New Guidance on Aquatic and Riparian Plant Management - Controls for Vegetation in Watercourses

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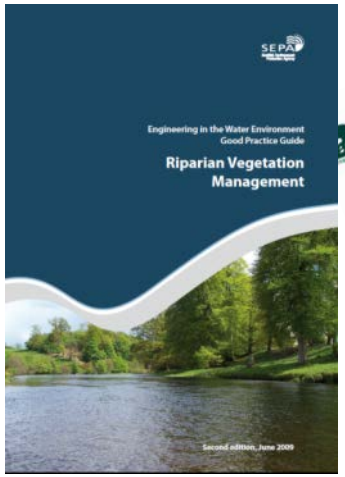
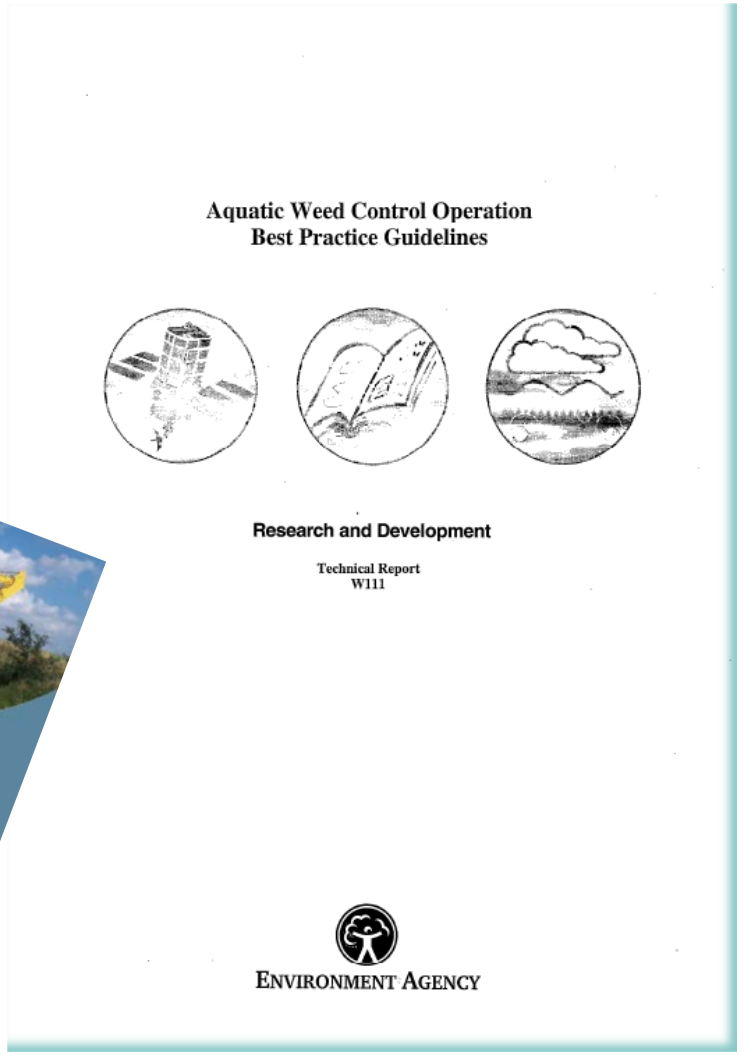
PROJECT BACKGROUND

Project Background

- Previous guidance – Barrett *et al* (1999) and other updates

- Legislative changes
- New guidance published
- New techniques developed





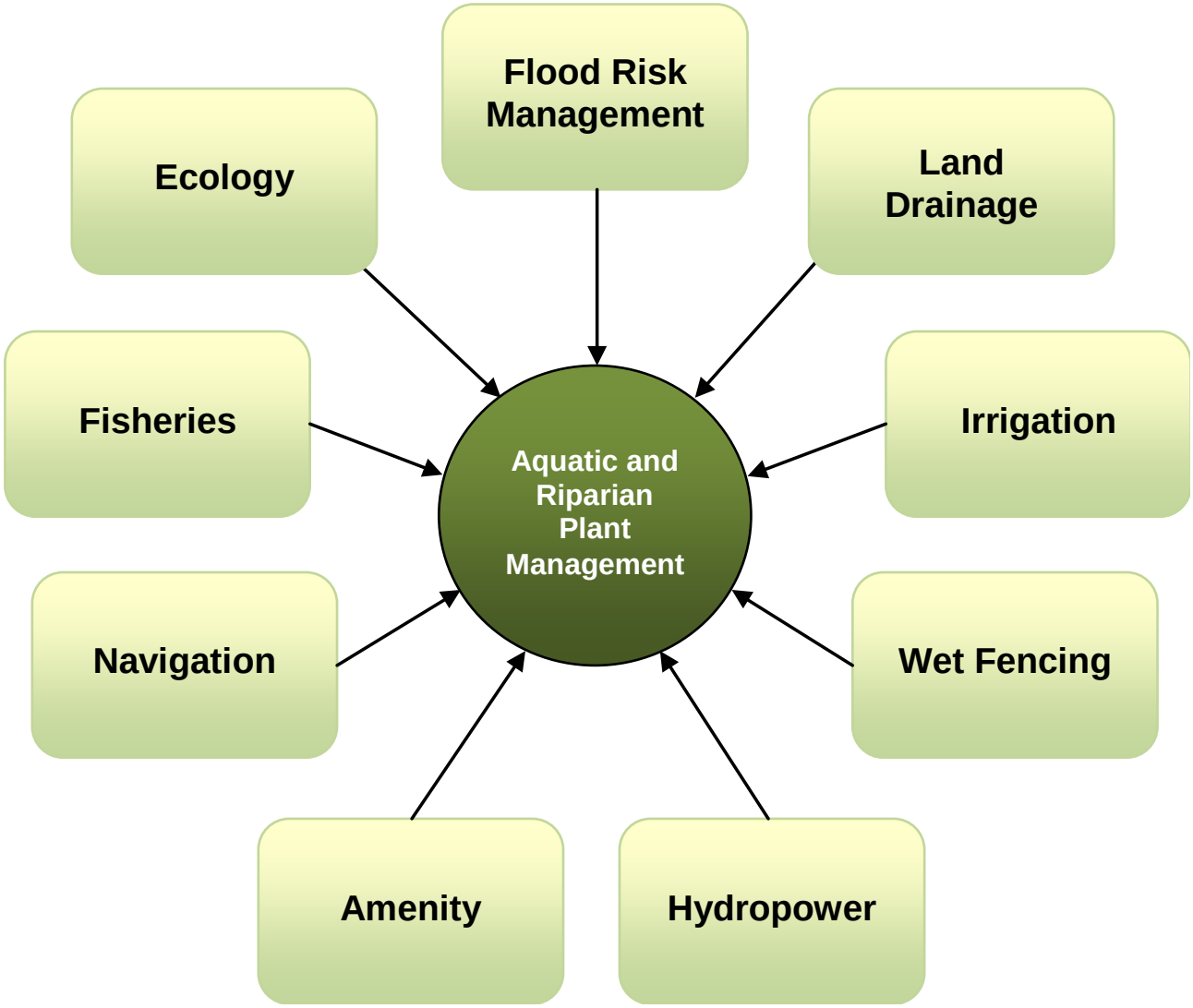
Project Background

- Benefits of aquatic and riparian plants
  - Aerate water
  - Habitat, shelter and refuge
  - Food source
  - Water quality / mitigate diffuse pollution
  - Consolidate banks and beds
  - Amenity and recreation
  - Aesthetic value
  - Reduce flood risk and increas drought resilience

- **Problems can arise where the vigour of vegetation growth adversely impacts on the human uses/function of the watercourse**

Project Background

Drivers of Management

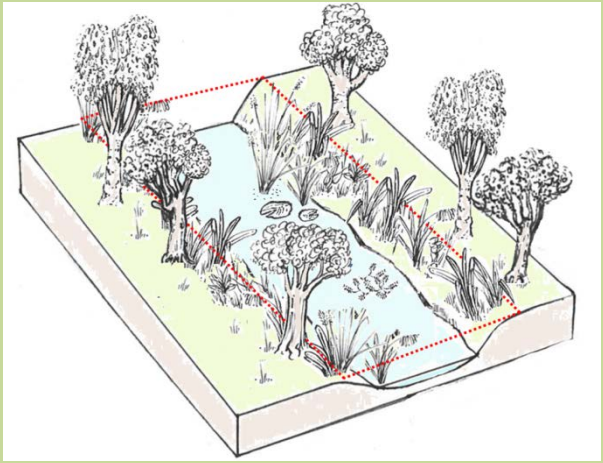


Project Objective

"***Develop good practice guidance on the management of aquatic plants and vegetation both in and alongside watercourses. It provides a decision-making framework for watercourse managers, taking account of the range of management techniques available and different watercourse types***"

Scope of Works

- Aquatic and riparian vegetation
- Algae
- Non-native invasive bankside species
- Canals
- England and Wales



"The characteristic vegetation along watercourses that forms the link between the environments of water and land"

- The guide **does not** cover:
  - Lakes and ponds
  - Riparian trees / woody vegetation
  - Wider floodplain vegetation
  - Terrestrial bankside species (i.e. nettles, tall grasses)

Target Audience

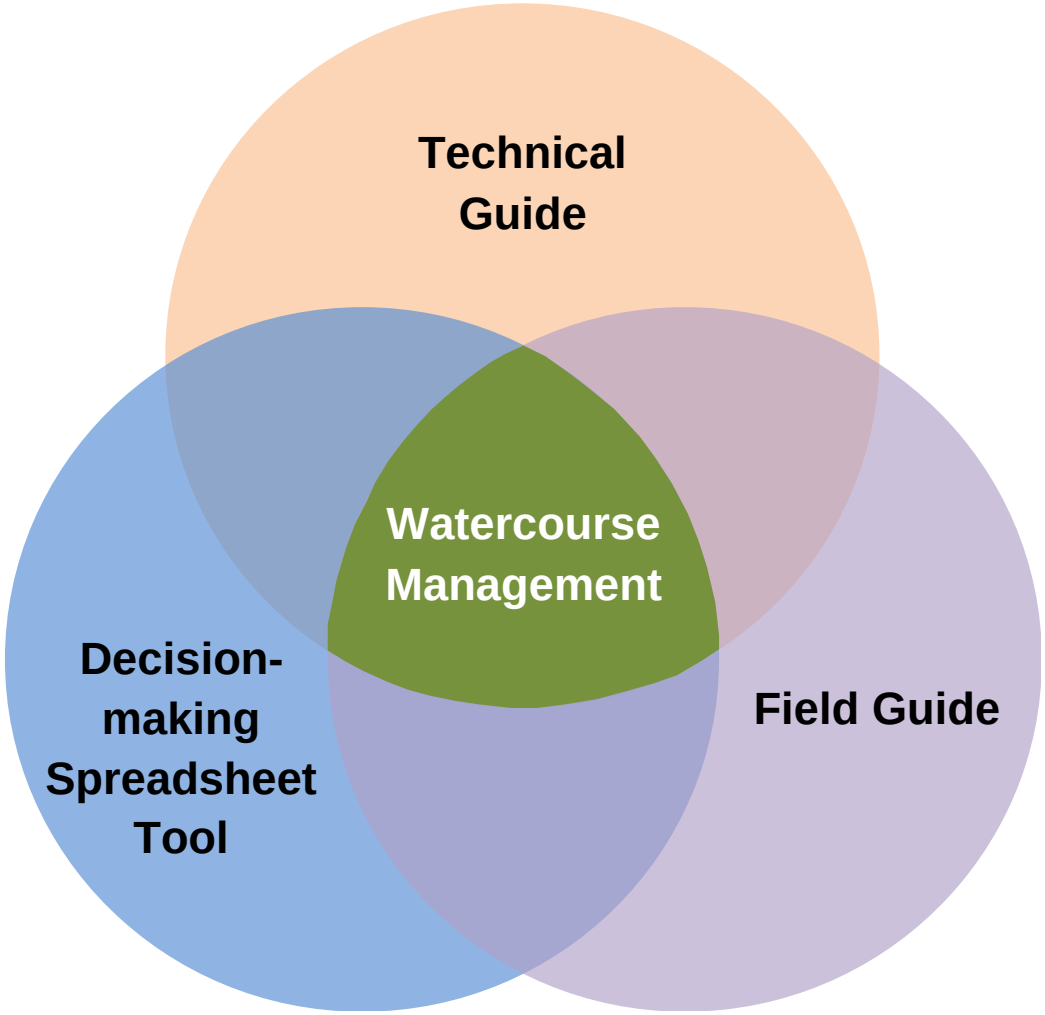
- Environment Agency
- Natural Resources Wales
- Internal Drainage Boards
- Lead Local Flood Authorities/local authorities
- Canal & River Trust
- Other organisations (e.g. Natural England, wildlife trusts, rivers trusts, angling trusts and the RSPB).

- Secondary Audience = riparian landowners. We recommend that riparian landowners seek further advice from relevant authorities

THE NEW GUIDANCE

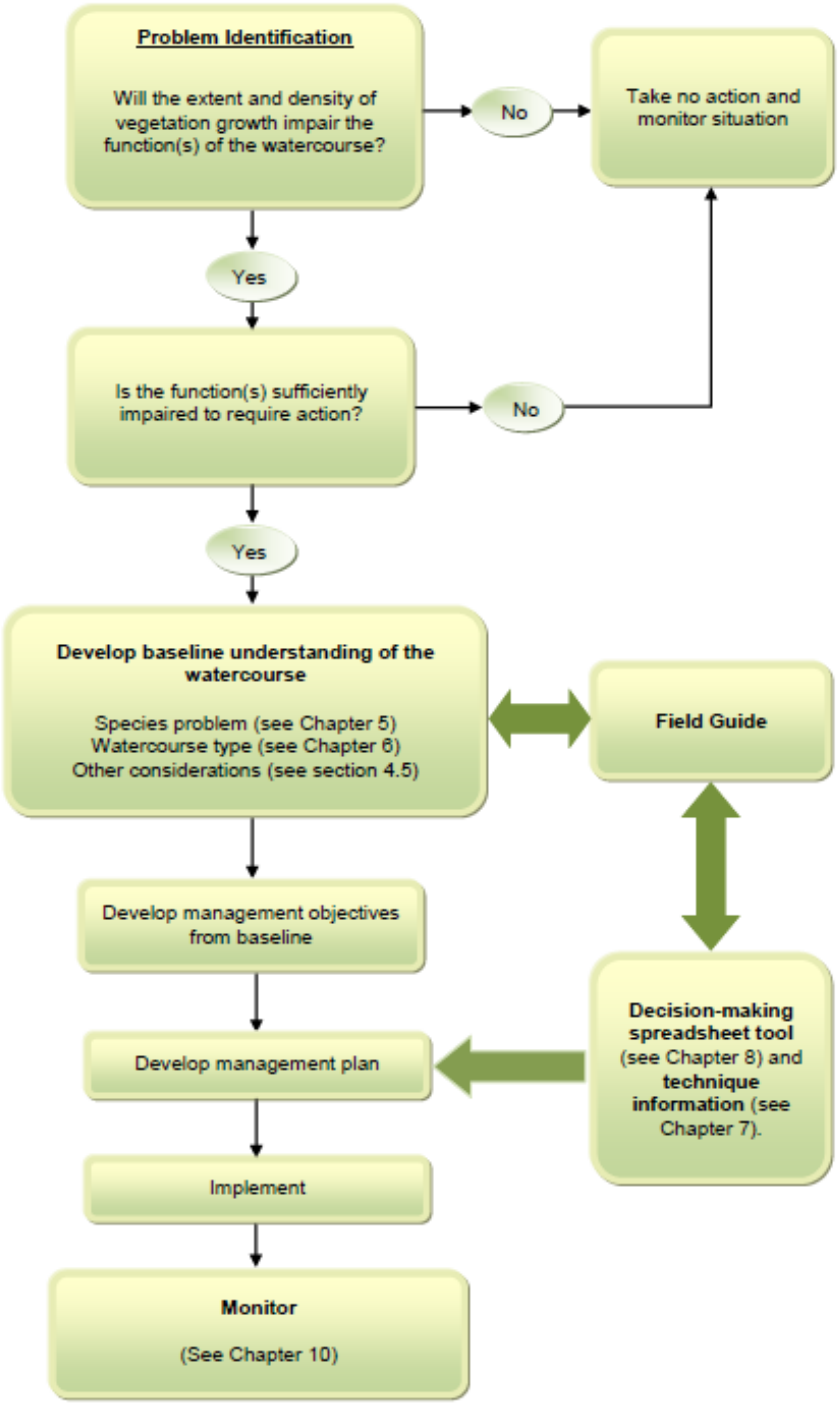
Content of the Guidance

- **Technical Guide** - detailed information on planning, undertaking and monitoring management
- **Decision-making Spreadsheet Tool** – to inform selection of management technique
- **Field Guide** – use to collect information needed for tool

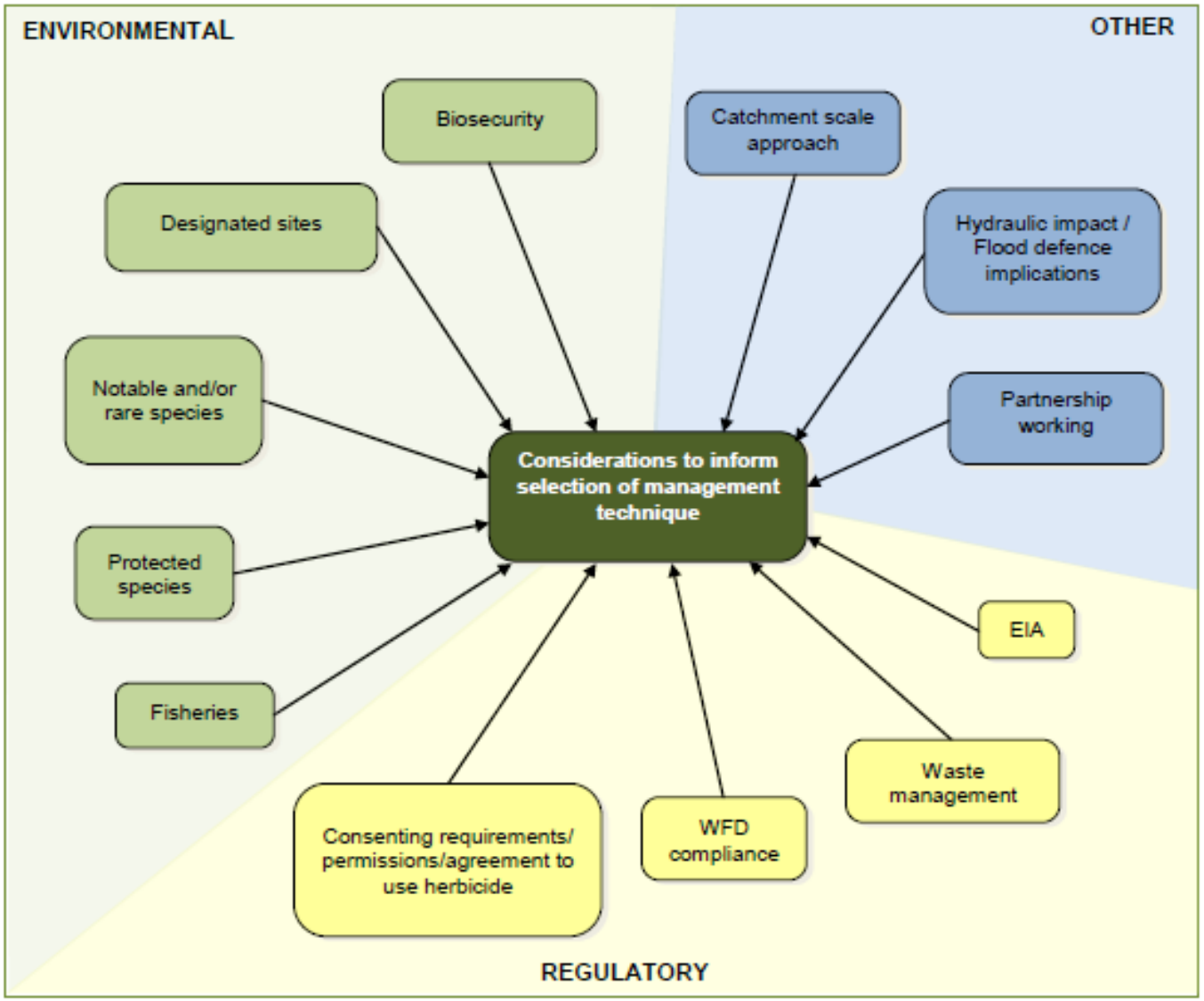


- ***Must use all 3 together***

Planning Aquatic and Riparian Plant Management



Planning Aquatic and Riparian Plant Management



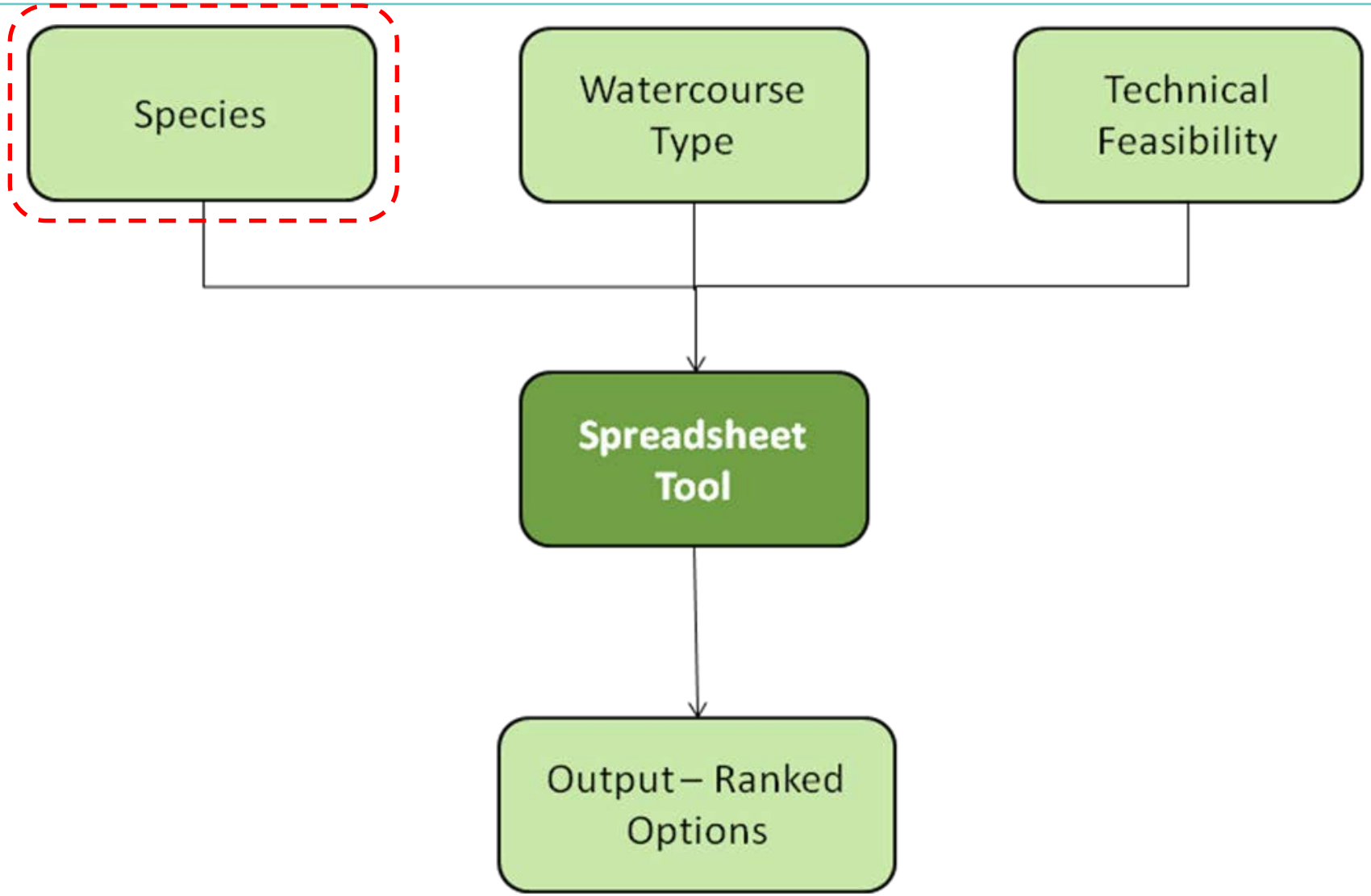
Available Techniques

Category	Technique
Physical	Hand pulling
	Hand cutting
	Hand raking
	Mechanical harvesters
	Weed boats
	Amphibious vehicles
	De-weeding with a weed bucket
	De-weeding with a solid bucket
	Excavator and tractor mounted cutter/flail
Chemical	Glyphosate-based herbicide
	Glyphosate-based herbicide with adjuvant
	Barley straw
	Barley straw extract
Environmental	Shading through tree/hedgerow/bankside planting
	Fencing to allow bankside vegetation growth for shading
	Shading with native, broad-leaved floating species
	Shading with opaque materials suspended over water
	Shading with benthic barriers
	Dyes
	Water level manipulation
	Manipulation of flow characteristics
	Channel narrowing to increase velocity (two-stage channel)
	Buffer strips
	Diffuse and point source pollution management
	Nutrient-binding chemicals
	Disturbance by boat traffic
Biological	Grazing of banks by cattle, sheep and horses
	Waterfowl
	Native Fish species
	Invertebrates (e.g. *Daphnia spp*., weevils)
Novel techniques	Hot foam
	Ultrasound
	Electromagnetic water treatment
	Suction harvesting
	Diver-operated suction harvesting
	Hydro Venturi
	Infrared

Technique Selection – Spreadsheet Tool

- Tool developed to support decision-making
- Composed of 3 elements:
  - Assessment of effectiveness of management technique in relation to **species**
  - Impact of management technique on **watercourse type** – looking at sediment alteration and channel process alteration
  - **Technical feasibility** assessment

Decision-making Spreadsheet Tool



Species Identification

- Species divided by growth habit
  - Submerged
  - Floating-leaved (free-floating and rooted)
  - Emergent (tall and broad-leaved)
  - Algae

  - Non-native Invasive Bankside Species
    - Japanese Knotweed
    - Himalayan Balsam
    - Giant Hogweed

5.4.2 Water-lilies *Nuphar spp.* and *Nymphaea spp.*

Water-lilies are plants of static and slow-flowing water bodies, and are characterised by their floating oval/circular leaves and yellow or white flowers. They can grow in water depths of up to 5m but favour 1m to 3m.

There are 3 native water-lily species in the UK; the most common in watercourses is Yellow Water-lily *Nuphar lutea* (see photograph opposite). White Water-lily *Nymphaea alba* (see photograph below) occasionally occurs in watercourses and management of this species should be carefully considered. A third species, Least Water-lily *Nuphar pumila*, is quite uncommon; **you should take care to accurately identify the species prior to management**. The table below summarises the key features to identify these three species.

Yellow Water-lily *Nuphar lutea*	White Water-lily *Nymphaea alba*	Least Water-lily *Nuphar pumila*
Leathery heart-shaped floating leaves	Almost circular floating leaves	Leathery heart-shaped floating leaves
Has submerged, thin 'cabbage' leaves on triangular stems	Mature leaves rarely submerged, and if so like floating leaves	
Leaves up to 40 x 30cm	Leaves 9-30cm diameter	Leaves up to 17 x 12.5cm
23 or more veins divided in parallel, 'tuning forks'	Leaf veins join up to form a network	18-11 veins divided in parallel, 'tuning forks'
Large yellow flowers	Large white flowers	Small yellow flowers

Water-lilies form extensive slow-spreading rhizomes from which leaves and flowers arise each year. The narrow leaf and flower stalks cause little flow impedance. Also, the shading effect of the leaves can help to control submerged plants and algae.

Key Problems Caused:

- Dense cover of leaves may impair recreational activities.
- Dense cover of leaves may cause deoxygenation as a result of die-back of submerged species from the shading generated.

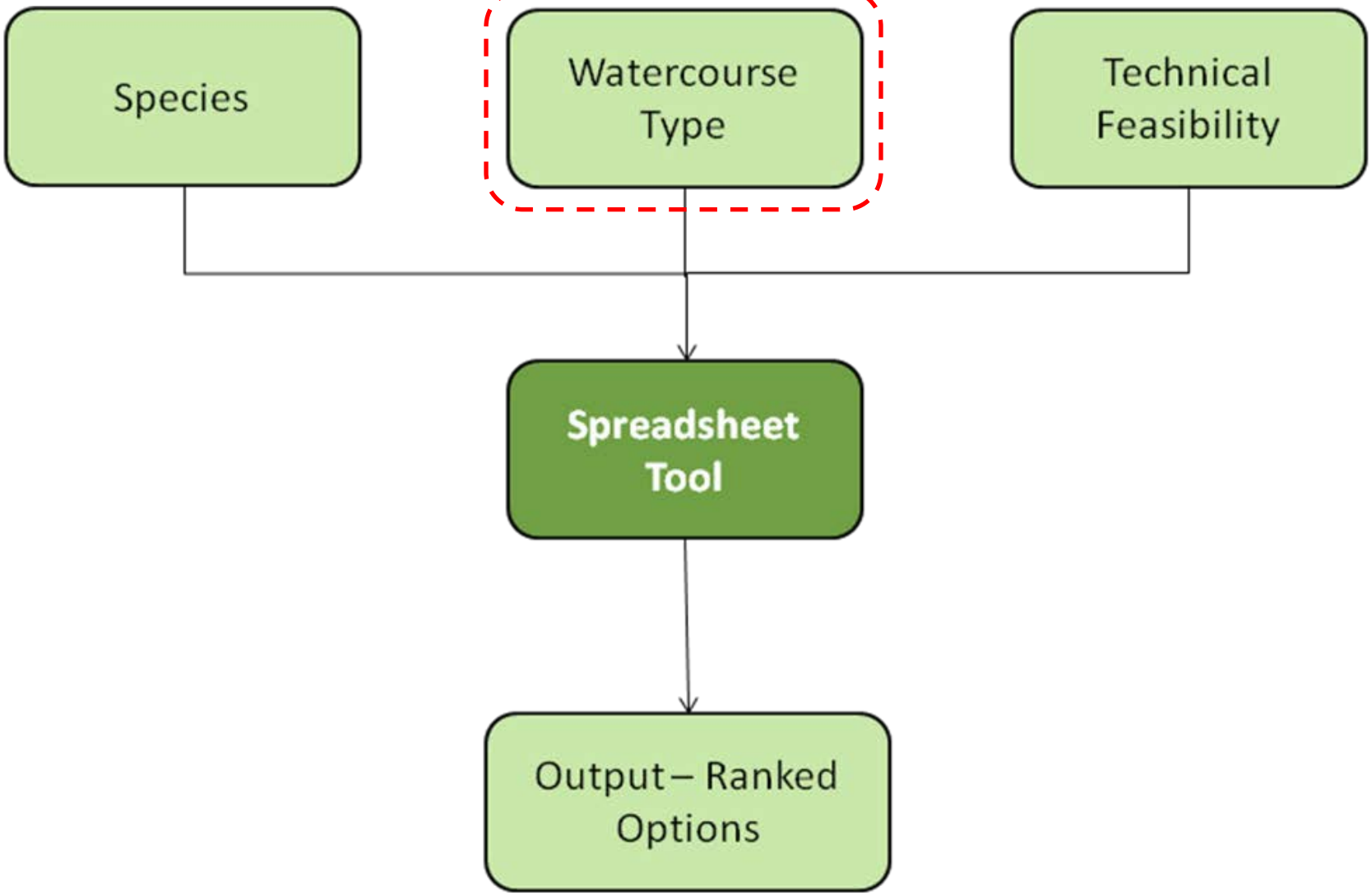
Technique Type	Applicability	Timing	Relevant Sections
Physical	Physical techniques using a variety of methods provide short-term control, but rapid re-growth of leaves typically occurs later in the season or the following spring.	Mid July-Sept	7.3
	De-weeding with a solid bucket removes rhizomes and provides longer term control of more than one season; this is rarely entirely effective.		7.3.4
Chemical	Glyphosate-based herbicide application to the floating leaves is effective.	July-Aug	7.4.1
	No chemical control technique is available for the submerged 'cabbage' leaves of Yellow Water-lily *Nuphar lutea*.		
Environmental	Shading, through a variety of techniques, is effective.	n/a	7.5.1 7.5.2
	Deepening the channel to more than 2m may limit growth and the areas that this species can colonise, but may not be practical.	n/a	7.5.4
Biological	Ducks readily eat the buds and submerged leaves of water-lilies; increasing waterfowl populations may have some impact, but there is limited ability to control this technique and associated impacts of nutrient enrichment may arise.	n/a	7.4.1
Novel	None recommended.	n/a	n/a

Decision-making Framework Tool - Species

Vegetation Management Technique	Submerged Species	Water-weeds Elodea spp.	Water Milfoils *Myriophyllum spp.*	Submerged Pondweeds Potamogeton spp. *(e.g. Fennel Pondweed)*	Rigid Hornwort *Ceratophyllum demersum*	Mare's-tail *Hippuris vulgaris*	Water-crowfoots *Ranunculus spp*	Parrot's Feather *Myriophyllum aquaticum*	Curly Water-thyme *Lagarosiphon major*	Free-floating Species	Duckweeds *Lemna spp*	Least Duckweed *Lemna minuta*	Water Fern *Azolla filiculoides*
	Submerged									Free-floating			
Hand pulling	1	1	2	1	1	1	1	2	1	0	0	0	0
Hand cutting	1	1	2	1	0	2	2	2	1	0	0	0	0
Hand raking	2	1	2	1	2	2	2	2	1	1	1	1	1
Mechanical harvesters	2	2	2	2	2	2	2	2	2	2	2	2	2
Weed boats	2	2	2	2	0	2	2	2	2	0	0	0	0
Amphibious vehicles	2	2	2	2	0	2	2	2	2	0	0	0	0
De-weeding with a weed bucket	2	2	2	2	2	2	2	2	2	1	1	1	1
De-weeding with a solid bucket	3	3	3	3	1	2	0	2	2	1	1	1	1
Excavator and tractor mounted cutter/flail	0	0	0	0	0	0	0	0	0	0	0	0	0
Glyphosate-based herbicide	0	0	0	0	0	0	0	1	0	0	1	0	1
Glyphosate-based herbicide with adjuvant	0	0	0	0	0	0	0	2	0	0	1	0	1
Barley straw	0	0	0	0	0	0	0	0	0	0	0	0	0
Barley straw extract	0	0	0	0	0	0	0	0	0	0	0	0	0
Shading through tree/hedgerow/bankside planting	2	1	2	2	1	0	2	2	2	2	2	2	1
Fencing to allow bankside vegetation growth for shading	1	1	1	1	1	0	1	1	1	1	1	1	1
Shading with opaque materials suspended over water	2	1	2	2	1	0	2	1	2	1	1	1	1

0 = Not an option for control
1 = Limited potential for control
2 = Moderate potential for effective control
3 = Most potential for effective control

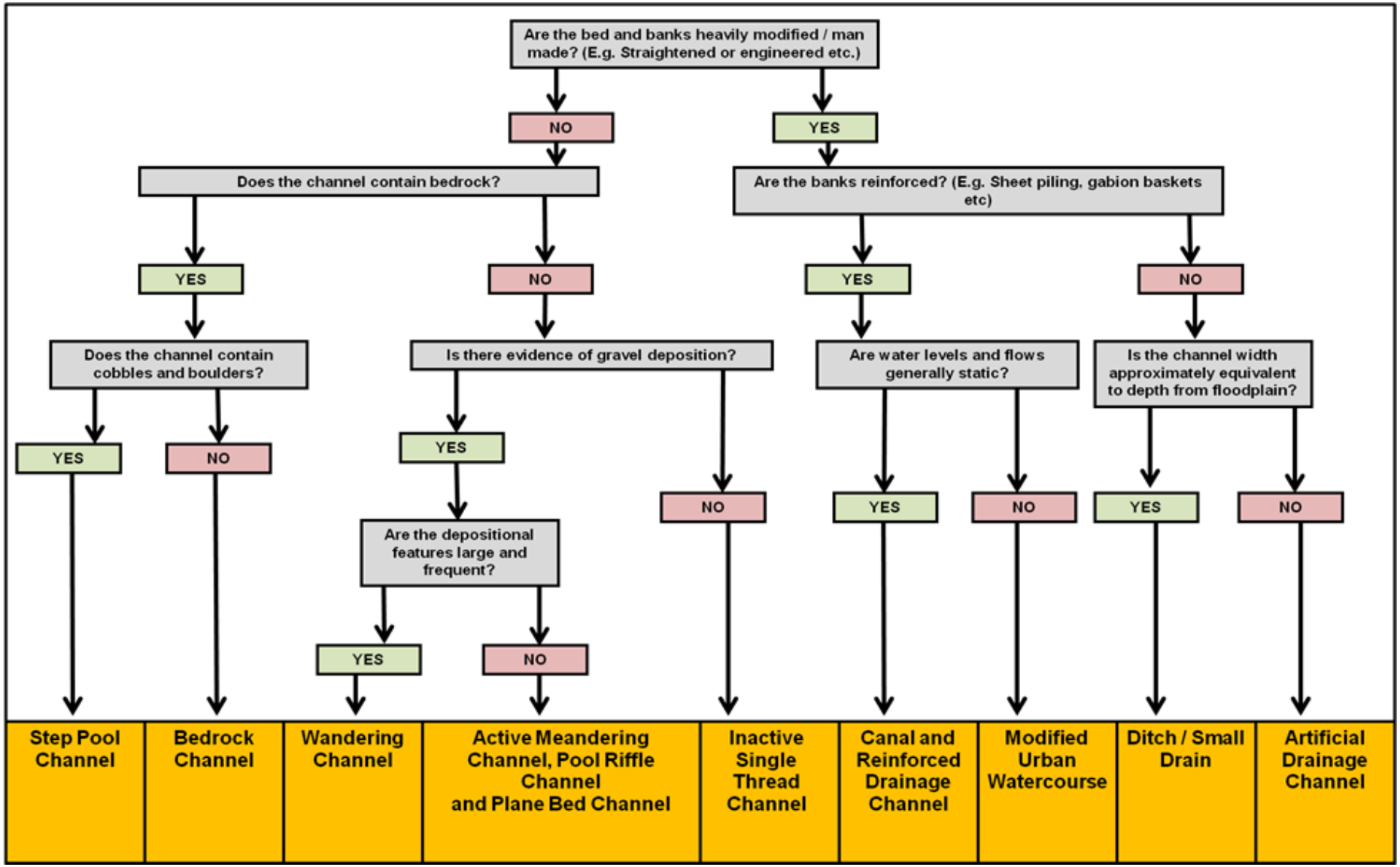
Decision-making Spreadsheet Tool



Watercourse Type Classification

- Understanding watercourse type will help to select a technique that is not detrimental to the watercourse and its WFD status
- Vegetation in watercourses is linked to hydraulics, sediment characteristics and flow dynamics

Watercourse Type Classification

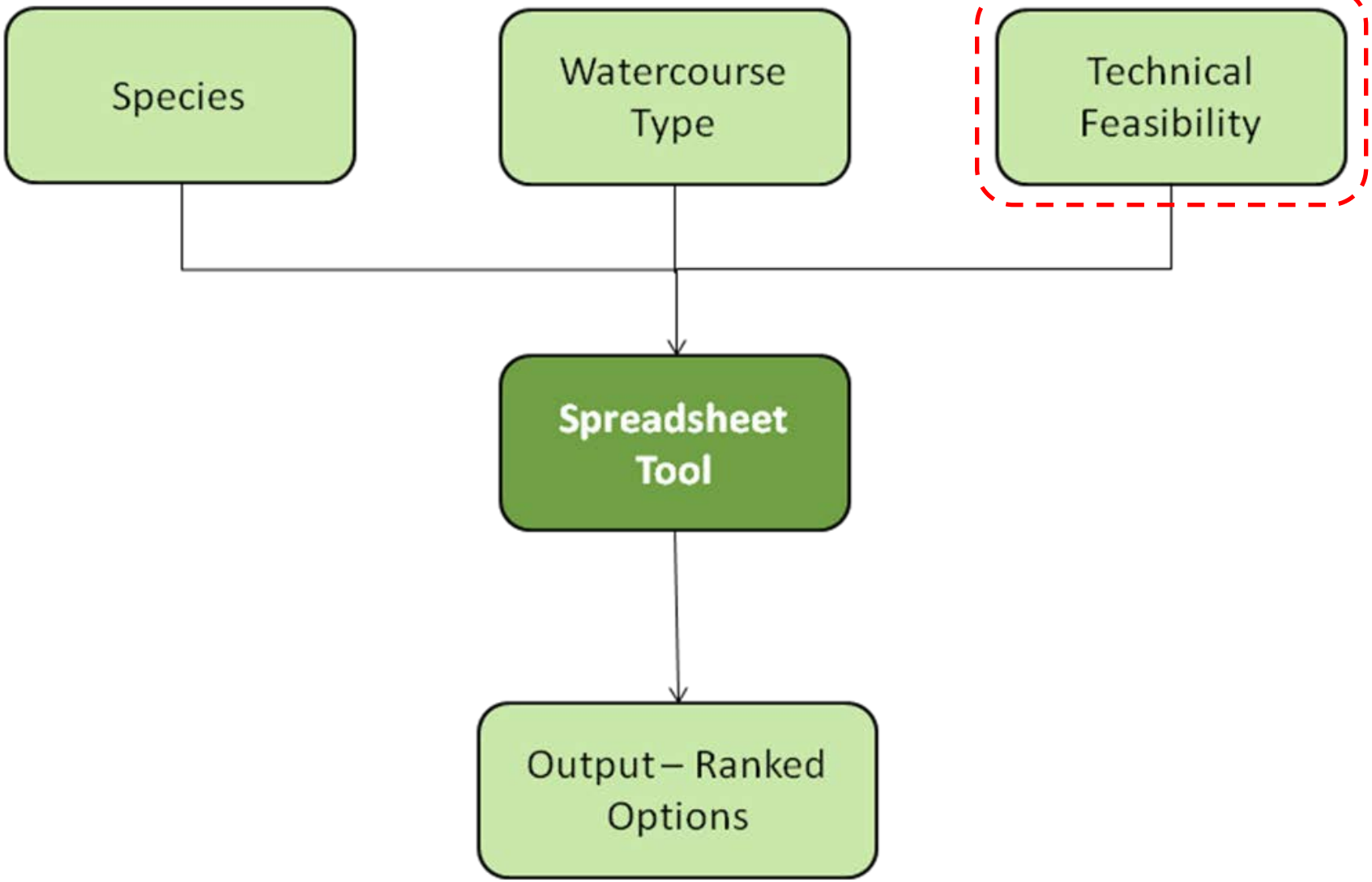


Decision-making Framework Tool – Watercourse Type

Blue	Not applicable
Green	Considered appropriate
Yellow/Amber	Medium risk of damage
Red	High risk of damage

	Sediment alteration	Channel process alteration	Canal and Reinforced Drainage Channel	Modified Urban Watercourse	Artificial Drainage Channel	Ditch / Small Drain	Inactive Single Thread	Active Meandering / Riffle - Pool / Plane Bed	Wandering	Step-Pool	Bedrock
Impact on Fine Sediment			2	1	3	3	3	1	1	0	0
Impact on Channel Dynamics			0	0	0	0	0	2	3	1	0
Vegetation management technique											
Hand pulling	1		0.11	0.06	0.17	0.17	0.17	0.06	0.06	0.00	0.00
Hand cutting	0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hand raking	3		0.33	0.17	0.50	0.50	0.50	0.17	0.17	0.00	0.00
Mechanical Harvesters	2		0.22	0.11	0.33	0.33	0.33	0.11	0.11	0.00	0.00
Weed boats	1		0.11	0.06	0.17	0.17	0.17	0.06	0.06	0.00	0.00
Amphibious vehicles	3		0.33	0.17	0.50	0.50	0.50	0.17	0.17	0.00	0.00
De-weeding with a weed bucket	4		0.44	0.22	0.67	0.67	0.67	0.22	0.22	0.00	0.00
De-weeding with a solid bucket	5		0.56	0.28	0.83	0.83	0.83	0.28	0.28	0.00	0.00
Excavator and tractor mounted cutter/flail	1		0.11	0.06	0.17	0.17	0.17	0.06	0.06	0.00	0.00
Glyphosate-based herbicide	1		0.11	0.06	0.17	0.17	0.17	0.06	0.06	0.00	0.00
Glyphosate-based herbicide with adjuvant	1		0.11	0.06	0.17	0.17	0.17	0.06	0.06	0.00	0.00
Barley straw	0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley straw extract	0		0.00	0.00	0.00	0.00	0.00	**-1.00**	**-1.00**	**-1.00**	**-1.00**
Shading through tree/hedgerow/bankside planting	-2		0.22	0.11	0.33	0.33	0.33	0.11	0.11	0.00	0.00
Shading with native, broad-leaved floating species		3	0.00	0.00	0.00	0.00	0.00	0.33	0.50	0.17	0.00

Decision-making Spreadsheet Tool

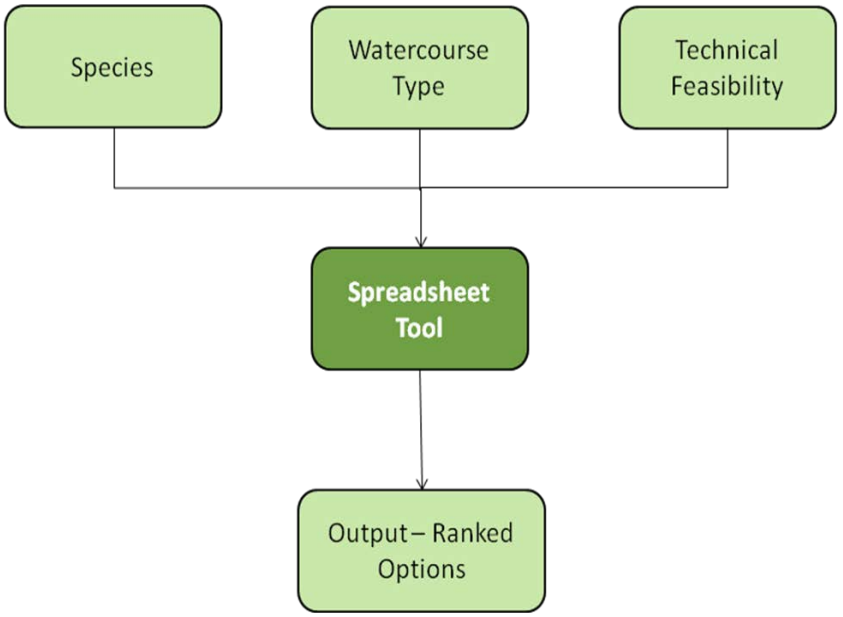


Decision-making Framework Tool – Technical Feasibility

		Length (i.e. Length to be maintained)		Width (i.e. Watercourse wetted width)		Water Depth		Constraints - Access		
Vegetation management technique	Means of application	Minimum (m)	Maximum (m)	Minimum (mm)	Maximum (mm)	Minimum (mm)	Maximum (mm)	Is machine access required?	Is boat access required?	Relative, Indicative Cost Banding
Hand pulling		1	5000	1	100000	0	10000	No	No	£££ / £ (*)
Hand cutting		1	5000	1	100000	0	10000	No	No	£££
Hand raking		1	5000	1	4000	0	10000	No	No	£££
Mechanical Harvesters		500	100000	6000	100000	400	5000	No	Yes	££
Weed boats		500	100000	4000	100000	500	5000	No	Yes	£
Amphibious vehicles		500	100000	4000	100000	0	5000	No	No	£
De-weeding with a weed bucket		1	100000	1500	27000	50	5000	Yes	No	££
De-weeding with a solid bucket		1	100000	1500	27000	0	5000	Yes	No	£££
Excavator and tractor mounted cutter/flail		1	100000	1	100000	0	10000	Yes	No	£
Glyphosate-based herbicide	lance	1	100000	1	5000	0	10000	No	No	£
Glyphosate-based herbicide	boat	500	100000	3000	100000	400	10000	No	Yes	£
Glyphosate-based herbicide with adjuvant	lance	1	100000	1	5000	0	10000	No	No	£
Glyphosate-based herbicide with adjuvant	boat	500	100000	3000	100000	400	10000	No	Yes	£
Barley straw		10	1000	1000	100000	300	10000	No	No	££
Barley straw extract		1	5000	1	100000	100	10000	No	No	££
Shading through tree/hedgerow/bankside planting		10	100000	1	15000	0	10000	No	No	££
Fencing to allow bankside vegetation growth for shading		10	100000	1	2000	0	10000	No	No	££
Shading with opaque materials suspended over water		1	200	1	5000	0	10000	No	No	£££
Shading with native, broad-leaved floating species		1	100000	500	100000	300	2500	No	No	£
Shading with benthic barriers		1	200	500	5000	300	5000	No	No	£££
Dyes		1	500	1	100000	600	10000	No	No	£

Decision-making Framework Tool - Process

1. Input audit trail information
2. Select species
3. Select watercourse type
4. Input technical parameters
    a. length of reach
    b. channel depth
    c. channel width
    d. access issues (boat/machine)



Score = (Effectiveness of technique) x (1 - Damage to watercourse type) x (Technically feasible)

5. List of ranked techniques are returned – use ranking to inform selection

Watercourse Name

Boating Dike

Location

Thorne, South Yorkshire

WFD Watercourse number: n/a
Start Grid Reference: SE67771338
End Grid Reference: SE67501340

Prepared by: Laura Thomas
Date: 18/10/2013

Is the watercourse a designated site or is it adjacent to a designated site? Yes - site is of local importance (eg LNR, LWS, etc)

Liaise with local planning authority/site owner or manager with regards to appropriate techniques/working methods and a site management plan may already be in place.

Does the watercourse support populations of protected species (eg Water Vole, Otter, White-clawed Crayfish)? Yes

Contact Natural England/Natural Resources Wales/Environment Agency for further advice and follow appropriate species guidance. See section 4.5.2 of the Technical Guide.

Select Species

Duckweeds Lemna spp

Data must be entered into all the white cells in this section before any recommendations can be made

Select Watercourse Type

Ditch / Small Drain

Length of watercourse to be managed (m): 735
Channel width (m) (ie wetted width): 5
Water depth (m): 0.5

Machine access possible? Yes

Boat access possible? No

Notes for selected species:

Care should be taken in identification as Rootless Duckweed Wolffia arrhiza is a rare species in this group.

Recommended control options are (always consider site-specific factors in technique selection):

Rank	Control Technique	Relevant Section of Technical Guide	Means of Application (where more than one method)	Effectiveness for selected species (0 = low, 3 = high)	Damage to Watercourse Type (0 = low, 1 = high, -1 = N/A)	Technically feasible? (0 = No, 1 = Yes)	Score (0 = low, 3 = high)	Indicative Cost
1	Shading with native, broad-leaved floating species	7.5.1		2	0.00	1	2.00	£
2=	Channel narrowing to increase velocity (two-stage channel)	7.5.5		2	0.33	1	1.33	£££
2=	Shading through tree/hedgerow/bankside planting	7.5.1		2	0.33	1	1.33	££
2=	Suction harvesting	7.7.4		2	0.33	1	1.33	£££
5	Native fish species	7.6.4		1	0.00	1	1.00	£
6=	Buffer Strips	7.5.6		1	0.17	1	0.83	££
6=	Diffuse and point source pollution management	7.5.6		1	0.17	1	0.83	£££
6=	Glyphosate-based herbicide	7.4.1	lance	1	0.17	1	0.83	£
6=	Glyphosate-based herbicide with adjuvant	7.4.1	lance	1	0.17	1	0.83	£
10	De-weeding with a weed bucket	7.3.3		1	0.67	1	0.33	££
11	De-weeding with a solid bucket	7.3.4		1	0.83	1	0.17	£££

Note: Score = (Effectiveness of technique) x (1 - Damage to watercourse type) x (Technically feasible)

The maximum possible score is 3

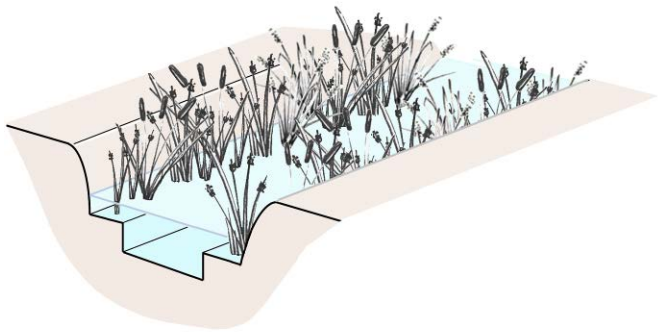
Techniques

- Information included on:
  - Method
  - Consenting requirements/permissions
  - Best Practice
  - Disadvantages/Benefits
  - Timings
  - Useful links

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Submerged					Cutting now will likely require repeat cuts					Die-back reduces need for management		
Rooted Floating Leaved					Cutting now will likely require repeat cuts					Die-back reduces need for management		
Tall Emergent					Cutting now will likely require repeat cuts					Standing dead material may require management		
Broad-leaved Emergent					Cutting now will likely require repeat cuts							
			Caution required with all physical techniques as birds nests may be									
	Optimal period											
	Sub-optimal period											

The tool provides a list of possible techniques.

The watercourse manager must always use their own judgement and site-specific knowledge when selecting a technique.



7.3.2 Mechanical harvesters, weed boats and amphibious vehicles

Summary: Mechanical management of vegetation using a vehicle working from within the channel itself. A range of vehicles are available for undertaking this work.

Cost: £ / ££ (depending on type of vehicle used)

Short-term option

These mechanical techniques require specialist machinery that can work from within the channel, such as mechanical harvesters, weed boats and amphibious vehicles. The machines are capable of being fitted with a range of mechanical and hydraulic attachments to undertake specific management tasks and for the management of different groups of species. In general, attachments for vegetation management can include:

- ***Cutter bars*** - these can be either a unit on the front of the vehicle (e.g. a T-front cutterbar) or a side cutterbar often used to mow embankments.
- ***Weed cutting baskets and cutting knives*** - a perforated bucket or cutter with reciprocating cutting blades to cut vegetation.
- ***Trailing knives*** - a chain with a V-shaped blade that is pulled over the watercourse bed with a jolting movement to cut and pull out vegetation. This type of attachment can adversely impact on the bed of a watercourse and mobilise significant quantities of silt.
- ***Push or Collecting frames/rakes*** - an attachment to collect cut vegetation and floating debris and deposit it at the side of the watercourse.

The attachments can either be on an arm which allows the head to work up and down the banks and reach other locations, or they can be in fixed positions.

Weed boats can be fitted with a wide range of attachments as detailed above to manage submerged, floating and emergent vegetation.

Mechanical harvesters are boats that, as well as being fitted with equipment to cut the vegetation, are also able to collect and store cut material on board for disposal once the operation is complete and the machine returns to land. Mechanical harvesters are often the best physical technique for managing free-floating species such as duckweeds, as the plants are collected and removed from the watercourse, which other physical techniques do not.

Amphibious vehicles have the benefit of being able to work in much shallower waters than required for weed boats or mechanical harvesters. They are either wheeled or tracked machines and can generally access watercourses much more easily and in more locations than other types of in-channel vehicle. As they are tracked or wheeled they can damage the bottom of watercourses and should be used with extreme care in watercourses sensitive to sediment mobilisation, and also where important features such as spawning gravels are present. Working with amphibious vehicles should be avoided during fish spawning seasons (i.e. generally November to March for Salmon and Trout and April to June for coarse fish).

These vehicles cannot be used in narrow watercourses, and in the case of weed boats and mechanical harvesters, watercourses with shallow water (approximately 0.4m).

These in-channel vehicles can be very effective at managing submerged, rooted floating-leaved, tall emergent and broad-leaved emergent species and also stoneworts (charophytes). With the exception of mechanical harvesters, they are generally ineffective on free-floating species and filamentous green algae. Extreme care should be undertaken when managing non-native invasive species with these in-channel vehicles as many of the attachments result in fragmentation of the plant, which can result in their re-establishment and spread downstream.

Best Practice Working Methods

When undertaking management using these in-channel vehicles you should not remove vegetation from the entire channel width. Management should be undertaken selectively, with some vegetation retained for biodiversity and for bank stabilisation purposes.

There are many approaches to how and to what extent vegetation may be managed within a channel to bring both flood risk management and biodiversity benefits, amongst others. Further information can be found in:

- Environment Agency FCRM Asset Management Maintenance Standards
- The Drainage Channel Biodiversity Manual (Buisson *et al*, 2008)

When working within flowing watercourses, you should cut the vegetation in an upstream direction as this makes the operation easier and allows plant fragments and

associated invertebrates to drift downstream and re-colonise the watercourse. In still and very slow-flowing water bodies in-channel vehicles can operate in either direction.

In large, wide channels, the vehicle may need to pass up and down the channel more than once to ensure that the desired quantity of vegetation is cut. In some watercourses, to increase the diversity of flow conditions and habitats within the channel, you could cut a meandering channel through the vegetation, although this is not as hydraulically efficient as a straight channel.

The **timing** of management is also important, as generally management is only required once significant growth has occurred, usually by late spring or early summer, although this varies depending on site conditions and the species present. Management undertaken during the spring and summer carries a significant risk of damaging and destroying birds' nests in and alongside watercourses and is discouraged until mid-July. After mid-July, till the end of September, you should be alert to the potential presence of nests in and alongside watercourses, or surveys should be undertaken immediately before the works. If found, a nest should be safeguarded with an appropriate buffer zone (a minimum of five metres either side is recommended) to prevent damage and/or destruction.

Cutting before mid to late summer may require a second cut to be undertaken later in the autumn as re-growth is stimulated. Cutting in mid to late summer, or later, can be more difficult and time-consuming as there is usually a greater density of vegetation. The function(s) of the watercourse needs to be assessed to determine whether you need two or more regular cuts during the year, which remove less plant material, or one later operation which removes significant quantities of plant material. Regular cutting operations are generally only implemented in exceptional circumstances, such as in high flood risk locations.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Submerged					Cutting now will likely require repeat cuts					Die-back reduces need for management		
Rooted Floating Leaved					Cutting now will likely require repeat cuts					Die-back reduces need for management		
Tall Emergent					Cutting now will likely require repeat cuts					Standing dead material may require management		
Broad-leaved Emergent					Cutting now will likely require repeat cuts							
			Caution required with all physical techniques as birds nests may be									
	Optimal period											
	Sub-optimal period											

For most mechanical techniques it is the removal of the vegetation from the water which takes the most time and incurs the most cost; mechanical harvesters can help by reducing the time and costs associated with collecting material. It is best practice to remove cut material from the watercourse to prevent deoxygenation as it decomposes, and also the blockage of screens, culverts and other structures. With weed boats and

amphibious vehicles it may also be possible to allow cut material to float downstream to a boom, weed screen or specified collection point allowing for easier collection. When collected in one location, off-site disposal may be required which will increase costs.

It is also best practice to place the cut material on the bank top, either to decompose entirely or to allow it to drain prior to off-site disposal, and also allow any invertebrates that have been removed incidentally with the plant material to re-colonise the watercourse. Section 4.5.9 discusses waste management in further detail, including the need for waste exemptions and environmental permits.

Benefits	Disadvantages
Impact is immediate.	Short-term option which leads to re-growth. Repeat treatment, often within the same season, will be required.
Generally rapid and cost effective, particularly on large watercourses.	Non-selective and destructive techniques that impact on non-target species, including fish and invertebrates.
Costs may be offset by finding a use for the cut vegetation (e.g. as livestock fodder).	Cut plant material requires collection from the water (not with mechanical harvesters) and appropriate disposal. You will need to apply for appropriate exemptions/permits from us/Natural Resources Wales.
	Some species can be poisonous to livestock, and remain so following cutting.
	Fragments are created from which plants can re-establish and potentially spread downstream.
	Machines are often only used seasonally and remain unused for significant portions of a year.
	You will require a suitable and safe launching site.
	Skilled and competent staff will be required to operate these vehicles, or specialist contractors will need to be appointed.

Key Considerations:

- ***Waste disposal*** - you must apply for appropriate exemptions/permits for waste disposal from us/Natural Resources Wales, if required.
- ***Timing*** - you must schedule the work carefully, taking into account nesting birds and other environmental constraints.
- ***Access*** - you will need to find a safe and suitable launching site.
- ***Size of Watercourse*** - in-channel vehicles are only suitable for use on larger watercourses (approximately 4m wide and 0.4m deep).
- ***Selective Control*** - you should aim to retain as much in-channel vegetation as possible whilst ensuring the function(s) of the watercourse is maintained.

7.5.3 Dyes

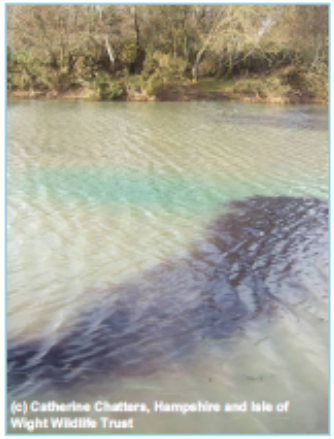
Summary: Plants require light to photosynthesise and some species are intolerant of shade. Preventing light penetration of the water column through the use of dyes can be effective at controlling some species.

Cost: £

Short-term option

Limiting light penetration of the water column can be achieved through the use of specialist dyes, usually in black or blue. There are several dyes that are commercially available which colour the water and absorb sunlight, preventing light penetration.

The use of dyes to control aquatic vegetation tends to be for ponds rather than watercourses. This technique **cannot be used on flowing waters**, only static, usually small ones, such as ditches. It is a technique that can be used on submerged species and algae, and, as the dye is applied early in the growing season, potentially other species of aquatic plant that have yet to develop emergent or floating leaves.



Apply dyes before the target species has started to grow; this can be as early as mid-February. Dyes should then be topped up every month at 10% of the initial dose rate to maintain control throughout the season as the pigment breaks down and becomes diluted by rain. Do not undertake the initial application of dye during the summer as this can cause rapid die-back of plants and carries the risk of deoxygenating waters. Water temperatures for application should be below 8°C to 10°C.

Benefits	Disadvantages
No major adverse effects upon non-target organisms have been reported.	Cannot be used over long lengths of watercourse.
Can be effective on small, localised infestations, particularly of non-native invasive species.	Can only be used on species which have submerged parts and algae.

Benefits	Disadvantages
No specific consents/licenses are required to use dyes.	Cannot be used on flowing watercourses, although it may be suitable for on-line ponds with higher water retention times.
	Non-selective technique; all plants beneath the dye will be impacted upon.
	Can be unsightly.

Key Considerations:

- ***Water use*** - cannot be used where water is used for human consumption and may be undesirable in an amenity setting.
- ***Monitoring*** - you will need to monitor the site to ensure that the dye remains effective.
- ***Watercourse type*** - limited applicability in static waters only.

EXAMPLE: Use of Dyes at Maidenhead Sailing Club

Many sailing clubs, including that at Maidenhead, undertake management of aquatic vegetation so that it does not impede recreational activities. Past management methods have involved the use of herbicides (which are now unavailable for submerged species) or physical techniques, such as cutting. From 2011 onwards, the Maidenhead Sailing Club has been experimenting with the use of blue dye to control submerged species, including Canadian Waterweed *Elodea canadensis*.

The first deployment of dye in 2011 was initially successful, however, low water levels allowed the submerged plants to re-grow and physical techniques were also required to prevent sailing activities being impeded. In 2012 greater success with dyes was achieved, with the use of physical techniques limited to shallow/difficult areas. The deployment of 105 litres of blue in 2013 achieved good control and higher water levels ensured the issues encountered in 2011 did not recur. As a result the use of physical control techniques was discontinued.

The trials of dyes at Maidenhead Sailing Club have concluded that (Dibble, 2013):

- Blue dye does control submerged aquatic vegetation, but monitoring is needed to ensure dye concentration is sufficient and that algal growth does not occur.
- Care needs to be taken in shallow water where evaporation can bring plants to the surface and photosynthesising environment, making the dye ineffective.
- Integrated use of dyes with targeted physical control has been successful.
- Growth of other aquatic and riparian vegetation, including reeds and water lilies was unaffected, and no decline in bird activity was reported.
- Stakeholder engagement with all water body users and authorities is important.

Whilst this example relates to a lake environment, the technique and lessons learnt from it can be applied to static watercourses.

Case Study – Nafferton Beck, East Yorkshire

- Problem Species = Branched Bur-reed
- Need to manage for land drainage and flood risk management purposes
- Water Vole are also present

Watercourse Name

Nafferton Beck

Location

Nafferton, East Yorkshire

Is the watercourse a designated site or is it adjacent to a designated site? No

WFD Watercourse number	GB104026067090
Start Grid Reference	TA06525669
End Grid Reference	TA06515722

Does the watercourse support populations of protected species (eg Water Vole, Otter, White-clawed Crayfish)? Yes

Contact Natural England/Natural Resources Wales/Environment Agency for further advice and follow appropriate species guidance. See section 4.5.2 of the Technical Guide.

Prepared by	Rachael Brady
Date	20/11/2013

Select Species

Branched Bur-reed Sparganium erectum

Data must be entered into all the white cells in this section before any recommendations can be made

Select Watercourse Type

Artificial Drainage Channel

Length of watercourse to be managed (m)	575
Channel width (m) (ie wetted width)	4
Water depth (m)	0.1

Machine access possible? Yes

Boat access possible? Yes

Notes for selected species:

Tall emergent species are often very important in stabilising the toes of banks and management should aim to ensure that a protective fringe of tall emergent vegetation is retained.

Tall emergent species can often provide nesting sites for a range of bird species; management of large stands of tall emergent species should always be conducted outside of the bird breeding season (March-September).

Recommended control options are (always consider site-specific factors in technique selection):

Rank	Control Technique	Relevant Section of Technical Guide	Means of Application (where more than one method)	Effectiveness for selected species (0 = low, 3 = high)	Damage to Watercourse Type (0 = low, 1 = high, -1 = N/A)	Technically feasible? (0 = No, 1 = Yes)	Score (0 = low, 3 = high)	Indicative Cost
1=	Glyphosate-based herbicide	7.4.1	lance	3	0.17	1	2.50	£
1=	Glyphosate-based herbicide with adjuvant	7.4.1	lance	3	0.17	1	2.50	£
3	Hand cutting	7.3.1		2	0.00	1	2.00	£££
4	Shading through tree/hedgerow/bankside planting	7.5.1		2	0.33	1	1.33	££
5	Amphibious vehicles	7.3.2		2	0.50	1	1.00	£
6=	Buffer Strips	7.5.6		1	0.17	1	0.83	££
6=	Diffuse and point source pollution management	7.5.6		1	0.17	1	0.83	£££
6=	Excavator and tractor mounted cutter/flail	7.3.5		1	0.17	1	0.83	£
6=	Hand pulling	7.3.1		1	0.17	1	0.83	£££ / £ (*)
10=	Channel narrowing to increase velocity (two-stage channel)	7.5.5		1	0.33	1	0.67	£££
10=	De-weeding with a weed bucket	7.3.3		2	0.67	1	0.67	££
12=	De-weeding with a solid bucket	7.3.4		2	0.83	1	0.33	£££

Note: Score = (Effectiveness of technique) x (1 - Damage to watercourse type) x (Technically feasible)

The maximum possible score is 3

(*) = lower cost if use volunteers

Case Study – River Mole, Surrey

- Problem Species = Floating Pennywort
- Non-native Invasive species
- Covers the water surface
- Blocks weirs and structures

Watercourse Name

River Mole

Location

East Molesley, Surrey

WFD Watercourse number GB106039017622
Start Grid Reference TQ14346756
End Grid Reference TQ15266817

Prepared by Laura Thomas
Date 16/12/2013

Is the watercourse a designated site or is it adjacent to a designated site? No

Does the watercourse support populations of protected species (eg Water Vole, Otter, White-clawed Crayfish)? No

Select Species

Floating Pennywort Hydrocotyle ranunculoides

Data must be entered into all the white cells in this section before any recommendations can be made

Select Watercourse Type

Modified Urban Watercourse

Length of watercourse to be managed (m) 3500
Channel width (m) (ie wetted width) 10
Water depth (m) 0.5

Machine access possible? Yes

Boat access possible? Yes

Notes for selected species:

Floating Pennywort is a non-native invasive species listed on Schedule 9 of the Wildlife and Countryside Act 1981 (as amended); it is an offence to plant or cause its spread in the wild.
Physical control techniques should be implemented with care; fragmentation can result in spread.

Recommended control options are (always consider site-specific factors in technique selection):

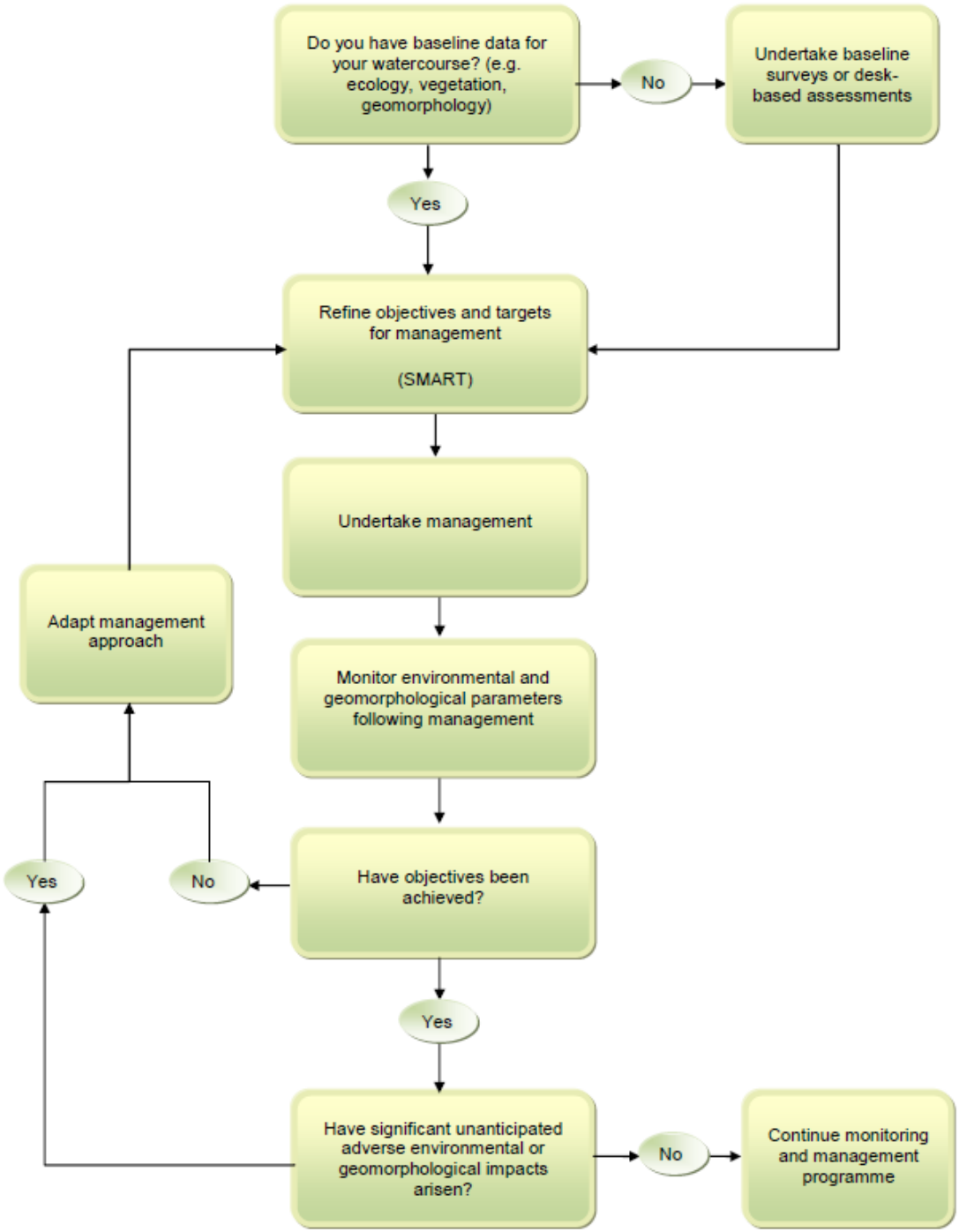
Rank	Control Technique	Relevant Section of Technical Guide	Means of Application (where more than one method)	Effectiveness for selected species (0 = low, 3 = high)	Damage to Watercourse Type (0 = low, 1 = high, -1 = N/A)	Technically feasible? (0 = No, 1 = Yes)	Score (0 = low, 3 = high)	Indicative Cost
1	Glyphosate-based herbicide with adjuvant	7.4.1	boat	3	0.06	1	2.83	£
2	Hand cutting	7.3.1		2	0.00	1	2.00	£££
3	Hand pulling	7.3.1		2	0.06	1	1.89	£££ / £ (*)
4	Shading through tree/hedgerow/bankside planting	7.5.1		2	0.11	1	1.78	££
5=	Glyphosate-based herbicide	7.4.1	boat	1	0.06	1	0.94	£
5=	Weed boats	7.3.2		1	0.06	1	0.94	£
7=	Channel narrowing to increase velocity (two-stage channel)	7.5.5		1	0.11	1	0.89	£££
7=	Mechanical Harvesters	7.3.2		1	0.11	1	0.89	££
9	Amphibious vehicles	7.3.2		1	0.17	1	0.83	£
10	De-weeding with a weed bucket	7.3.3		1	0.22	1	0.78	££
11=	De-weeding with a solid bucket	7.3.4		1	0.28	1	0.72	£££
11=	Grazing of banks by cattle, sheep and horses	7.6.1		1	0.28	1	0.72	£

Note: Score = (Effectiveness of technique) x (1 - Damage to watercourse type) x (Technically feasible)

The maximum possible score is 3

(*) = lower cost if use volunteers

Adaptive Monitoring



Field Guide

- Use on site to collect the information needed to complete the spreadsheet tool

Canadian Waterweed *Elodea canadensis* and Nuttall's Waterweed *Elodea nuttallii*

Are **non-native invasive species** in the UK listed on Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) and **it is an offence to plant or cause their spread in the wild.**

These species grow from stolons rooted in the sediments at the bottom of watercourses and have dark green translucent leaves in whorls of three (occasionally four).

Canadian Waterweed *Elodea canadensis*	Nuttall's Waterweed *Elodea nuttallii*
Broad leaves, widest at the middle	Narrower leaves, widest at the base
Leaf tip is blunt	Leaves taper to a pointed tip
Minute teeth on lower leaf margins	Minute teeth on all leaves
Leaves not strongly curved backwards or twisted	Leaves are curved backwards (i.e. recurved) or twisted

Both these species have small white-pink flowers that float at the water surface on very long, thin stalks. They have three petals and sepals.

AQUATIC AND RIPARIAN PLANT MANAGEMENT – WATERCOURSE RECORDING FORM

Author:		Date:	

Watercourse Name:		WFD ID Number:	
Location:		Start Grid Ref:	
		End Grid Ref:	

Is the watercourse designated, or is it adjacent to a designated site?	
Notes:	
Does the watercourse support populations of protected species?	
Notes:	

Plant Species					
Arrowhead		Himalayan Balsam		Unicellular algae	
Branched Bur-reed		Japanese Knotweed		Cyanobacteria	
Broad-leaved Pondweed		Least Duckweed		Water Fern	
Charophytes/Stoneworts		Lesser Water-parsnip		Water Milfoils	
Common Club-rush		Mare's-tail		Water Solider	
Common Reed		Australian Swamp Stonecrop		Water-cress	
Curly Water-thyme		Parrot's Feather		Water-crowfoots	
Duckweeds		Reed Canary-grass		Water-lilies	
Filamentous green algae		Reed Sweet-grass		Water-primroses	
Floating Pennywort		Reedmaces		Water-starworts	
Fool's Water-cress		Rigid Hornwort		Water-weeds	
Fringed Water-lily		Submerged Pondweeds			
Giant Hogweed		Tall Sedges			
Other Species:					
Species Groups					
Submerged		Free-floating		Broad-leaved Emergent	
		Rooted floating-leaved		Tall Emergent	

Watercourse Type					
Active meandering/riffle - pool/ plane bed		Canal/Reinforced Drainage Channel		Modified Urban Watercourse	
Artificial Drainage Channel		Ditch/Small Drain		Step-pool	
Bedrock		Inactive single thread		Wandering	

Length of watercourse to be managed (m)		Access possible by:	
Channel width (m) (i.e. wetted width)		Machine?	
Water depth (m)		Boat?	

Coming Soon....

- **Channel Management Handbook**

- A new guide to help:
  - Reduce flood risk
  - Manage water levels
  - Ensure maintenance decisions are evidence based
  - Promote best practice techniques

(c) Paul Sharman, North Level District Internal Drainage Board

Publication

- A series of workshops and webinars to be held in April/May.
- With cover both this guidance and the developing Channel Management Handbook

- If you or your colleagues are interested in attending one of these, please email:

workshop@pennyanderson.com