Observations on the impact of dredging on aquatic plants in the Huddersfield Broad Canal and some canal lengths of the Calder & Hebble Navigation

A report for the Canal & River Trust

R Goulder

Honorary Senior Fellow, University of Hull

This vegetation survey and report were undertaken by the author working as a volunteer for the Canal & River Trust, Leeds

[redacted]

May 2019

Contents

1 Summary

- The long-term effects of dredging on the aquatic flora of the Huddersfield Broad Canal were investigated by examining plant records from over nearly 40 years. The c.6km canal was comprehensively dredged in 2002 and records from after dredging (2012, 2017 and 2018) were compared with records from before dredging (1980, 1996 and 2000).
- It was shown that the Broad Canal has continued to be a valuable resource for plant conservation. The aquatic flora is species rich and abundant and most plants found before dredging were still there afterwards – the important plant, *Luronium natans*, continued to thrive.
- The short-term effects of dredging were investigated in the Calder & Hebble Navigation along c.11km of canal between Brighouse and Sowerby Bridge. Dredging was in winter 2015-2016 and plant records made shortly afterwards, in 2017 and 2018, were compared with pre-dredging records from 2014.
- Most aquatic plants recorded before dredging were still to be found afterwards; unsurprisingly, however, there were notable reductions in abundance and extent of distribution. A substantial decrease in the abundance and range of *Luronium natans* is of concern.
- Aquatic plants in the c.1.2km of the Dewsbury Arm of the Calder & Hebble Navigation were recorded in summer 2014 and 2017, before the arm was dredged in winter 2017-2018, and again, shortly afterwards in summer 2018.
- The Dewsbury Arm had a species rich and abundant aquatic flora before dredging. Most plants were still to be found after dredging although their abundance was reduced; the retention of marginal shelves benefitted the flora. The abundance of *Luronium natans* was less but plants survived in the margin.
- Plants in the adjacent main line of canal, along c.2.3km from Thornhill Double Locks to Thornhill Flood Lock, were also surveyed in 2014, 2017 and 2018 – this provided an un-dredged control.
- This length of canal had a notably conservation-worthy aquatic flora throughout the study period. *Luronium natans* thrived; its submerged growth form of stolon-linked rosettes was abundant, and its floating elliptic leaves were not uncommon.
- It is too soon to know whether the rich vegetation that was formerly to be found between Brighouse and Sowerby Bridge, that included abundant *Luronium natans*, will be re-established. In view of this, it is suggested that the canal between Thornhill Double Locks and Thornhill Flood Lock, with its abundant *L. natans*, should not be comprehensively dredged until the long-term effects of the Brighouse to Sowerby Bridge dredging are more fully understood. Additionally, the use of temporary on-line reserves – found to be successful in conservation of *L. natans* in the Huddersfield Broad Canal – might be considered.

2 Introduction

The effects of canal dredging on aquatic wildlife are addressed by the IWAC report *Britain's Inland Waterways: Balancing the Needs of Navigation and Aquatic Wildlife* (Anon., 2008). That report acknowledged that dredging is likely to have short-term adverse impacts upon aquatic plants. These are, however, likely to be mitigated by recommended good practice that stipulates retention of marginal strips of vegetation. In the longer term the IWAC report suggests that dredging may have benefits for aquatic plants. These include: limiting plant succession through restoration of open water and so allowing greater species richness; removal of sediment-bound pollutants; removal of sediment-bound inorganic nutrients, for example phosphate, leading to reduction in eutrophication; removal of fine sediments with re-establishment of a firmer rooting substratum.

Dredging of navigable canals is periodically necessary to preserve navigation. It may be comprehensive, or there may be spot dredging where there is localised siltation. It is to be hoped that water plants will, in the longer term, survive and continue to thrive subsequent to dredging. This is especially important with navigable canals that have been notified as SSSI based on their valuable plant communities, such the c.8.4km of the Leeds & Liverpool Canal between Armley Mill through the Kirkstall Valley to Calverley Lodge Swing Bridge (Goulder, 2016). It is also important in canals that are not SSSIs but nevertheless support conservation-worthy aquatic plant communities; for example, parts of the Calder & Hebble Navigation and the Huddersfield Broad Canal. These have valuable plant communities that include the internationally protected *Luronium natans* as well as other important plants such as *Potamogeton epihydrus* and *Potamogeton trichoides* (Goulder, 2012, 2014a, 2015; Goulder & Morphy, 2013).

This report provides information about long- and short-term effects of dredging of navigable canals that are important for plant conservation. These are: (1) the Huddersfield Broad Canal that was dredged in 2002; (2) The Calder & Hebble Navigation between Brighouse and Sowerby Bridge, dredged in 2015-2016; (3) the Dewsbury Arm of the Calder & Hebble Navigation, dredged in 2017-2018 – this length of canal was compared with the adjacent un-dredged main line of canal between Thornhill Double Locks and Thornhill Flood Lock.

3 Methods

Water plants were recorded along discrete lengths of canal. These were fixed at 0.5km when recording in the Huddersfield Broad Canal. The lengths recorded in the Calder & Hebble Navigation were delineated by topographical features, usually locks, and varied between 0.3km and 2.3km, with mean length 1.1km. Recording was by eye from the towing path. Submerged plants were retrieved for identification using a grapnel or a walking pole, extensible to 1.5m, with a hook attached to its end. Emergent plants on the far side were, so far as possible, identified using binoculars. Water plants were defined as those that appear on the JNCC (2005) checklists for native aquatic plants and non-native aquatic vascular plants that occur or are liable to occur in UK canals. There are wetland and riparian plants, that were encountered, but which do not feature on the JNCC checklists; for example, *Asplenium scolopendrium*, *Carex remota*, *Filipendula ulmaria*, *Impatiens glandulifera* and many others. These are not routinely included in the data for aquatic plants that are included herein.

An estimate of the abundance of plants in each length was made. For the 0.5km lengths along the Huddersfield Broad Canal, the percentage whole-channel cover of each species was estimated, using the scale 1=<0.1% cover, 2=0.1-5% cover, and 3=>5% cover. This procedure was developed for use on rivers by Holmes (1983). The abundance of each species in the variable lengths of the Calder & Hebble Navigation was expressed using a truncated three-point DAFOR scale, where d/a=dominant or abundant, f=frequent, and o/r=occasional or rare. This use of the DAFOR scale was based on approximate judgement of abundance. Comparison of the two approaches, however, showed that the categories d/a, f and o/r roughly corresponded to 3, 2 and 1 on the Holmes (1983) scale (Goulder, 2019, pp. 171-172). My use of the DAFOR scale differed from its use by JNCC (2005); the JNCC procedure anticipates that each of five DAFOR values will correspond to a specific estimated range of percentage cover.

To help presentation and interpretation of results, I have separated plants into (1) submerged and floating-leaved plants and (2) emergent plants. It is acknowledged that this is sometimes an arbitrary classification and that many plants overlap, having growth form and morphology that varies in relation to, for example, water depth and time of year. An obvious example is *Sagittaria sagittifolia* which may have extensive underwater ribbon-like leaves, floating leaves and/or emergent arrow-shaped leaves. Another is *Persicaria amphibia* which is sometimes a floating-leaved plant and sometimes an emergent plant. Problems with identification were sometimes encountered. Such a problem was posed by *Eleocharis acicularis*. The underwater, sterile, form of this plant with long fine trailing, septate stems grows in the Dewsbury Arm of the Calder & Hebble Navigation and loose floating material is sometimes found, sparsely, elsewhere in the Calder & Hebble system. I formerly identified this as the submerged form of *Juncus bulbosus* (Goulder, 2014a, 2015) but in June 2018 CRT ecologist Tom King suggested to me that it is *E. acicularis*. Material subsequently sent to BSBI referee Richard Lansdown was confirmed as *E. acicularis*. Plant nomenclature follows Stace (2019).

4 Huddersfield Broad Canal

4.1 Introduction

The Huddersfield Broad Canal extends for c.6km from the River Calder (part of the Calder & Hebble Navigation) at Cooper Bridge to the centre of Huddersfield where it makes an end-on junction with the Huddersfield Narrow Canal. The waterway, which has nine locks, remained open to navigation, with leisure boating replacing commercial traffic from the mid-20th century. Current boat usage is moderate with Lock 2 (Colne Bridge) being operated 490 times in 2017 (CRT, 2018).

The Broad Canal was dredged throughout in 2002 with the work beginning in February (Butterworth, 2002). The dredging complemented the late 20th century restoration of the Huddersfield Narrow Canal (Gibson, 2002) and the re-establishment of a through trans-Pennine navigation route. This report aims to explore long term changes in water plants and aquatic vegetation in the Broad Canal in relation to the 2002 dredging. Plant records from c.20 years before and shortly before dredging are examined and are compared with records from 10 years and 15-16 years after dredging.

4.2 Aquatic plants in the Broad Canal before dredging

The 1981 *Huddersfield Canals Towpath Guide* (Charlesworth, 1981) described the environs of the Broad Canal as a mixture of industry, and post-industrial dereliction, although also in part rural and semi-rural. The Guide describes the canal as having a relatively open channel, depth 1.2-1.5m, kept free of silt by boat traffic. The aquatic flora of the canal was surveyed in summer 1980 by Lucas & Morphy (1985). They recorded water plants at 31 sites at 200m intervals along the whole canal. They found that aquatic plants were diverse and abundant throughout.

They recorded 11 JNCC checklist water plants that are usually found with a submerged or floating-leaved growth form. Three pondweeds (*Potamogeton natans*, *P. berchtoldii* and *P. crispus*) were widely distributed along the canal, as was *Elodea nuttallii* and the duckweeds *Lemna minor* and *L. gibba.* A valuable find was *Luronium natans*, a plant with Europe-wide protection (Preston & Croft, 1997), although it appears to have been relatively sparse, being found at only two of 31 sites. Note, however, that the submerged form of this plant is easily overlooked. The alien *Lagarosiphon major* was found at one site. Lucas & Morphy also recorded 13 emergent JNCC checklist water plants. Of these, *Glyceria maxima* and *Juncus effusus* were most widely distributed, while *Acorus calamus*, *Iris pseudacorus*, *Phalaris arundinacea* and *Sparganium erectum* were frequently encountered. Both *Alisma plantago-aquatica* and *A. lanceolatum* were recorded, the latter being the more widely distributed.

Approaching 20 years later there were two further surveys of aquatic vegetation in the Broad Canal. These were in 1996 for the West Yorkshire local authorities by A R Barker (Ecological Advisory Service, 1996) and in 2000 for British Waterways in anticipation of dredging (Philip Parker Associates, 2001). Abundant and diverse water plants continued to thrive. The 1996 survey found rich submerged/floating-leaved communities with *Elodea canadensis* dominant; also important were, *Ceratophyllum demersum*, *Elodea nuttallii*, *Lemna minor*, *Potamogeton crispus*, *P. natans* and *Stuckenia pectinata* (formerly *Potamogeton pectinatus*). The emergent vegetation was mostly *Glyceria maxima*.

The 2000 survey reported a submerged/floating-leaved flora dominated by relatively few species. These were recognised as plants that are associated with eutrophic waters; i.e. *Callitriche* spp., *Elodea nuttallii*, *Lemna minor*, *Potamogeton natans* and *Sparganium emersum*. The emergent marginal vegetation was dominated by *Glyceria maxima*, but also important were *Sparganium erectum* and *Acorus calamus*. Less abundant were *Alisma lanceolatum*, *Nasturtium officinale* and *Typha latifolia*. It is notable that *Luronium natans* was found to persist in the canal in both the 1996 and 2000 surveys.

The water plants found during the pre-dredging surveys are listed in Table 1. Most of the plants found by Lucas & Morphy in 1980 were still there around 20 years later; that is in 1996 and/or 2000. The only no-longer-found species were the alien submerged plant *Lagarosiphon major* and the emergent plants *Ranunculus sceleratus* and *Solanum dulcamara*. Apparently new submerged/floating-leaved plants were *Azolla filiculoides*, *Ceratophyllum demersum*, and *Sparganium emersum*. New emergent plants were *Equisetum fluviatile* and *Typha latifolia*.

There are also brief accounts of plants in the Broad Canal in July 1997 (Ferguson, 1997) and September 1998 (Tebbutt, 1998) written by British Waterways staff from the perspective of water plants being a hinderance to navigation. They clearly perceived that water plants in

places along the canal were enough to hinder boats. Ferguson (1997) suggested that weed control by harvesting might be appropriate since this would not adversely affect *Luronium natans*. Information from these accounts is not included in Table 1. This is because, although broadly the plants mentioned also feature in the reports of the 1996 and 2000 surveys, interpretation is difficult because some plants are referred to only by their generic name.

4.3 Dredging of the Broad Canal in 2002

The dredging works are described by Butterworth (2002). Prior to dredging the distribution of *Luronium natans* along the Broad Canal was surveyed and mapped by British Waterways' ecologists Karen Butterworth and Jonathan Hart-Woods. The plant had a patchy distribution and was concentrated on shallow marginal shelves, although in places it extended across the channel. Additionally, loose floating plants were frequently observed. During the dredging work several strategies were adopted to conserve this plant.

- Stands of the plant growing on shallow marginal shelf were, as far as possible, left undisturbed.
- On-line reserves for the plant were installed along the off-side of the canal. These were 2m wide and extended to a total length of 490m; they were constructed using wooden posts and vertical 'Nicospan' permeable geotextile curtain. The ends of the reserves were left open to encourage recolonization of the canal.
- Two additional temporary reserves (90m x 1.5m and 36m x 1.5m), bounded by geotextile curtain, were established to conserve two of the larger populations on marginal shelf. These were removed after dredging.
- Plants that formed stands across the channel were collected before dredging began and were transferred to the reserves.
- During dredging, uprooted and disturbed plants were removed from the canal and transferred to the reserves.
- Plants transferred to reserves were encouraged to root by being held down to the silt by weighted loose-weave biodegradable hessian cloth.
- Some dislodged plants were encouraged to root in plastic trays containing silt and water from the canal. Once established the rooted plants, in their trays, were returned to parts of the canal not already occupied by the plant, with the intent that the area of colonisation would be extended.

Measures were also taken to conserve other aquatic plants during dredging. Essentially, areas of 'reed' fringe with high species richness and ecological value were identified and preserved during the dredging work.

Butterworth (2002) reported on the success of the measures taken to conserve *Luronium natans*. It was apparent by the time of her report in September 2002 that plants left undisturbed on marginal shelves had survived the dredging operations. Plants transferred to the on-line reserves had quickly established themselves. Within two months of planting, flowering plants with floating leaves were observed within the reserves. The populations within the two temporary reserves survived the dredging work and soon developed numerous floating leaves and flowers.

It is clear from the September 2002 account that a substantial population of *Luronium natans* had survived dredging. The key to this appears to be that plants survived well in shallow areas that were spared dredging; i.e. on marginal shelfs and in the temporary reserves. In retrospect, it is not clear to what extent the permanent reserves were needed; they were perhaps more an insurance than a necessity. The 2002 report noted that continuing maintenance of the reserves would be needed to keep them free of encroaching emergent plants, to remove rubbish, and prevent shading by tree growth. It was envisaged that, in the long term, gaps might be made in the geotextile curtain to allow *L. natans* to spread back into the canal, or the curtain might be removed.

4.4 Aquatic plants in the Broad Canal subsequent to dredging

Aquatic plants along the Broad Canal were surveyed in June-July 2012 (Goulder, 2012; Goulder & Morphy, 2013). Plants were recorded in twelve 0.5km lengths along the whole canal (Table 2). Ten years after dredging, there were diverse and abundant water plants along the canal. Twelve principally submerged or floating-leaved plants were recorded. *Luronium natans* was found in nine of twelve 0.5km lengths and was recorded as having >5% cover in three of these. Its floating leaves and flowers were often seen growing against the wash wall on the towing path side of the canal. Other submerged/floating-leaved plants that were recorded along much of the canal, and achieved >5% cover in some lengths, were *Elodea nuttallii*, *Potamogeton natans* and *Sparganium emersum*.

Also, in 2012 fifteen emergent aquatic plants were recorded. Amongst these *Glyceria maxima* was found along the whole canal and achieved >5% cover in ten out of twelve lengths. Additionally, *Agrostis stolonifera* and *Oenanthe crocata* were also found in most lengths but were far less abundant, usually having <0.1% cover.

In August 2017, and again in July 2018, five of the 0.5km lengths that had been recorded in 2012 were resurveyed (i.e. 15-16 years after dredging). These were contiguous lengths extending from 25m west of Lock 7 eastwards for 2.5km to Colne Bridge (lengths from 15.5-18km east of Standedge Tunnel in Goulder, 2012). This represents less than half of the canal (c.42%); nevertheless, nine submerged/floating-leaved plants and 12 emergent plants were found (Table 1).

Luronium natans was observed in all five lengths in both years (Table 3). In 2018 its cover was estimated as >5% in one length and as 0.1-5% in three lengths. Rooted plants with underwater rosettes and with floating elliptical leaves were easily seen from the towing path, against the wash wall. In addition, free-floating stolon-linked rosettes, probably dislodged by boats, were to be seen.

Much the most conspicuous submerged/floating leaved plant in 2017 and 2018 was *Elodea nuttallii*. This often occupied much of the channel and was recorded as having >5% cover in all five lengths in 2017 and in four out of five in 2018 (Table 3). The floating leaves of *Potamogeton natans* were also often conspicuous. This plant was recorded in four of five lengths and reached >5% cover in the two most easterly lengths in both 2017 and 2018. The trailing underwater and floating ribbon-like leaves of *Sparganium emersum*, and floating fronds of *Lemna minor*, were also often present. These were observed in all five lengths in both 2017 and 2018 but were never recorded as having >5% cover.

Glyceria maxima was the most abundant amongst marginal emergent plants (Table 3). Although vertical margins often discourage emergent plants, this species readily colonised silt that had accumulated against the wash wall. It was recorded at >5% cover in three of the five lengths in both 2017 and 2018. The second most conspicuous emergent plant was *Sparganium erectum*. This was recorded four lengths in 2017, and in all five lengths in 2018, although it was never recorded as having >5% cover. No other emergent plant was recorded as having >0.1% cover.

4.5 Change in the aquatic vegetation of the Broad Canal 1980-2018

Over the period of nearly 40 years from 1980 to 2018 there has been little change in the species composition of aquatic plants in the Broad Canal. The plants found before dredging from 1980 to 2000 and after dredging in 2012 and 2017-2018 are shown in Table 1. Most plants recorded before dredging were still there afterwards. Especially notable is *Luronium natans*, which continues to thrive. The number of water plants found before and after dredging was much the same; 18 to 25 species were found by the three pre-dredging surveys of 1980, 1996 and 2000, while 27 and 21 species were found by the post-dredging 2012 and 2017-2018 surveys.

Nevertheless, some plants that were found before dredging were not found afterwards. These were the submerged plants *Ceratophyllum demersum*, *Elodea canadensis*, *Lagarosiphon major* and *Potamogeton berchtoldii*, and emergent plants *Myosotis scorpioides* and *Ranunculus sceleratus*. None of these apparent losses is of conservation significance in the sense that none of them are threatened in VC63 South West Yorkshire; i.e. they do not feature on the *Provisional Vascular Plant Red Data List for VC63* (Wilmore, 2013). Indeed, two of them, *E. canadensis* and *Lagarosiphon major*, are aliens. If *P. berchtoldii* is indeed lost this is regrettable, although it is a plant that is easily missed. The loss of *E. canadensis* is probably a reflection of the general trend towards its replacement in Yorkshire canals by the more competitive *E. nuttallii* (Goulder, 2019).

In contrast, some of the plants found after dredging had not been recorded in the earlier surveys. These were the submerged plants *Potamogeton obtusifolius* and *Potamogeton trichoides*, and emergent plants *Agrostis stolonifera*, *Butomus umbellatus* and *Rumex hydrolapathum*. Of these, *P. obtusifolius* and *P. trichoides* were both regarded by Wilmore (2013) as very rare in VC63. It is likely, however, that they are under-recorded in Yorkshire canals. I have elsewhere found *P. obtusifolius* in the New Junction Canal and *P. trichoides* in the Calder & Hebble Navigation, the Leeds & Liverpool Canal and the Knottingley & Goole Canal (Goulder, 2019). The apparent new appearance of *A. stolonifera* is certainly an anomaly because of the survey method. This plant is included as an aquatic on the JNCC checklists for canals but was obviously not considered to be an aquatic plant by the earlier surveyors – it will have been present although it may not have been in its aquatic form. The new appearance of *R. hydrolapathum* is interesting; this plant was described by Lavin & Wilmore (1994) as having a limited distribution in West Yorkshire, centred in the Castleford area. I have found it elsewhere in Yorkshire canals in the Knottingley & Goole Canal, the Leven Canal, the New Junction Canal and the South Yorkshire Navigations (Goulder, 2019) and it may be increasing its range.

Although the species of plants in the Broad Canal were found not to have changed much in response to dredging, the question of whether there was notable change in the abundance and distribution of plants along the canal can be addressed. The records suggest that they

had not greatly changed. Several submerged/floating-leaved plants were widespread and abundant along the canal both before and after dredging; e.g. *Elodea nuttallii*, *Luronium natans* and *Potamogeton natans*. Similarly, *Glyceria maxima* continued to be the dominant emergent plant.

Some of the reserve areas, along the off-side of the canal behind geotextile curtain, were still *in situ* in 2017 and 2018. Three lengths survive; one of c.40m just west of Lock 3 and two lengths of c.50-60m, east of Lock 3. They are entirely occupied by emergent vegetation; mostly *Glyceria maxima* but with some *Impatiens glandulifera*. They may have contributed materially to the survival of *Luronium natans* immediately after dredging but have become irrelevant. Today this plant is doing well, but largely on the opposite, towing path, side of the canal.

5 Calder & Hebble Navigation: Brighouse to Sowerby Bridge

5.1 Introduction

The Calder & Hebble Navigation between Brighouse and Sowerby Bridge comprises c.11km of broad canal. There is a moderate level of boat traffic; Woodside Mills Lock near Elland was used 814 times during 2017 (CRT, 2018). The canal was dredged during winter 2015-2016. This was done mostly before the floods of late December 2015.

The dredging contract (Weatherall, 2015) specified a dredged channel with depth 1.5m over a minimum width of 7m. It was additionally expected that the canal bed would slope from the deep water to a depth of c.50cm against the wash wall on the towing path side and c.30cm on the offside, but with deeper water approaching bridges and locks and at moorings. In places between Brighouse and Elland an un-dredged shelf was to be left at the canal edge to preserve vegetation. These were to include a 2m-wide stand-off along c.400m on the towing path side between Ganny lock and Brookfoot Lock, and a 1m-wide stand-off along c.375m immediately west of Crowther Bridge also on the towing path side.

5.2 Aquatic plants in 2014 – before dredging

Aquatic plants were recorded along the Calder & Hebble Navigation in June 2014 (Goulder, 2014a, 2015). For this purpose, the canal between Brighouse and Sowerby Bridge was divided into 11 unequal lengths (0.3km-2.3km) delineated by topographical features (Table 4). The results of the survey are summarised in Table 5. A wide range of aquatic plants was found; 30 species were recorded. These included 17 submerged or floating-leaved plants and 13 emergent plants. Some plants were more widespread than others. For example, amongst submerged and floating-leaved plants, *Callitriche* sp., *Lemna minor* and *Sagittaria sagittifolia* were found in nine or more canal lengths (out of 11). In contrast 10 plants were found in three or fewer lengths. Similarly, amongst emergent plants, *Glyceria maxima* and *Oenanthe crocata* were found in 10 or more lengths while seven were found in only one or two lengths. The full results from the 2014 survey are given in Table 6.

Submerged and floating-leaved plants were most abundant in Lengths 2 to 4, that is along the 3.2km between Ganny Lock and Park Nook Lock (Table 6). *Callitriche* sp., *Elodea nuttallii*, *Luronium natans*, *Potamogeton natans*, *Sagittaria sagittifolia* and *Sparganium emersum* were recorded as dominant/abundant in one or more of these three lengths. Elsewhere the only other submerged/floating-leaved plant recorded as dominant/abundant

was *S. sagittifolia* in Length 9 (Salterhebble Top Lock to Copley Viaduct). Much the most abundant emergent plant was *Glyceria maxima*. This plant was often conspicuous in the margin and was recorded as dominant/abundant in eight of 10 lengths. No other emergent plant was recorded as dominant/abundant in any length, although *Butomus umbellatus* was frequent in four lengths (1 to 4), *Oenanthe crocata* was frequent in two lengths (5 & 6), and *Typha latifolia* was frequent two lengths (1 & 4).

An important botanical feature of the canal in 2014 was the abundance of *Luronium natans*. This plant was recorded as dominant/abundant along Lengths 3 and 4 (Brookfoot Lock to Cromwell Lock and Cromwell Lock to Park Nook Lock) and as frequent in Length 2 (Ganny Lock to Brookfoot Lock). The water was relatively clear, and the underwater linear-leaved, stolon-linked rosettes could be seen to occupy much of the canal bed (Goulder, 2014a&b, 2015). The elliptic floating leaves were sparse, and flowers were not observed.

Another feature of botanical interest was *Potamogeton epihydrus* which was frequent in Length 10 (Copley Viaduct to Sowerby Bridge Lock) and occasional/rare in Length 9 (Salterhebble Top Lock to Copley Viaduct). This plant, since it was found in the Calder & Hebble and Rochdale canals in 1907, has been regarded as an alien of North American origin (Preston, 1995). More recently (1943-1944) the plant has been discovered in lochans in the Outer Hebrides where it is regarded as a UK native (Preston & Croft, 1997). This is the extent of its European distribution.

5.3 Aquatic plants in 2017 and 2018 – after dredging

Aquatic plants were recorded after dredging, in June-July 2017 and 2018. The results are summarised in Table 5. Much the same aquatic plants were still to be found; overall 24 plants were found in 2017 and 23 in 2018 compared to 30 in 2014.

Taken together, 15 submerged and floating-leaved plants were recorded in 2017 and 2018 compared to 17 in 2014. Plants no longer found were *Azolla filiculoides*, *Chara/Nitella*, *Eleocharis acicularis*, *Lemna trisulca* and *Nuphar lutea*. Gains were *Spirodela polyrhiza* and *Stuckenia pectinata*. The five seemingly-lost plants had all been very sparsely distributed in 2014. None had ever been more than occasional/rare and all but *E. acicularis* had been found in only one length. Furthermore, this latter plant had been found only as loose, floating, fragments that may have originated elsewhere. Some of the submerged/floating-leaved plants were found in fewer lengths after dredging (Table 5). For example: *Callitriche* sp. was found in seven lengths in 2017 and 2018 compared to ten in 2014; *Sagittaria sagittifolia* was found in 5 lengths in 2018 compared to nine in 2014 (although it was in 10 lengths in 2017); *Luronium natans* was found in one length in 2017 and 2018 compared to three in 2014; *Potamogeton natans* was found in one length in 2017 and 2018 compared to four in 2014.

In all, 13 emergent plants were recorded in 2017 and 2018, which is the same number as found in 2014. *Solanum dulcamara* was not found after dredging, but *Caltha palustris* was new (Table 5).

A fuller picture of change in distribution and abundance of plants, subsequent to dredging, is given by comparison of the full data set for 2014 (Table 6) with that for 2017 (Table 7) and 2018 (Table 8). There had clearly been substantial losses of submerged/floating-leaved vegetation along Lengths 2 to 4 (c.3.2 km from Ganny Lock to Park Nook Lock). After

dredging, only *Potamogeton natans* was recorded as dominant/abundant in any of these lengths (i.e. in Length 2 in 2017); it was also frequent in this length in 2018. Otherwise only *Sagittaria sagittifolia* was ever recorded as frequent (in Length 3 in 2017). This was a great contrast to 2014 when *Callitriche* sp., *Elodea nuttallii*, *Lemna minor*, *Luronium natans*, *Potamogeton natans*, *Sagittaria sagittifolia* and *Sparganium emersum* were dominant/abundant or frequent in one or more of these three lengths (Table 6).

There were also decreases shown by emergent plants. After dredging *Glyceria maxima* was recorded as dominant/abundant in only five (2017) or six (2018) lengths compared to eight in 2014 (Tables 6-8). Also notable is that *Butomus umbellatus* was only occasional/rare in lengths 1-4, having been frequent in these four lengths in 2014. Similarly, *Typha latifolia* was no longer frequent in any of the post-dredging lengths.

Changes in emergent plants were especially obvious in some lengths. Emergent flowering clumps of *Butomus umbellatus*, which were a feature of the canal in central Brighouse (Length 1) in June 2014 were no longer there in 2017 and 2018. After dredging this plant was reduced from frequent to occasional/rare status and was found only as loose leaves that may have originated further upstream. In Length 2 there is about 250m of canal immediately east of Camms Mill Bridge where there are steel fishing stages alongside the towing path. In 2014 the marginal vegetation here was 3-4m wide, mainly of *Glyceria maxima*, but also with flowering plants of *B. umbellatus* on its outside edge, and additionally with *Typha latifolia*. This stretch of marginal vegetation was earmarked for conservation during dredging by leaving a 2m un-dredged stand-off. Nevertheless in 2017 and 2018 the marginal vegetation had been reduced to a 1-2m width of *G. maxima* while *T. latifolia* had been lost and *B. umbellatus* survived only sparsely in its trailing underwater form.

The substantial decrease in range and abundance of *Luronium natans* in the canal between Brighouse and Sowerby Bridge is worrying. In both 2017 and 2018, this plant was found only in Length 4 (Cromwell Lock to Park Nook Lock) where it was recorded as occasional/rare. This is a great contrast to 2014, before the canal was dredged, when this plant was dominant/abundant from Brookfoot Lock to Cromwell Lock and from Cromwell Lock to Park Nook Lock, and frequent from Ganny Lock to Brookfoot Lock. The area from which abundant *L. natans* had apparently been lost included the length where a 1m-wide stand off was to be left immediately west of Crowther Bridge.

The meagre 2017 record consisted of three loose, floating, plants of *Luronium natans* that were found on 6 July behind the top gate of Cromwell Lock. These were the underwater form of the plant with rosettes of linear leaves linked by stolons. Two plants consisted of four stolon-linked rosettes and one of two linked rosettes. It is likely that they had been uprooted by a boat and had drifted until held behind the lock gates. CRT ecologist Phillippa Baron and I revisited the site on 13 July and used a grapnel to search for the plant adjacent to Freemans Bridge (c.300m west of Cromwell Lock). The plant had been abundant here in 2014 but we could not find it in 2017. We did on that day, however, find a loose, floating plant of three rosettes against the top gate of Cromwell Lock.

In 2018 *Luronium natans* was again found only in Length 4 (Cromwell Lock to Park Nook Lock). On 14 June four, floating, loose plants of stolon-linked rosettes were found behind the top gate of Cromwell Lock. Additionally, elsewhere in this length, adjacent to Crowther bridge for example, loose shoots were found floating amongst wind-accumulated surface

debris. When, however, grapnel hauls were made adjacent to Freemans Bridge and Crowther Bridge they failed to yield any *L. natans*. The plant appears to have survived dredging, and may have increased between 2017 and 2018, in that more loose plants were found in 2018, but the location of where it survives is not yet established.

It is encouraging that *Potamogeton epihydrus* continued to thrive after dredging. In 2017 and 2018, as in 2014, it was recorded as frequent in Length 10 (Copley Viaduct to Sowerby Bridge Lock 1). Submerged beds of this plant, with abundant submerged ribbon-like leaves and often also with floating elliptic leaves, continued to be in places conspicuous along the edges of the canal.

6 The Dewsbury Arm and adjacent main line of the Calder & Hebble Navigation from Thornhill Double Locks to Thornhill Flood Lock (2014, 2017 & 2018)

6.1 Introduction

The Dewsbury Arm of the Calder & Hebble Navigation extends for c.1.2km from the main line of canal, immediately downstream of Thornhill Double Locks, towards Dewsbury. The arm is less heavily navigated than the main line and potentially provides a refuge for water plants. Water plants in the arm were surveyed in summer 2014 and comparison was made with the plants in c. 2.3km of the main line of canal, from Thornhill Double Locks westward (upstream) to where the navigation re-joins the River Calder at Thornhill Flood Lock (Goulder, 2014a, 2015). These surveys were repeated in summer 2017 (Goulder, 2019). The Dewsbury Arm was dredged in winter 2017-2018 and the arm, and the adjacent un-dredged main line, were again surveyed in summer 2018.

6.2 Aquatic plants in the Dewsbury Arm before dredging (2014 & 2017) and after dredging (2018)

Plants in the Dewsbury Arm were surveyed in late May 2014 (Table 9). Although the water was moderately clear, relatively few submerged/floating-leaved plants were seen. Only seven species were found; *Callitriche* sp. and *Eleocharis acicularis* were frequent while the other five were only occasional/rare. These included the invasive alien *Hydrocotyle ranunculoides*. Three years later, in July 2017, the water was more turbid but even so more submerged/floating-leaved plants were found and they were more abundant (Table 9). Twelve species were found; amongst these *Eleocharis acicularis*, *Elodea nuttallii*, *Hydrocotyle ranunculoides* and *Sparganium emersum* were dominant/abundant, while *Callitriche* sp., *Lemna minor*, *Lemna trisulca* and *Luronium natans* were frequent. It is notable that plants of conservation significance, *L. natans* and *Potamogeton trichoides*, were now recorded. The increase of *Hydrocotyle ranunculoides* was less welcome. Certainly, there appears to have been a substantial increase in diversity and abundance of submerged/floating-leaved plants, although it is possible that this was accentuated by the 2017 recording being on 27 July, whereas recording in 2014 was earlier in the growing season on 30 May.

Emergent plants were diverse and conspicuous along the Dewsbury Arm before dredging. Twelve species were found in both 2014 and 2017. A 2-3m wide marginal stand of largely *Glyceria maxima* along much of the east side of the canal (the towing-path side) was a notable feature. In July 2017 a mass of this plant had been dislodged from the margin, perhaps by boat movements, and had drifted as a floating island that more-or-less blocked

the navigable channel. In 2014 and/or 2017 emergent plants, in addition to *G. maxima*, that were dominant/abundant were *Acorus calamus*, *Alisma lanceolatum*, *Alisma plantago-aquatica* and *Typha latifolia* (Table 9). In addition, *Iris pseudacorus*, *Oenanthe crocata* and *Persicaria amphibia* were frequent in one or both years.

The plan for the dredging of the Dewsbury Arm during winter 2017-2018 (McKeown, 2017) specified a dredged central channel of 7.6m minimum width with a depth of 1.5m. The specification required that a shallow stand-off, width 1-1.5m and depth c.0.5m, be retained along both sides of the channel except at bridges. Water plants along the arm were surveyed in the summer following dredging on 25 June 2018. The number and abundance of submerged/floating-leaved plants were markedly less than recorded the previous summer, although they were much the same as in 2014. In June 2018 only eight submerged/floating-leaved plants were recorded and of these none was dominant/abundant and only *Callitriche* sp. was frequent. *Luronium natans* persisted, sparsely, in the margin. *Potamogeton trichoides* was not re-found.

In June 2018, subsequent to dredging, there had been no reduction in species richness of emergent plants. Fourteen species were recorded, compared to 12 in 2014 and 2017. *Typha angustifolia* was no longer found. I had first seen this plant in 2017 when it formed a stand c.2m x 30m on the west side of the channel. It was perhaps an introduction by water-gardening householders. New finds in 2018 were *Mentha aquatica* and *Ranunculus sceleratus*.

The abundance of emergent vegetation was, however, much reduced in 2018. Marginal emergent vegetation had, to a degree, been preserved and much of it was still relatively species rich, its width, however, was mostly not more than c.1m. In consequence, *Glyceria maxima* was the only emergent plant recorded as dominant/abundant. Nevertheless, *Acorus calamus*, *Alisma lanceolatum*, *Alisma plantago-aquatica*, *Iris pseudacorus*, *Oenanthe crocata* and *Persicaria amphibia* were recorded as frequent.

Thus, the overall impact of recent dredging on the vegetation of the Dewsbury Arm was very evident in June 2018. Notwithstanding this, however, the signs for the preservation of botanical conservation value looked to be good. *Eleocharis acicularis* and *Luronium natans* were sparse but had survived and appeared to be re-establishing in shallow marginal water. The preservation of narrow marginal shelves during dredging had allowed the persistence of a diverse emergent plant community that included interesting mixed stands of *Alisma lanceolatum* and *A. plantago-aquaticum*.

6.3 Aquatic plants in the un-dredged main line of the Calder & Hebble Navigation from Thornhill Double Locks to Thornhill Flood Lock (2014, 2017 & 2018)

It became apparent during the summer 2014 survey of the main line of canal, between Thornhill Double Locks and Thornhill Flood Lock, that this c.2.3km of canal is of substantial plant conservation value (Goulder 2014a, 2015). Species richness, with 19 aquatic plants recorded, was relatively high (Table 9). The water was moderately clear and submerged plants were conspicuous, especially in the less tree-shaded c.1.8km, west of Slaithwaite Bridge. Nine submerged/floating-leaved plants were recorded; amongst these *Callitriche* sp., *Luronium natans* and *Potamogeton trichoides* were dominant/abundant while *Elodea nuttallii* was frequent. *L. natans* and *P. trichoides* were of notable conservation significance. The submerged form of *L. natans* was readily visible through the moderately clear water, and its

floating leaves were also frequently seen. Much of this length has a sheer masonry wash wall that tends to discourage emergent plants. In places, however, there were wide stands of emergent vegetation, notably colonising silt on the towing path side, at the western end, between Schofield Bridge and Long Cut End Viaduct. These were species rich. Ten emergent plants were recorded in 2014 (Table 9); *Glyceria maxima* was dominant/abundant while *Alisma lanceolatum* and *Oenanthe crocata* were frequent.

The records from 2017 and 2018 (Table 9) indicate that, in the absence of dredging, the valuable population of *Luronium natans* continued to be dominant/abundant. Also, amongst submerged and floating-leaved plants, *Callitriche* sp. continued to be dominant/abundant. There had, however, been some change amongst submerged floating-leaved plants. *Potamogeton trichoides* was not found, although it was diligently searched for. *Elodea nuttallii* had increased to the extent that it was recorded as dominant/abundant. Overall, six species of submerged/floating leaved plants were recorded in 2017 and 2018 compared to nine in 2014. The emergent plants, in contrast, showed little change. *Glyceria maxima* continued to be dominant/abundant. The number of emergent plants found was ten in 2017 and eight in 2018 – much the same as the ten found in 2014.

7 Discussion

The Huddersfield Broad Canal continues to be an important site for plant conservation. Plant surveys have shown that species-rich and abundant aquatic vegetation has persisted over nearly 40 years and that the key species *Luronium natans* continues to thrive. This and most other water plants survived the comprehensive dredging of the waterway in 2002. During that operation, extensive steps were taken to ensure the preservation of *L. natans* (Section 4.3) and these were very successful. The provision of on-line marginal reserves for *L. natans* was a success in the short term, in that the plant thrived in the reserves immediately after its transfer to them. The extent to which its long-term regeneration depended upon the reserves is unclear. The project was expensive in terms of input from ecological staff. They were on site throughout, with the dredging contractors, and more than 600 hours of field work were put in by ecologists over the dredging project (Butterworth, 2002). It is perhaps unlikely that such extensive staff resources would be available today.

Post-dredging appraisal of the Calder & Hebble Navigation between Brighouse and Sowerby Bridge is more difficult because relatively little time has passed since the work was done as recently as the winter of 2015-2016. Nevertheless, there are some positive features to be seen. Most of the plants recorded before dredging were still there afterwards. The rare but botanically interesting alien *Potamogeton epihydrus* continued to do well between Copley Viaduct and Sowerby Bridge. A few plants that were formerly present were not re-found in the 2017 and 2018 surveys, but these possible losses were largely of no great conservation significance.

A more significant post-dredging feature is the marked reduction in the abundance of some plants. This is a not unexpected outcome of dredging and it is to be hoped that they will recover in the longer term. The substantial reduction in *Luronium natans* is of obvious concern and it is notable that in 2017 and 2018 it was not yet possible to find rooted plants re-establishing in the margins, even though they were searched for using grapnel hauls. This was so even where the dredging specification had required the retention of a 1m-wide stand-

off, immediately west of Crowther Bridge. It is possible that the dredging work was over-enthusiastic – although the situation in this length may be complicated by the effects of the December 2015 flood event and subsequent restoration works, that included the rebuilding of Crowther Bridge.

The other submerged and floating-leaved plants that were notably reduced in abundance (*Callitriche* sp., *Elodea nuttallii*, *Lemna minor*, *Potamogeton natans*, *Sagittaria sagittifolia* and *Sparganium emersum*) all have the potential to recover in that they survived in the canal albeit they became sparser. Amongst emergent plants that had become less abundant, *Glyceria maxima* survived in considerable quantity and appears to be recovering. Additionally, *Butomus umbellatus*, *Oenanthe crocata* and *Typha latifolia*, although much reduced, survived and are likely to recover, despite being reduced in abundance and more scattered in distribution. Submerged plants of *B. umbellatus* and *G. maxima*, with trailing underwater leaves were also observed, presumably an indication of roots and rhizomes displaced into deeper water by the dredging operation. The, hopefully short term, loss of flowering clumps of *B. umbellatus* from the centre of Brighouse is regrettable. It is also unfortunate that flowering stands of this plant have been lost from the margin on the towing path side on the approach to Camms Mill Bridge where it grew along the front of the *Glyceria* margin. The retention of a 2m-wide stand-off here has conserved a narrow *G. maxima* margin, with its fishing stages, but the more-interesting *B. umbellatus* has become sparse and in 2017 and 2018 was largely represented by the trailing leaves of occasional submerged plants.

Submerged/floating-leaved plants were well represented in the Dewsbury Arm of the Calder & Hebble Navigation in July 2017 before dredging. Twelve species were recorded of which *Eleocharis acicularis*, *Elodea nuttallii*, *Hydrocotyle ranunculoides* and *Sparganium emersum* were dominant or abundant. Indeed, this was a marked increase since 2014, although it has been noted that the 2017 survey was later in the growing season than that in 2014. The increase by the invasive alien *H. ranunculoides* was, obviously, regrettable. When the arm was re-surveyed in June 2018, a few months after dredging, it is unsurprising that submerged and floating-leaved plants were less abundant and some plants found in 2017 were not found in 2018; i.e. *Potamogeton crispus*, *Potamogeton natans*, *Potamogeton trichoides* and *Sparganium emersum*. Nevertheless, it is encouraging that scattered *Luronium natans* was still to be found rooted alongside the margin; the plants were healthy and both the underwater form and plants with floating leaves were present.

It is also relevant that CRT ecologists harvested plants of *Luroniunm natans* from the Dewsbury Arm before dredging. These were grown, rooted in gravel or matting, in tanks and ponds. These plants were re-introduced to the Dewsbury Arm in late June 2018. Although the plant had survived the dredging process, the reintroduction provided additional support for this species.

A valuable conservation-worthy feature of the Dewsbury Arm before dredging was the species rich and abundant community of emergent plants. A striking feature, in both 2014 and 2017, was that *Alisma lanceolatum* and *Alisma plantago-aquatica* were both dominant/abundant and were found growing together in deeper water beyond the *Glyceria*-dominated margin. Also interesting is that *Acorus calamus*, usually a rather sparsely-scattered plant in canals, was dominant/abundant. It is good to record that this community, although somewhat diminished, had largely survived dredging. Probably because of the

stand-off shelves retained along the margin. Thus, 14 species of emergent plants were recorded after dredging, compared to 12 in both 2014 and 2017. Also, although *Glyceria maxima* was the only emergent plant recorded as dominant/abundant in 2018, *A. calamus*, *A. lanceolatum*, *A. plantago-aquatica*, *Iris pseudacorus*, *Oenanthe crocata* and *Persicaria amphibia* were all recorded as frequent.

The plant survey records for the un-dredged main line of the Calder & Hebble Navigation between Thornhill Double Locks and Thornhill Flood Lock are included in this report because this length is, to a degree, a control for the dredged canal between Brighouse and Sowerby Bridge. Both were in 2014 recognised as having substantial plant conservation value. They were species rich and both had significant populations of the key species *Luronium natans* (Goulder, 2014a, 2015). Comparison shows that whereas the vegetation between Brighouse and Sowerby Bridge was much diminished between 2014 and 2017-2018 this was not so between Thornhill Double Locks and Thornhill Flood Lock. Especially notable was the substantial loss of *Luronium natans* along the c.3.2km between Ganny Lock and Park Nook Lock. This is a great contrast to the c.2.3km of canal between Thornhill Double Locks and Thornhill Flood Lock (especially the c.1.8km west of Slaithwaite Bridge) where *Luronium natans* was dominant/abundant in 2014, 2017 and 2018. This emphasises that loss of plants between Brighouse and Sowerby Bridge was caused by dredging rather than other events such as the extreme flood conditions of December 2015. The records for the canal between Thornhill Double Locks and Thornhill Flood Lock do, however, show that, even without dredging, there can be losses of plants of conservation interest. *Potamogeton trichoides* was dominant/abundant in this length in 2014 but was not found in 2017 or 2018.

All in all, the information in this report shows that, when a long view is taken, conservation worthy aquatic plant communities in canals can survive dredging. This may be especially the case when stand-offs are retained, and care is taken to spare valuable marginal communities, as was the case in the Huddersfield Broad Canal. Similar care appears to have been taken in the Dewsbury Arm of the Calder & Hebble Navigation and, even within a few months of dredging, much of the former valuable marginal vegetation, and the key species, were still to be seen. The situation after dredging of the Calder & Hebble Navigation between Brighouse and Sowerby Bridge is more uncertain. It is encouraging that *Potamogeton epihydrus* continues to thrive between Copley Viaduct and Sowerby Bridge Lock 1. Is it possible that dredging here was gentler that the specifications for the work suggest? It has been noted that the substantial reduction in *Luronium natans* between Ganny Lock and Park Nook Lock is worrying, nevertheless this species was sparingly found there in 2017 and 2018, and in the long term there is the potential for recolonization. With hindsight, it is perhaps regrettable that temporary marginal reserves for *L. natans* were not established to protect this plant during the dredging work – given that experience on the Huddersfield Broad Canal had demonstrated their success.

In view of the post-dredging reduction in *Luronium natans*, great care should be taken to conserve this plant where it continues to thrive in the un-dredged canal between Thornhill Double Locks and Thornhill Flood Lock. Ideally, this length should not be dredged until it can be shown that the plant has recovered between Ganny Lock and Park Nook Lock. Furthermore, if dredging is unavoidable, the dredging process might be gentler than that employed between Ganny Lock and Park Nook Lock. Spot dredging might be employed, and wider shallow marginal shelves might be retained. Locations where the plant is abundant

should be identified before dredging. Ideally, these should, so far as possible, be avoided when the dredging takes place, and the use of temporary reserves might be considered.

8 References

Anon. (2008) *Britain's Inland Waterways: Balancing the Needs of Navigation and Aquatic Wildlife.* Inland Waterways Advisory Council, London.

Butterworth K (2002) *Huddersfield Broad Canal Dredging: Report on Work Carried Out Under DEFRA Licence Number WLF018450, with Respect to Floating-leaved Water Plantain (*Luronium natans*).* British Waterways, North East Region, Leeds.

CRT (2018) *Annual Lockage Report 2017.* https://canalrivertrust.org.uk/media/original/35365-annual-lockage-report-2017.pdf?v=939805.

Charlesworth D (ed.) (1981) *The Huddersfield Canals Towpath Guide*. Huddersfield Canal Society, Huddersfield.

Ecological Advisory Service (1996) *Second Tier Sites of Ecological Importance in West Yorkshire: Sir John Ramsden Canal.* West Yorkshire Joint Services, Bradford.

Ferguson CM (1997) *Site Visit to Huddersfield Broad Canal*. Environmental and Scientific Services, File Note, Waterway Conservation & Regeneration, British Waterways, Gloucester.

Gibson K (2002) *Pennine Dreams: The Story of the Huddersfield Narrow Canal*. Tempus Publishing, Stroud.

Goulder R (2012) *Aquatic Plants in the Huddersfield Canals in 2012 and Change Since 1978-1985.* A report for the Canal and River Trust, Leeds.

Goulder R (2014a) *Aquatic Plants in Canal Lengths of the Calder & Hebble Navigation, May-June 2014*. A report for the Canal and River Trust, Leeds.

Goulder R (2014b) Positive news of Floating Water-plantain in the Calder & Hebble Navigation. *The Naturalist* 139, 220.

Goulder R (2015) Aquatic plants in the Calder & Hebble Navigation: distribution and conservation value. *The Naturalist* 140, 165-177.

Goulder R (2016) Freshwater plants and SSSI canals in the East Midlands and North of England 1: Leeds & Liverpool Canal and Huddersfield Narrow Canal. *The Naturalist* 141, 169-185.

Goulder R (2019) *Canals, Plants and People: a Yorkshire Perspective.* PLACE, York.

Goulder R & Morphy MJ (2013) The response of aquatic plants to restoration and continuity of navigation in canals: the example of the Huddersfield canals. *BSBI News* 124, 7-15.

Holmes NTH (1983) *Focus on Nature Conservation No. 4: Typing British Rivers According to their Flora.* Nature Conservancy Council, Shrewsbury.

JNCC (2005) *Common Standards Monitoring Guidance for Canals*. Joint Nature Conservation Committee, Peterborough.

Lavin JC & Wilmore GTD (1994) *The West Yorkshire Plant Atlas*. City of Bradford Metropolitan Council, Bradford.

Lucas MJ & Morphy MJ (1985) The larger plants of the Huddersfield Broad Canal. *Bulletin of the Yorkshire Naturalists' Union* 3, 3-8.

Mc Keown L (2017) *National Dredging Contract: Dewsbury Arm (Calder and Hebble) Dredging*. CRT, Leeds.

Philip Parker Associates (2001) *Huddersfield Broad Canal: Aspley Basin to the River Calder. Initial Ecological Survey.* A report by Philip Parker Associates, Coleshill, Wiltshire for British Waterways, Leeds.

Preston CD (1995) *Pondweeds of Great Britain and Ireland*. BSBI, London.

Preston CD & Croft JM (1997) *Aquatic Plants in Britain and Ireland*. Harley Books, Colchester.

Stace CA (2019) *New Flora of the British Isles.* 4th edition. C & M Floristics, Middlewood Green, Suffolk.

Tebbutt SA (1998) *Huddersfield Broad Site Visit – 7 September*. Environmental and Scientific Services, File Note, Waterway Conservation & Regeneration, British Waterways, Gloucester.

Weatherall M (2015) *National Dredging Contract (Draft): North East, Calder & Hebble Navigation, CA-001 to CA-011. Drawing No. P/09054/a.* Canal & River Trust and Land & Water Services, Newark.

Wilmore GTD (2013) A provisional vascular plant red data list for VC63 – an evaluation of current status. *The Naturalist* 138, 18-31.

Table 1. JNCC Aquatic plants recorded in the Huddersfield Broad Canal before and after dredging in 2002

	Survey date				
	1980[1]	1996[2]	2000[3]	2012[4]	2017 & 2018[5]
Submerged and floating-leaved plants					
Azolla filiculoides Water Fern	0	+	0	+	+
Callitriche spp. Water-starworts	+	+	+	+	+
Ceratophyllum demersum Rigid Hornwort	0	+	0	0	0
Chara/Nitella Stonewort	+	0	+	+	+
Elodea canadensis Canadian Waterweed	+	+	0	0	0
Elodea nuttallii Nuttall's Waterweed	+	+	+	+	+
Lagarosiphon major Curly Waterweed	+	0	0	0	0
Lemna gibba Fat Duckweed	+	+	0	0	+
Lemna minor Common Duckweed	+	+	+	+	+
Luronium natans Floating Water-plantain	+	+	+	+	+
Potamogeton berchtoldii Small Pondweed	+	+	0	0	0
Potamogeton crispus Curled Pondweed	+	+	+	+	0
Potamogeton natans Broad-leaved Pondweed	+	+	+	+	+
Potamogeton obtusifolius Blunt-leaved Pondweed	0	0	0	+	0
Potamogeton trichoides Hairlike Pondweed	0	0	0	+	0
Sparganium emersum Unbranched Bur-reed	0	+	+	+	+
Stuckenia pectinata Fennel Pondweed	0	+	0	+	0
Number of submerged and floating-leaved plants	11	13	8	12	9
Emergent plants					
Acorus calamus Sweet-flag	+	+	+	+	+
Agrostis stolonifera Creeping Bent	0	0	0	+	+
Alisma lanceolatum Narrow-leaved Water-plantain	+	+	+	+	+
Alisma plantago-aquatica Water-plantain	+	+	0	+	0
Butomus umbellatus Flowering-rush	0	0	0	+	0
Equisetum fluviatile Water Horsetail	0	+	0	+	+
Glyceria maxima Reed Sweet-grass	+	+	+	+	+
Iris pseudacorus Yellow Iris	+	+	+	+	+
Juncus effusus Soft-rush	+	+	+	+	+
Myosotis scorpioides Water Forget-me-not	+	+	0	0	0
Nasturtium officinale Water-cress	+	+	+	+	0
Oenanthe crocata Hemlock Water-dropwort	+	+	+	+	+
Phalaris arundinacea Reed Canary-grass	+	+	+	+	+
Ranunculus sceleratus Celery-leaved Buttercup	+	0	0	0	0
Rumex hydrolapathum Water Dock	0	0	0	0	+
Solanum dulcamara Bittersweet	+	0	0	+	0
Sparganium erectum Branched Bur-reed	+	+	+	+	+
Typha latifolia Bulrush	0	0	+	+	0
Veronica beccabunga Brooklime	0	0	0	0	+
Number of emergent plants	13	12	10	15	12
Total number of plants	24	25	18	27	21

Records from: [1]Lucas & Morphy (1985); [2] Ecological Advisory Service (1996); [3]Philip Parker Associates (2001); [4]Goulder (2012) and Goulder & Morphy (2013); [5]Goulder (unpublished) – the 2017-2018 surveys covered only 2.5km of canal from near Lock 10 to Colne Bridge (five lengths from 15.5-18km east of Standedge Tunnel in Goulder, 2012). +=present, 0=not recorded.

Table 2. Distribution of aquatic plants along the Huddersfield Broad Canal, June-July 2012

	Approximate distance (km) eastwards from Lock 1E (i.e. the junction of the Broad and Narrow canals)											
	0-0.5*	0.5-1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6
Submerged and floating-leaved plants												
Azolla filiculoides	0	1	0	1	1	1	0	0	0	0	0	0
Callitriche sp.	1	1	1	1	1	1	1	1	1	1	1	1
Chara/Nitella	0	1	1	1	0	1	1	1	0	0	0	0
Elodea nuttallii	3	3	2	3	2	3	2	2	1	3	2	2
Lemna minor	1	1	1	1	1	1	1	1	1	1	1	2
Luronium natans	0	0	0	1	1	1	2	3	3	1	3	2
Potamogeton crispus	2	2	2	1	1	1	1	1	1	0	2	1
Potamogeton natans	0	3	3	3	3	2	1	0	2	3	3	2
Potamogeton obtusifolius	0	1	0	0	0	0	0	1	0	0	0	0
Potamogeton trichoides	1	1	1	1	1	0	1	1	1	0	1	0
Sparganium emersum	1	1	0	1	2	0	1	3	3	2	2	2
Stuckenia pectinata	0	0	1	1	0	0	0	0	0	0	0	0
Number of submerged and floating-leaved plants	6	10	8	11	9	8	9	9	8	6	8	7
Emergent plants												
Acorus calamus	0	0	0	1	0	0	0	0	1	0	2	0
Agrostis stolonifera	1	1	1	1	1	1	1	1	1	0	0	1
Alisma lanceolatum	0	0	0	1	0	0	0	0	1	0	2	1
Alisma plantago-aquatica	0	1	1	1	0	0	0	0	1	0	0	0
Butomus umbellatus	1	0	0	0	0	0	0	0	0	0	0	0
Equisetum fluviatile	0	1	0	0	0	0	0	0	0	0	0	0
Glyceria maxima	1	3	3	2	3	3	3	3	3	3	3	3
Iris pseudacorus	1	0	0	0	0	0	0	0	0	0	0	0
Juncus effusus	0	0	0	0	0	0	1	0	0	0	0	1
Nasturtium officinale	0	0	0	0	0	1	0	0	0	0	0	0
Oenanthe crocata	1	1	1	1	1	2	1	1	1	1	2	1
Phalaris arundinacea	0	0	0	0	0	0	1	0	0	0	0	0
Solanum dulcamara	0	0	0	1	0	0	0	0	0	0	0	0
Sparganium erectum	1	0	0	0	0	0	2	0	2	0	2	1
Typha latifolia	0	0	0	0	1	0	0	0	0	0	0	2
Number of emergent plants	6	5	4	7	4	4	6	3	7	2	5	7
Total number of plants	12	15	12	18	13	12	15	12	15	8	13	14

Abundance scores: 1=<0.1% cover, 2=0.1-5% cover, 3=>5% cover (shaded), 0=not recorded. *Includes Aspley Basin.

Table 3. Aquatic plants along 3.5km of the Huddersfield Broad Canal: July 2012, August 2017 and July 2018

	Approximate distance (km) eastwards from Lock 1E (i.e. the junction of the Broad and Narrow canals)															
	July 2012						August 2017						July 2018			
Length	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5		3-3.5	3.5-4	4-4.5	4.5-5	5-5.5		3-3.5	3.5-4	4-4.5	4.5-5	5-5.5
Submerged and floating-leaved plants																
Azolla filiculoides	0	0	0	0	0		0	0	0	0	0		1	0	0	0	0
Callitriche sp.	1	1	1	1	1		1	1	1	1	0		1	1	1	1	0
Chara/Nitella	1	1	0	0	0		1		0	0	0		0	1	0	0	0
Elodea nuttallii	2	2	1	3	2		3	3	3	3	3		3	3	3	2	3
Lemna gibba	0	0	0	0	0		0	0	0	0	0		1	1	1	1	1
Lemna minor	1	1	1	1	1		2	2	2	2	2		1	1	1	1	1
Luronium natans	2	3	3	1	3		1	1	1	1	2		2	2	2	1	3
Potamogeton crispus	1	1	1	0	2		0	0	0	0	0		0	0	0	0	0
Potamogeton natans	1	0	2	3	3		1	0	2	3	3		1	0	1	3	3
Potamogeton obtusifolius	0	1	0	0	0		0	0	0	0	0		0	0	0	0	0
Potamogeton trichoides	1	1	1	0	1		0	0	0	0	0		0	0	0	0	0
Sparganium emersum	1	3	3	2	2		1	2	2	1	2		1	2	2	1	2
Number of submerged and floating-leaved plants	9	9	8	6	8		7	5	6	6	5		8	7	7	7	6
Emergent plants																
Acorus calamus	0	0	1	0	2		0	0	1	0	1		0	0	1	1	1
Agrostis stolonifera	1	1	1	0	0		1	1	1	1	1		1	1	1	1	1
Alisma lanceolatum	0	0	1	0	2		0	0	0	0	1		0	0	0	0	1
Alisma plantago-aquatica	0	0	1	0	0		0	0	0	0	0		0	0	0	0	0
Equisetum fluviatile	0	0	0	0	0		0	0	0	0	0		0	0	0	0	1
Glyceria maxima	3	3	3	3	3		3	3	2	2	3		2	3	3	2	3
Iris pseudacorus	0	0	0	0	0		0	0	1	0	0		0	0	1	0	0
Juncus effusus	1	0	0	0	0		1	1	1	0	0		1	1	1	0	0
Oenanthe crocata	1	1	1	1	2		1	1	1	1	1		1	1	1	1	2
Phalaris arundinacea	1	0	0	0	0		0	0	0	0	0		1	1	0	0	0
Rumex hydrolapathum	0	0	0	0	0		0	1	0	0	0		0	0	0	0	0
Sparganium erectum	2	0	2	0	2		2	0	2	1	2		2	1	1	1	2
Veronica beccabunga	0	0	0	0	0		1	0	0	0	0		0	0	0	0	0
Number of emergent plants	6	3	7	2	5		6	5	7	4	6		6	6	7	5	7
Total number of plants	15	12	15	8	13		13	10	13	10	11		14	13	14	12	13

1=<0.1% whole-channel cover; 2=0.1-5% cover; 3 (with infill) =>5% cover, 0=not recorded.

Table 4. Calder & Hebble Navigation; Canal lengths surveyed between Brighouse and Sowerby Bridge, 2014, 2017 and 2018

(1) Brighouse Bottom Lock to Ganny Lock (c.1.1km)
(2) Ganny Lock to Brookfoot Lock (c.0.8km)
(3) Brookfoot Lock to Cromwell Lock (c.0.6km)
(4) Cromwell Lock to Park Nook Lock (c.1.8km)
(5) Park Nook Lock to Elland Lock (c.0.4km)
(6) Elland Lock to Woodside Mills Lock (c.1.3km)
(7) Woodside Mills Lock to Long Lees Lock (c.0.5km)
(8) Long Lees Lock to Salterhebble Top Lock (c.0.8km)
(9) Salterhebble Top Lock to Copley Viaduct (c.1.2km)
(10) Copley Viaduct to Sowerby Bridge Lock 1 (c.2.3km)
(11) Sowerby Bridge Lock 1 to Tuel Lane Tunnel portal (c.0.3km)

Table 5. The number of canal lengths (out of 11) in which aquatic plants were recorded in the Calder & Hebble Navigation between Brighouse Bottom Lock and Sowerby Bridge, in June-July, before dredging (2014) and after dredging (2017 & 2018)

	2014	2017	2018
Submerged and floating-leaved plants			
Azolla filiculoides	1	0	0
Callitriche sp.	10	7	7
Chara/Nitella sp.	1	0	0
Eleocharis acicularis	2	0	0
Elodea nuttallii	5	3	2
Fontinalis antipyretica	5	6	3
Lemna gibba	1	1	0
Lemna minor	11	10	7
Lemna trisulca	1	0	0
Luronium natans	3	1	1
Nuphar lutea	1	0	0
Potamogeton berchtoldii	0	0	1
Potamogeton crispus	2	0	1
Potamogeton epihydrus	2	2	2
Potamogeton natans	4	1	1
Potamogeton pusillus	1	1	0
Sagittaria sagittifolia	9	10	5
Sparganium emersum	7	7	5
Spirodela polyrhiza	0	0	2
Stuckenia pectinata	0	1	0
Number of submerged and floating-leaved plants recorded	17	12	12
Emergent plants			
Agrostis stolonifera	8	9	9
Alisma lanceolatum	1	0	1
Butomus umbellatus	4	4	4
Caltha palustris	0	1	0
Glyceria maxima	10	10	11
Iris pseudacorus	4	4	3
Juncus effusus	2	5	5
Mentha aquatica	1	2	3
Oenanthe crocata	11	10	9
Persicaria amphibia	2	1	1
Phalaris arundinacea	2	2	1
Ranunculus sceleratus	1	1	0
Solanum dulcamara	1	0	0
Typha latifolia	6	3	6
Number of emergent plants recorded	13	12	11
Total number of plants recorded	30	24	23

Table 6. Aquatic plants in the Calder & Hebble Navigation between Brighouse and Sowerby Bridge in 2014 (before dredging)

	Length										
	1	2	3	4	5	6	7	8	9	10	11
Submerged and floating-leaved plants											
Azolla filiculoides	0	0	0	0	0	0	o/r	0	0	0	0
Callitriche sp.	o/r	f	o/r	d/a	o/r	o/r	o/r	o/r	o/r	o/r	0
Chara/Nitella	0	0	0	0	0	o/r	0	0	0	0	0
Eleocharis acicularis	0	0	0	0	0	0	0	0	o/r	o/r	0
Elodea nuttallii	0	d/a	o/r	f	o/r	o/r	0	0	0	0	0
Fontinalis antipyretica	0	0	o/r	o/r	0	0	o/r	0	0	o/r	o/r
Lemna gibba	0	0	0	0	0	0	0	0	0	o/r	0
Lemna minor	o/r	o/r	o/r	f	o/r	o/r	o/r	o/r	o/r	o/r	o/r
Lemna trisulca	0	0	o/r	0	0	0	0	0	0	0	0
Luronium natans	0	f	d/a	d/a	0	0	0	0	0	0	0
Nuphar lutea	0	0	0	0	0	o/r	0	0	0	0	0
Potamogeton crispus	0	0	0	0	0	o/r	0	0	0	o/r	0
Potamogeton epihydrus	0	0	0	0	0	0	0	0	o/r	f	0
Potamogeton natans	o/r	d/a	f	o/r	0	0	0	0	0	0	0
Potamogeton pusillus	0	0	0	0	0	0	0	0	o/r	0	0
Sagittaria sagittifolia	o/r	o/r	o/r	d/a	o/r	f	0	o/r	d/a	f	0
Sparganium emersum	f	0	0	d/a	o/r	0	o/r	o/r	o/r	f	0
Number of submerged and floating-leaved plants	5	6	8	8	5	7	5	4	7	9	2
Emergent plants											
Agrostis stolonifera	o/r	o/r	0	o/r	0	o/r	o/r	o/r	f	o/r	0
Alisma lanceolatum	0	0	0	0	0	0	0	0	0	o/r	0
Butomus umbellatus	f	f	f	f	0	0	0	0	0	0	0
Glyceria maxima	d/a	d/a	d/a	d/a	d/a	d/a	d/a	0	d/a	f	f
Iris pseudacorus	o/r	o/r	0	o/r	0	0	0	0	0	o/r	0
Juncus effusus	0	0	0	0	0	0	0	0	0	o/r	o/r
Mentha aquatica	0	0	0	0	0	0	0	0	o/r	0	0
Oenanthe crocata	o/r	o/r	o/r	o/r	f	f	o/r	o/r	o/r	o/r	o/r
Persicaria amphibia	0	0	0	o/r	0	0	0	0	0	o/r	0
Phalaris arundinacea	0	o/r	0	o/r	0	0	0	0	0	0	0
Ranunculus sceleratus	0	0	0	0	0	0	0	0	0	0	o/r
Solanum dulcamara	o/r	0	0	0	0	0	0	0	0	0	0
Typha latifolia	f	o/r	o/r	f	o/r	0	0	0	0	o/r	0
Number of emergent plants	7	7	4	8	3	3	3	2	4	8	4
Total number of plants	12	13	12	16	8	10	8	6	11	17	6

d/a (infilled)=dominant or abundant, f=frequent, o/r=occasional or rare, 0=not recorded

Table 7. Aquatic plants in the Calder & Hebble Navigation between Brighouse and Sowerby Bridge in 2017 (after dredging)

	Length										
	1	2	3	4	5	6	7	8	9	10	11
Submerged and floating-leaved plants											
Callitriche sp.	0	0	o/r	o/r	0	o/r	o/r	o/r	o/r	o/r	0
Elodea nuttallii	0	o/r	0	0	0	0	0	o/r	o/r	0	0
Fontinalis antipyretica	0	0	o/r	o/r	0	o/r	o/r	o/r	0	0	o/r
Lemna gibba	0	0	0	0	0	0	0	0	0	0	o/r
Lemna minor	0	o/r	o/r	o/r	o/r	o/r	o/r	o/r	o/r	o/r	o/r
Luronium natans	0	0	0	o/r	0	0	0	0	0	0	0
Potamogeton epihydrus	0	0	0	0	0	0	0	0	o/r	f	0
Potamogeton natans	0	d/a	0	0	0	0	0	0	0	0	0
Potamogeton pusillus	0	0	0	0	0	0	0	0	o/r	0	0
Sagittaria sagittifolia	o/r	o/r	f	o/r	o/r	f	o/r	o/r	f	o/r	0
Sparganium emersum	0	0	o/r	f	0	f	d/a	f	d/a	f	0
Spirodela polyrhiza	0	0	0	0	0	0	0	0	0	0	0
Stuckenia pectinata	0	o/r	0	0	0	0	0	0	0	0	0
Number of submerged and floating-leaved plants	1	5	5	6	2	5	5	6	7	5	3
Emergent plants											
Agrostis stolonifera	o/r	o/r	0	o/r	o/r	o/r	o/r	o/r	o/r	f	0
Butomus umbellatus	o/r	o/r	o/r	o/r	0	0	0	0	0	0	0
Caltha palustris	0	0	0	0	0	0	0	0	0	o/r	0
Glyceria maxima	d/a	d/a	d/a	d/a	d/a	f	o/r	o/r	f	f	0
Iris pseudacorus	o/r	o/r	0	o/r	0	0	0	0	0	o/r	0
Juncus effusus	0	o/r	0	o/r	o/r	o/r	0	0	0	o/r	0
Mentha aquatica	0	0	0	0	0	o/r	0	0	o/r	0	0
Oenanthe crocata	o/r	o/r	o/r	o/r	o/r	f	0	o/r	o/r	o/r	o/r
Persicaria amphibia	0	0	0	o/r	0	0	0	0	0	0	0
Phalaris arundinacea	0	o/r	0	o/r	0	0	0	0	0	0	0
Ranunculus sceleratus	0	0	0	0	0	0	0	0	0	o/r	0
Typha latifolia	o/r	0	0	o/r	o/r	0	0	0	0	0	0
Number of emergent plants	6	7	3	9	5	5	2	3	4	7	1
Total number of plants	7	12	8	15	7	10	6	9	11	12	4

d/a (infilled)=dominant or abundant, f=frequent, o/r=occasional or rare, 0=not recorded.

Table 8. Aquatic plants in the Calder & Hebble Navigation between Brighouse and Sowerby Bridge in 2018 (after dredging)

	Length										
	1	2	3	4	5	6	7	8	9	10	11
Submerged and floating-leaved plants											
Callitriche sp.	0	0	0	o/r	o/r	o/r	o/r	o/r	o/r	o/r	0
Elodea nuttallii	0	o/r	0	0	0	0	0	o/r	0	0	0
Fontinalis antipyretica	0	0	0	o/r	0	o/r	0	0	0	0	o/r
Lemna minor	o/r	o/r	0	o/r	0	0	0	o/r	o/r	o/r	o/r
Luronium natans	0	0	0	o/r	0	0	0	0	0	0	0
Potamogeton berchtoldii	0	0	0	0	0	0	0	0	0	o/r	0
Potamogeton crispus	0	0	0	0	0	0	0	0	0	o/r	0
Potamogeton epihydrus	0	0	0	0	0	0	0	0	o/r	f	0
Potamogeton natans	0	f	0	0	0	0	0	0	0	0	0
Sagittaria sagittifolia	0	o/r	0	o/r	0	o/r	0	0	d/a	f	0
Sparganium emersum	0	0	0	o/r	0	0	d/a	f	d/a	f	0
Spirodela polyrhiza	0	0	0	0	0	0	0	o/r	o/r	0	0
Number of submerged and floating-leaved plants	1	4	0	6	1	3	2	5	6	7	2
Emergent plants											
Agrostis stolonifera	0	o/r	o/r	o/r	0	o/r	o/r	o/r	o/r	o/r	o/r
Alisma lanceolatum	0	0	0	0	0	0	0	0	0	o/r	0
Butomus umbellatus	o/r	o/r	o/r	o/r	0	0	0	0	0	0	0
Glyceria maxima	d/a	d/a	d/a	f	d/a	d/a	f	o/r	d/a	f	o/r
Iris pseudacorus	0	o/r	0	o/r	0	o/r	0	0	0	0	0
Juncus effusus	o/r	o/r	0	0	o/r	o/r	0	0	0	o/r	0
Mentha aquatica	o/r	o/r	0	0	0	0	0	0	o/r	0	0
Oenanthe crocata	f	o/r	o/r	o/r	o/r	o/r	0	o/r	o/r	o/r	0
Persicaria amphibia	0	0	0	o/r	0	0	0	0	0	0	0
Phalaris arundinacea	0	0	0	o/r	0	0	0	0	0	0	0
Typha latifolia	o/r	0	o/r	o/r	o/r	o/r	0	0	0	o/r	0
Number of emergent plants	6	7	5	8	4	6	2	3	4	6	2
Total number of plants	7	11	5	14	5	9	4	8	10	13	4

d/a (infilled)=dominant or abundant, f=frequent, o/r=occasional or rare, 0=not recorded.

Table 9. Aquatic plants in the Dewsbury Arm and between Thornhill Double Locks and Thornhill Flood Lock; 2014, 2017 and 2018

	Dewsbury Arm			**Thornhill Double Locks to Thornhill Flood Lock**		
	2014	**2017**	**2018***	**2014**	**2017**	**2018**
Submerged and floating-leaved plants						
Callitriche sp.	f	f	f	d/a	d/a	d/a
Eleocharis acicularis	f	d/a	o/r	o/r	0	0
Elodea nuttallii	o/r	d/a	o/r	f	o/r	d/a
Hydrocotyle ranunculoides	o/r	d/a	o/r	0	f	f
Lemna gibba	0	0	0	0	o/r	o/r
Lemna minor	o/r	f	o/r	o/r	f	f
Lemna trisulca	o/r	f	o/r	o/r	0	0
Luronium natans	0	f	o/r	d/a	d/a	d/a
Potamogeton crispus	0	o/r	0	o/r	0	0
Potamogeton natans	0	o/r	0	0	0	0
Potamogeton trichoides	0	o/r	0	d/a	0	0
Sagittaria sagittifolia	0	o/r	o/r	0	0	0
Sparganium emersum	o/r	d/a	0	o/r	0	0
Number of submerged and floating-leaved plants	7	12	8	9	6	6
Emergent plants						
Acorus calamus	d/a	d/a	f	o/r	0	0
Agrostis stolonifera	o/r	f	o/r	o/r	o/r	o/r
Alisma lanceolatum	d/a	d/a	f	f	o/r	o/r
Alisma plantago-aquatica	d/a	d/a	f	0	0	0
Glyceria maxima	d/a	d/a	d/a	d/a	d/a	d/a
Iris pseudacorus	f	o/r	f	o/r	o/r	o/r
Juncus effusus	o/r	o/r	o/r	0	0	0
Mentha aquatica	0	0	o/r	0	o/r	0
Oenanthe crocata	f	f	f	f	o/r	f
Persicaria amphibia	f	f	f	0	0	0
Phalaris arundinacea	f	o/r	o/r	o/r	o/r	o/r
Ranunculus sceleratus	0	0	o/r	o/r	0	0
Solanum dulcamara	o/r	0	o/r	0	o/r	0
Sparganium erectum	0	0	0	o/r	o/r	o/r
Typha angustifolia	0	o/r	0	0	0	0
Typha latifolia	d/a	f	o/r	o/r	o/r	o/r
Number of emergent plants	12	12	14	10	10	8
Total number of plants	19	24	22	19	16	14

*The Dewsbury Arm was dredged in winter 2017-2018.

d/a (infilled)=dominant or abundant, f=frequent, o/r=occasional or rare, 0=not recorded.