* spp., *Crassula helmsii*, *Hydrocotyle ranunculoides*, and *Myriophyllum aquaticum*. If any of these species are present in any but very small quantities the condition of a canal should be considered unfavourable. *Elodea canadensis* and *Elodea nuttallii* are now so widely established in canals that their scope for invasive competitive exclusion of native species must be regarded as reducing. Other alien species

Attribute	Targets	Method of assessment	Comments
	occupy less than 50 m of the whole designated site AND None of these invasive species should be present at DAFOR cover more than Rare in any 150 m survey site		(listed in Appendix 3) may pose problems locally. The characteristics of canal environments (cross-catchment water movements, boat traffic as a vector) make them susceptible to native species introductions. A number of species, such as *Stratiotes aloides, Hydrocharis morsus-ranae* and *Potamogeton epihydrus*, have become established in canals outside their natural range. These species, although introduced, could arguably be considered as a characteristic component of a particular canal SSSI (an unnatural habitat) and therefore should not contribute to an unfavourable assessment unless picked up through adverse impacts on the plant community as a whole.
*** Indicators of local distinctiveness: rare species and quality indicators**	Populations of rare species and other species characteristic of high quality canal systems should persist.	The continued presence of populations should be checked during section surveys.	Each statutory site will have its own characteristic aquatic plant flora, varying according to geographical location, history and management regime. The aquatic flora may include internationally or nationally protected, nationally threatened or scarce species and should include other species indicative of high quality canal systems (i.e. plants sensitive to eutrophication and the effects of boat traffic). All these are listed in Appendix 2. A suite of these species should be selected. This attribute is mandatory for other notable species mentioned on the SSSI citation, such as invertebrates.
*** Indicators of local distinctiveness: unusual plant communities**	Where appropriate maintain the distribution and extent of unusual plant communities (e.g. those indicative of brackish water or chalk stream conditions) where appropriate	The continued presence of characteristic plant communities should be checked during section surveys. Conductivity measurements should be made to confirm the presence of brackish water.	Brackish water supports specialist species that would not otherwise be present in a canal system. Where this is a natural feature (i.e. not caused by pollution) it adds to the diversity of the canal biota. Salinity-tolerant aquatic plant species include *Bolboschoenus maritimus, Ceratophyllum submersum, Myriophyllum spicatum, Potamogeton pectinatus, Potamogeton pusillus, Phragmites australis, Ranunculus baudotii, Ruppia* spp., *Schoenoplectus tabernaemontani, Typha angustifolia, Zannichellia palustris* and some *Chara* spp. However, all these species except *Ruppia* spp. and *B. maritimus* may also occur in eutrophic fresh water. A conductivity of >2000 µ siemens cm^{-3} indicates either brackish water (salinity >500 mgL^{-1} NaCl) or highly polluted water. Vegetation more typical of chalk streams than canals is distinguished by high cover of *Ranunculus penicillatus* ssp. *pseudofluitans.*

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8. Appendix 1. Recommended Survey procedure

1. General procedure

1.1 This is a 'walking survey' (i.e. the surveyor moves along the towing path of a canal, making continuous, simple observations of the vegetation and other features and pausing at intervals to record representative 150 m sites in more detail). The emphasis is on covering the whole length of waterway being considered and detecting as many of the species present as possible. Thus it is part of the method to stop and investigate any place where subjective observation indicates special features that may be of conservation interest, in addition to the representative 150 m sites being recorded at regular intervals. The main value of the regular, intensively recorded sites is to focus the surveyor's attention at intervals on the whole ecosystem cross-section and to ensure that the submerged vegetation, which is often invisible to the bankside observer, is adequately sampled. They produce approximately standard descriptive units of survey that can later be compared visually to see whether there are any major disjunctions in vegetation quality along the canal.

1.2 The method is derived from those previously used for walking surveys of the Pocklington Canal (Tolhurst 1987, re-used with slight modification by Head 1991) and the Basingstoke Canal (Hall 1988). These seem to have been derived from the standard system developed for survey of ditch vegetation by Alcock and Palmer (1985), although the latter is not acknowledged as a source in the canal survey reports.

1.3 The canal is divided into **sections** with lengths of plain channel in the approximate range 0.5 – 1.0 km, using bridges as reference points for the divisions. Distances between bridges vary, but where they are much less than 0.5 km, intermediate ones may be excluded as dividers. In the rare cases where distances are much greater than 1.0 km, some other easily identifiable feature may be used. Single locks are sometimes useful alternatives markers. Where locks are in large groups they create lengths with frequently varying water levels, local scouring rushes of water as the locks are used and high incidences of boat manoeuvring, all of which stress channel vegetation more than the movement of the same number of boats along adjacent lengths of plain channel. For these reasons, lengths with groups of locks should be clearly identified in the survey results as should lengths of tunnel. Where canal junctions occur or major water feeders enter, these points should always be used as length dividers.

1.4 Within each canal section a representative 150 m **site** is chosen for detailed vegetation survey (see 1.3). Ideally this length should be midway along the section, but should always start at least 50 m from any bridge, tunnel, lock or mooring wharf, to obtain plain channel. It should be representative of the general character of the vegetation in that part of the canal. As far as possible it should also be straight and unshaded.

1.5 The exact starting and finishing points of canal sections and 150 m sites should be determined, preferably by GPS co-ordinates or, if a GPS recorder is not available, by six figure OS grid references. Where bridges and locks are numbered or named, these identifiers should also be recorded.

1.6 Surveys should not be undertaken after dredging until one complete growing season has elapsed after the end of the works.

2 Section survey

2.1 The canal sections are walked slowly and records (presence only) made of all aquatic species, categorised according to 4.1 above. The offside vegetation should be examined with binoculars. Additionally, the offside vegetation should be accessed where possible at bridges and locks and examined directly, paying particular attention to recording species at the back of the reed fringe and in any cattle-poached areas.

2.2 For each canal section an estimate should be made of the cover of each of two vegetation categories (emergent, floating-leaved + submerged). Cover is relative to the area of water between the two banks. Total cover can add up to more than 100% because of the layering of vegetation. Cover estimates are expressed on a version of the DAFOR scale:

D - dominant (over 70 % cover)
A - abundant (30-70 % cover)
F - frequent (10-30 % cover)
O - occasional (3-10 % cover)
R - rare (less than 3 % cover)

2.3 The following records (relating to attributes in Table 1) should also be made for each canal section:

- Water availability: note evidence of lowered water levels (large freeboard, tidemarks on emergent vegetation or banks).
- Water quality (clarity and colour): is the canal bed visible at 1 m depth or where water depth is less than 1m, is the bed visible at the deepest point? Measurement should be made with a Secchi disk, although in absence of this equipment direct visual observation is usually sufficient. Estimate the percentage length (to the nearest 10%) that does not reach this target.
- Water quality (indirect method): mean cover (to the nearest 10%) of filamentous algae and combined *Lemna* spp. and *Azolla* spp.
- Degree of shading by trees, buildings or canal cuttings: specifically, on each length do trees overhang the channel on average by more or less than 5 % of the water area?
- Quantity of aquatic vegetation: ten grapnel throws should be made at intervals along the section and for each throw a record made of whether or not submerged or floating plants are caught. Filamentous algae are disregarded in the assessment.
- Invasive non-native plants: records of the presence of *Azolla filiculoides, Crassula helmsii, Hydrocotyle ranunculoides and Myriophyllum aquaticum*.
- Notable species: the presence of any aquatic plants marked in Appendix 2 as rare species, indicators of 'quality' or indicators of mesotrophic conditions should be noted and their positions mapped.
- Brackish conditions: where saline influence is expected or where brackish water plant communities are present (see Appendix 2 for brackish water indicators), take conductivity readings.

2.4 Additionally, for **supporting information**, record the following for each canal section:

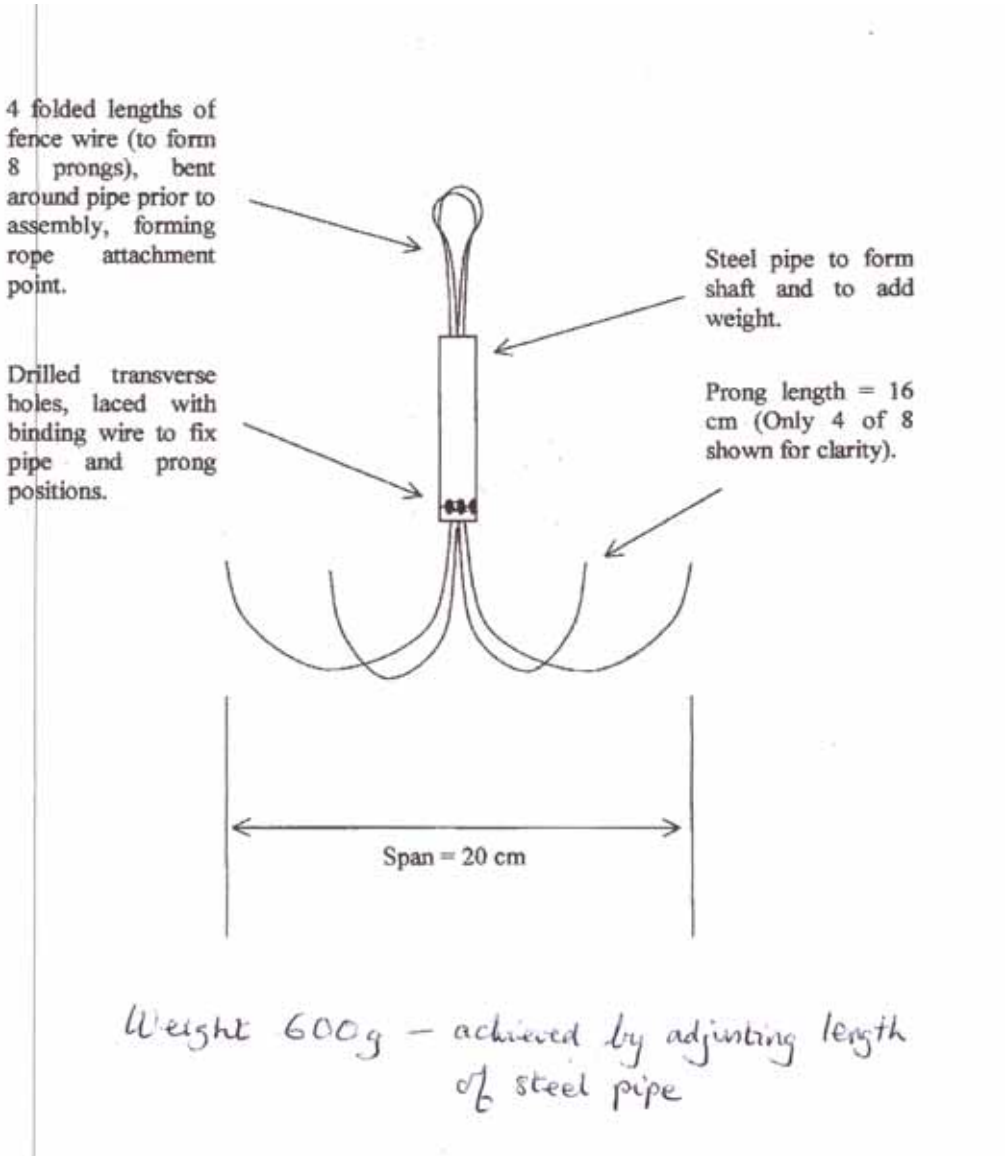
- Bank type (vegetated, stone, brick, steel, wood)
- Channel profile: any recent modification of the channel profile through dredging and bank re-inforcement.
- Recreational use: signs of intensified recreational use of the canal over and above any agreed level should be recorded.
- Special features such as water inputs, linear boat moorings, entrances to marinas and evidence of recent vegetation or channel maintenance operations
- Evidence of high fish biomass (sightings of large carp, anecdotal evidence from anglers) and any sightings of other introduced animals (e.g. mink, feral geese).

3 Site survey

3.1 Each 150 m site should be photographed (from a suitable point with photograph location recorded) and the following records (relating to attributes in Table 1) should be made:

- Sediment depth and texture: observe the passage of the grapnel during plant sampling for evidence of sediment re-suspension.
- Species richness of submerged and floating vegetation: all plants brought up by the 10 grapnel throws, or seen but not caught during throws, are recorded as present. Appendix 2 should be used as a checklist. Hybrids should be counted as additional species, even if not identified. Algae other than charophytes are not counted.
- Species richness of emergent vegetation: all emergent species seen in the 150 m length are recorded as present. Appendix 2 should be used as a checklist. Hybrids should be counted as additional species, even if not identified.
- Alien and introduced aquatic plants (especially the most invasive non-native plants: *Crassula helmsii, Hydrocotyle ranunculoides, Myriophyllum aquaticum* and *Azolla* spp.) should be recorded on the DAFOR scale.
- A conductivity reading if brackish conditions are expected.

Figure 1. Standard grapnel design



9. Appendix 2 Checklist of aquatic native plants recorded from or possibly occurring in canals in the UK

		Growth form	UK distribution	British status	NI status	Quality indicator	Mesotroph/ brackish
Vascular plants							
Agrostis stolonifera	Fiorin	Em/Fl	E S W NI				
Alisma lanceolatum	Narrow-leaved water-plantain	Em	E S W NI				
Alisma plantago-aquatica	Water-plantain	Em	E S W NI				
Apium inundatum	Lesser marshwort	Su	E S W NI				Meso
Apium nodiflorum	Fool's water-cress	Em	E S W NI				
Baldellia ranunculoides	Lesser water-plantain	Em	E S W NI			Q	Meso
Berula erecta	Narrow-leaved water-parsnip	Em	E S W NI				
Bolboschoenus maritimus	Sea club-rush	Em	E S W NI				Brackish
Butomus umbellatus	Flowering rush	Em	E W (intro S NI)				
Callitriche hamulata agg. (*C. brutia*/*hamulata*)	Intermediate water-starwort	Em/Fl/Su	E S W NI				Meso
Callitriche hermaphroditica	Autumnal water-starwort	Su	E S W NI			Q	Meso
Callitriche obtusangula	Blunt-fruited water-starwort	Em/Fl/Su	E S W NI				
Callitriche platycarpa	Various-leaved water-starwort	Em/Fl/Su	E S W NI				
Callitriche stagnalis	Common water-starwort	Em/Fl/Su	E S W NI				
Callitriche truncata	Short-leaved water-starwort	Su	E W	NS			
Caltha palustris	Marsh marigold	Em	E S W NI				
Cardamine amara	Large bitter-cress	Em	E S W NI				
Carex acuta	Slender-tufted sedge	Em	E S W NI				
Carex acutiformis	Lesser pond-sedge	Em	E S W NI				
Carex aquatilis	Water sedge	Em	E S W NI			Q	
Carex elata	Tufted sedge	Em	E S W NI			Q	
Carex lasiocarpa	Slender sedge	Em	E S W NI				
Carex nigra	Common sedge	Em	E S W NI				
Carex paniculata	Greater tussock-sedge	Em	E S W NI				
Carex pseudocyperus	Cyperus sedge	Em	E W NI (intro S)				
Carex riparia	Great pond-sedge	Em	E S W NI				
Carex rostrata	Bottle sedge	Em	E S W NI				Meso
Carex vesicaria	Bladder sedge	Em	E S W NI				
Catabrosa aquatica	Whorl-grass	Em/Fl	E S W NI				
Ceratophyllum demersum	Hornwort	Su	E S W NI			Q	
Ceratophyllum submersum	Soft hornwort	Su	E W NI			Q	(Brackish)

Cicuta virosa	Cowbane	Em	E S W NI	NS				
Cladium mariscus	Great fen-sedge / saw-sedge	Em	E S W NI			Q		
Eleocharis acicularis	Needle spike-rush	Em/Su	E S W NI			Q		
Eleocharis palustris	Common spike-rush	Em	E S W NI					
Eleogiton fluitans	Floating club-rush	Fl/Su	E S W NI					Meso
Equisetum fluviatile	Water horsetail	Em	E S W NI					
Equisetum palustre	Marsh horsetail	Em	E S W NI					
Eriophorum angustifolium	Common cotton-grass	Em	E S W NI					Meso
Glyceria declinata	Small sweet-grass	Em/Fl	E S W NI					
Glyceria fluitans	Flote-grass	Em/Fl	E S W NI					
Glyceria maxima	Reed sweet-grass	Em	E S W NI					
Glyceria notata	Plicate sweet-grass	Em	E S W NI					
Groenlandia densa	Opposite-leaved pond-weed	Su	E W NI (intro S)		IRL	Q		
Hippuris vulgaris	Mare's tail	Em/Su	E S W NI					
Hottonia palustris	Water-violet	Em/Su	E W NI (intro S)		Sch8 IRL	Q		
Hydrocharis morsus-ranae	Frogbit	Fl	E W NI (intro S)			Q		
Hydrocotyle vulgaris	Marsh pennywort	Em	E S W NI					
Iris pseudacorus	Yellow flag	Em	E S W NI					
Juncus bulbosus	Bulbous rush	Em/Su	E S W NI					Meso
Juncus effusus	Soft rush	Em	E S W NI					
Lemna gibba	Fat duckweed	Fl	E S W NI					
Lemna minor	Common duckweed	Fl	E S W NI					
Lemna trisulca	Ivy-leaved duckweed	Fl/Su	E S W NI					
Luronium natans	Floating water-plantain	Fl/Su	E W (intro S)	HD Sch8 NS				Meso
Lysimachia thyrsiflora	Tufted loosestrife	Em	E S	NS				
Lythrum portula	Water-purslane	Em	E S W NI					Meso
Mentha aquatica	Water-mint	Em	E S W NI					
Menyanthes trifoliata	Bogbean	Em	E S W NI					Meso
Myosotis laxa	Tufted forget-me-not	EM	E S W NI					
Myosotis scorpioides	Water forget-me-not	Em	E S W NI					
Myosotis secunda	Creeping forget-me-not	Em	E S W NI					Meso
Myosoton aquaticum	Water chickweed	Em	E W (intro S)					
Myriophyllum alterniflorum	Alternate water-milfoil	Su	E S W NI					Meso
Myriophyllum spicatum	Spiked water-milfoil	Su	E S W NI					
Myriophyllum verticillatum	Whorled water-milfoil	Su	E W NI	NS				
Nuphar lutea	Yellow water-lily	Fl/Su	E S W NI					
Nuphar pumila	Least yellow water-lily	Fl/Su	S	NS				Meso

Nymphaea alba	White water-lily	Fl	E S W NI				
Nymphoides peltata	Fringed water-lily	Fl	E (native S-E) (intro S W NI)	NS			
Oenanthe aquatica	Fine-leaved water-dropwort	Em/Su	E W NI				
Oenanthe crocata	Hemlock water-dropwort	Em	E S W NI				Meso
Oenanthe fistulosa	Tubular water-dropwort	Em	E S W NI				
Oenanthe fluviatilis	River water-dropwort	Em/Su	E NI			Q	
Persicaria amphibia	Amphibious bistort	Em/Fl	E S W NI				
Persicaria hydropiper	Water-pepper	Em	E S W NI				
Phalaris arundinacea	Reed canary-grass	Em	E S W NI				
Phragmites australis	Common reed	Em	E S W NI				
Pilularia globulifera	Pillwort	EmFl//Su	E S W	NS	Sch8 IRL		Meso
Potamogeton acutifolius	Sharp-leaved pondweed	Su	E	RL (Vulnerable)			
Potamogeton alpinus	Red pondweed	Su	E S W NI			Q	Meso
Potamogeton berchtoldii	Small pondweed	Su	E S W NI				
Potamogeton coloratus	Fen pondweed	Fl/Su	E S W NI	NS			
Potamogeton compressus	Grass-wrack pondweed	Su	E S W	NS			Meso
Potamogeton crispus	Curled pondweed	Su	E S W NI				
Potamogeton epihydrus	American pondweed	Fl/Su	S (Outer Hebrides) (intro. canal)	RL (Vulnerable)			Meso
Potamogeton filiformis	Slender-leaved pondweed	Su	E(N-E) S NI	NS			
Potamogeton friesii	Flat-stalked pondweed	Su	E S W	NS?		Q	
Potamogeton gramineus	Various-leaved pondweed	Fl/Em/Su	E S W NI				Meso
Potamogeton lucens	Shining pondweed	Su	E S W NI				
Potamogeton natans	Broad-leaved pondweed	Fl/Su	E S W NI				
Potamogeton nodosus	Loddon pondweed	Fl/Su	E	NT			
Potamogeton obtusifolius	Blunt-leaved pondweed	Su	E S W NI				Meso
Potamogeton pectinatus	Fennel-leaved pondweed	Su	E S W NI				
Potamogeton perfoliatus	Perfoliate pondweed	Su	E S W NI				
Potamogeton polygonifolius	Bog pondweed	Fl/Su	E S W NI				Meso
Potamogeton praelongus	Long-stalked pondweed	Su	E S W NI			Q	Meso
Potamogeton pusillus	Lesser pondweed	Su	E S W NI				
Potamogeton trichoides	Hairlike pondweed	Su	E S W	NS			
Potentilla palustris	Marsh cinquefoil	Em	E S W NI				Meso
Ranunculus aquatilis	Common water-crowfoot	Fl/Em/Su	E S W NI				
Ranunculus baudotii	Brackish water-crowfoot	Fl/Em/Su	E S W			Q	Brack
Ranunculus circinatus	Fan-leaved water-crowfoot	Su	E S W NI				

Ranunculus flammula	Lesser spearwort	Em	E S W NI			Meso
Ranunculus hederaceus	Ivy-leaved crowfoot	Em/Fl	E S W NI			
Ranunculus omiophyllus	Round-leaved crowfoot	Em/Fl	E S W			Meso
Ranunculus peltatus	Water crowfoot	Fl/Em/Su	E S W NI			
Ranunculus penicillatus ssp. *penicillatus*	Stream water-crowfoot	Fl/Su	E W NI		Q	Meso
Ranunculus penicillatus ssp. *pseudofluitans*	Stream water-crowfoot	Fl/Su	E S W NI		Q	
Ranunculus sceleratus	Celery-leaved buttercup	Em	E S W NI			
Ranunculus trichophyllus	Thread-leaved water-crowfoot	Su	E S W NI			
Rorippa amphibia	Great yellow-cress	Em	E W NI (intro S)			
Rorippa microphylla	Narrow-fruited water-cress	Em	E S W NI			
Rorippa nasturtium-aquaticum	Water-cress	Em	E S W NI			
Rumex hydrolapathum	Great water-dock	Em	E S W NI			
Ruppia maritima	Beaked tasselweed	Su	E S W NI		Q	Brack
Sagittaria sagittifolia	Arrow-head	EmFl//Su	E W NI (intro S)			
Schoenoplectus lacustris	Common bulrush	Em/Su	E S W NI			
Schoenoplectus tabernaemontani	Grey bulrush	Em	E S W NI			(Brack)
Sium latifolium	Greater water-parsnip	Em	E NI	NS		
Solanum dulcamara	Bitter-sweet	Em	E S W NI			
Sparganium angustifolium	Floating bur-reed	Fl/Em	E S W NI			Meso
Sparganium emersum	Unbranched bur-reed	Fl/Em	E S W NI			
Sparganium erectum	Branched bur-reed	Em	E S W NI			
Sparganium natans	Least bur-reed	Fl/Em/Su	E S W NI		Q	Meso
Spirodela polyrhiza	Greater duckweed	Fl	E W NI (intro S)			
Stratiotes aloides	Water-soldier	Fl/Su	E	NS		
		(native in east, intro S W NI & canals)				
Typha angustifolia	Lesser reedmace / lesser bulrush	Em/Fl	E S W NI			
Typha latifolia	Great reedmace / great bulrush	Em	E S W NI			
Utricularia australis	Bladderwort	Su	E S W NI		Q	
Utricularia intermedia agg. (*U. intermedia*/*ochroleuca*/*stygia*)	Intermediate bladderwort	Su	E S W NI		Q	Meso
Utricularia minor	Lesser bladderwort	Su	E S W NI		Q	Meso
Utricularia vulgaris	Greater bladderwort	Su	E S W NI		Q	
Veronica anagallis-aquatica	Blue water-speedwell	Em	E S W NI			
Veronica beccabunga	Brook-lime	Em	E S W NI			
Veronica scutellata	Marsh speedwell	Em	E S W NI			

Veronica catenata	Pink water-speedwell	Em	E S W NI				
Wolffia arrhiza	Rootless duckweed	Fl	E W	NS			
Zannichellia palustris	Horned pondweed	Su	E S W NI				
Mosses							
Fontinalis antipyretica	Willow moss	Su	E S W NI				
Sphagnum sp.	Bog moss	Em/Su	E S W NI				Meso
Other fully aquatic species		Em/Su	E S W NI				
Liverworts							
Riccia fluitans		Fl					
Ricciocarpos natans		Fl					
Charophytes							
Chara sp.		Su	E S W NI			Q	
Nitella sp.		Su	E S W NI			Q	Meso
Tolypella sp.		Su	E S W NI			Q	

Appendix 2 notes

Growth form	Em	emergent
	Fl	floating or attached to the bottom but with floating leaves
	Su	submerged
UK distribution	1987 to 1999 (Preston *et al*, 2002)	
	E	England
	S	Scotland
	W	Wales
	NI	Northern Ireland
British status	HD	listed in Annexes II and IV of the EC Habitats Directive and Bern Convention Appendix I
	Sch8	listed in Schedule 8 of the Wildlife and Countryside Act, 1981
	RL	Red List (Wigginton, 1999)
	NT	Near Threatened (i.e. not Red List but occurring in 15 or fewer 10 x 10 km squares in Great Britain and listed as Near Threatened in Wigginton, 1999)
	NS	Nationally Scarce (i.e. not Red List but occurring in 16 to 100 10 x 10 km squares in Great Britain and listed as Scarce in Stewart *et al*, 1994)
	NS?	*Potamogeton friesii* has been recorded since 1986 in only 95 10 x 10 km. squares in Britain (Preston *et al*, 2002) but is not listed as Nationally Scarce in Stewart *et al.* (1994)
Northern Ireland status	Sch8	listed in Schedule 8 of the Wildlife (Northern Ireland) Order, 1985
	IRL	Irish Red List (Curtis & McGough, 1988)
Quality indicator	Q	plants occurring in 101 to 250 10 x 10 km squares in Britain and/or indicative of good water quality and/or sensitive to boat traffic
Mesotroph/brackish	Meso	plants indicative of mesotrophic water
	Brack	plants indicative of brackish water (parentheses mean not confined to brackish water)

For the purpose of counting the number of 'species' in a 150 m length of channel, use only genus for charophytes. Some charophytes are Nationally Scarce, Near Threatened or on the British Red List (Stewart & Church, 1992). If such a species is known to be present on a site its continued presence should be checked during the assessment for 'Indicators of local distinctiveness'.

When counting the number of 'species' in a 150 m length of channel, hybrids of any of the vascular species listed above should be regarded as separate taxa.

Where identification is only possible to genus (e.g. for some *Callitriche*, *Utricularia* or *Potamogeton* species when not flowering) use genus when counting the number of taxa in a 150 m length of channel.

10. Appendix 3. Non-native aquatic vascular plants recorded from, or potentially occurring in canals in the UK

		Growth Form	UK distribution
Acorus calamus	Sweet-flag	Em	E S W NI
Aponogeton distachyos	Cape-pondweed	Em	E S W
***Azolla* spp.**	Water fern	Fl	E S W NI
***Crassula helmsii**	Australian swamp stonecrop	Fl/Su/Em	E S W NI
Egeria densa	Large-flowered waterweed	Su	E W
Elodea callitrichoides	South American waterweed	Su	E
Elodea canadensis	Canadian waterweed	Su	E S W NI
Elodea nuttallii	Nuttall's waterweed	Su	E S W NI
***Hydrocotyle ranunculoides**	Floating pennywort	Fl/Su	E W
Lagarosiphon major	Curly water-thyme	Su	E S W NI
Lemna minuta	Least duckweed	Fl	E S W
***Myriophyllum aquaticum**	Brazilian water-milfoil	Em/Su	E S W NI
Nymphaea spp. (exotic species, cultivars etc)	Water lilies	Fl	
Pontederia cordata	Pickerel Weed	Em	S
Sagittaria latifolia	Duck potato	Em/Fl/Su	E
Sagittaria rigida	Canadian arrowhead	Em/Fl/Em	E
Vallisneria spiralis	Tapegrass	Su	E

** the most invasive species

UK distribution 1987 to 1999 (Preston, Pearman & Dines, 2002)

E	England
S	Scotland
W	Wales
NI	Northern Ireland

11. Appendix 4 . Number of species detected versus month of survey

Numbers are totals of emergent, floating-leaved and submerged species.

Site	A	B	C	D
May	23	7	10	25
June	27	14	15	38
July	**29**	**15**	15	42
August	**29**	**15**	**16**	**44**
September	28	**15**	**16**	43
October	21	12	13	26

Source is the Montgomery Canal study of Harris (1988), means for five consecutive years at each of four sites (A, B, C and D) surveyed in the first week of each month. Months in which maximum numbers of **species** were detected are shown **bold**.