Introduction

An aquatic macrophyte survey of the Montgomery Canal Reserves was carried out from 27 June to 1 July, 2003. The survey assessed the present status of the aquatic and bankside plants within seven reserves. These were:

- The Weston Arm, grid reference SJ 369 311, 100 linear metres
- Rednal Basin, grid reference SJ 351 278
- Aston Locks Nature Reserve, grid reference SJ 336264
- Guilsfield Arm, grid reference SJ 252 148 to SJ 243 137, approximately 1600 linear metres
- Wern Reserve, grid reference SJ 252 141
- Whitehouse Bridge Reserve, grid reference SJ 223 061
- Brithdir Reserve, grid reference SJ 200 023

The first three reserves are in England and the remaining four are in Wales. All the reserves are thus geographically spaced along the canal starting at the junction with the Llangollen Canal at Lower Frankton, Shropshire and ending at the Brithdir Reserve approximately 6 kilometres south west of Welshpool. The reserves attempt to encapsulate the flora found in that section of the canal and overall be representative of the canal flora found throughout its length. A previous survey of the canal flora was undertaken in September, 2001 and the reserve survey has several objectives. First the condition of each reserve is to be assessed from the flora found comparing each reserve with historical data and consideration given as to whether or not the management of each reserve and the water quality is appropriate for conserving the intended flora. The second is to compare the flora of the canal with that found in the seven side reserves and discuss the effectiveness of the reserves in conserving a representative cross section of that flora. Thirdly to address any shortfall in the present geographical cover of the reserves as intended representatives of the present flora found within the canal. Fourthly to consider the most effective design for any future reserve.

Background

The Montgomery Canal at present extends from Frankton Junction (NGR SJ 371 317) to just south of Freestone Lock (SO 137 927) near to Newtown. It is part navigable, in part a remainder canal in water with a disused section between Gronwyn Bridge (SJ 305 246) and the Old Railway Bridge (SJ 271 214), Llanymynech. The total in-water length is 48 km with 12 km in England and 36 km in Wales. At present there are navigable sections in England from the junction with the Llangollen Canal (Shropshire Union Canal) at Lower Frankton (NGR SJ 371 317) to Queens Head (SJ 338 268). In Wales, there is a further section used by narrow boats from Burgedin Locks, near Wern (SJ 252 146) to Berriew (SJ 190 008) a few miles south of Welshpool. Sections not open to navigation and in water have exceptional wildlife value. Of particular importance is the aquatic and bankside flora. The canal is a Site of Special Scientific Interest (SSSI) mainly for its flora a kilometre north of Rednal (SJ 351 287) to Maesbury Marsh (SJ 310 249) in England and from Llanymynech (SJ 273 216) just in England to Newtown in Wales. The Welsh section is internationally important for floating water plantain *Luronium natans* and as such is a Candidate Special Area of Conservation (cSAC).

Over the last thirty years sections of the Montgomery Canal have been restored to navigation. The restoration is ongoing with works currently being undertaken on sections of the canal and its structures. It is due to be completely restored to navigation over the next few years. It is important that the restoration is carried out in a manner sympathetic to the flora and animal life of the canal. A number of surveys have been carried out notably in 1988 and 1997 resulting in a comprehensive species list for the canal. A full survey was undertaken in September 2001 giving both a comprehensive species list and abundance assessments for the flora found in or by the canal. Such an assessment was thought necessary to inform the process of restoration and after use of the canal but it also serves as a useful measure against which the seven side reserves can be assessed for their effectiveness in representing the flora of the canal as a whole.

Methodology

The survey was undertaken between 27 June and 1 July 2003. It was restricted to the reserve and its margins and the methodology provides a detailed assessment of the distribution and abundance of this flora. At the Whitehouse Bridge reserve part of the canal was also surveyed as this served as the inflow to the reserve and was a backwater to the main channel. All assessments of the flora were made from the towpath (where present) or bankside. The Whitehouse Bridge Reserve was also surveyed using a boat. The bankside flora and the visible aquatic vegetation within the "channel" were mapped using the DAFOR scale (Dominant, Abundant, Frequent, Occasional and Rare). In all reserves except the Guilsfield Arm and the last section of the Wern Reserve, visibility was excellent and accurate mapping was possible. The channel vegetation was also sampled using a double-sided rake. The distance between each "throw" or transect was variable dependent on the size of the reserve. For the Weston Arm, the Rednal Basin and the Aston Ponds this distance was approximately every 5 metres, for the Whitehouse Bridge and Wern Reserves the distance was every 10 metres and for the Guilsfield Arm every 50 metres. All species collected were identified and recorded and the abundance noted using the DAFOR scale. Any species not capable of being identified in the field was identified using a low power microscope during the same evening. BSBI recording cards were completed for each reserve.

Conductivity and pH readings were taken at all the reserves.

The vegetation was recorded on maps to a variable scale and they are as follows:

- The Weston Arm 1:250
- Rednal Basin 1:250
- Aston Locks Nature Reserve 1:416
- Guilsfield Arm 1:1250
- Wern Reserve 1:250
- Whitehouse Bridge 1:416
- Brithdir Reserve 1:200

The scale was determined as the largest practical size given the detailed amount of information recorded during the survey.

Results.

The species found in each reserve are given in Appendix 1. The numbers 1-7 represent,

1. The Weston Arm given as the Western Arm on the British Waterways Map
2. Rednal Basin
3. The Aston Locks Nature Reserve
4. The Guilsfield Arm
5. The Wern Reserve
6. Whitehouse Bridge
7. Brithdir Reserve.

Conductivity and pH.
Conductivity and pH readings were taken at all the reserves (Table 1). These were compared against those results obtained for the canal as a whole in September 2001 (Newbold 2001).

Table 1. The conductivity and pH for the Seven Reserves recorded in June 2003 (in bold type) and as a comparison the conductivity and pH recorded for those eleven sites on the Montgomery Canal in September 2001 (Newbold 2001).

Site	Conductivity	pH
Frankton Junction (SJ 371 317),	600	7.8
The Weston Arm Reserve (SJ 369 311)	**500**	**8.6**
Rednal Basin (SJ 351 278)	**275**	**8.7**
Queens Head (SJ 338 268)	600	7.9
Aston Locks Reserve (SJ 336 264)	600	8.0
Aston Locks Reserve (SJ 336 264)	**220 to 200**	**8.0to7.5**
Guilsfield Arm connected to main canal (SJ 252 148 to SJ 243 137)	**175**	**7.6**
Guilsfield Arm disused section (SJ 252 148 to SJ 243 137)	**225**	**7.7**
Bryn Tanat feeder, (SJ 253 203)	120	6.7
Correghofa Locks (SJ 253 200)	150	6.8
Vrnwy Aqueduct (SJ 253 196)	150	6.8
Wern (SJ 257 205)	300	7.5
Wern outflow (SJ 260 128)	600	8.1
Wern Reserve (SJ 252 141)	**375 to 350**	**8.2to 8.0**
Whitehouse Bridge Reserve (large pond) (SJ 223 061)	**125**	**7.8**
Whitehouse Bridge Reserve (small pond) (SJ 223 061)	**140**	**8.0**
Brithdir Ponds (Pond 1) (SJ 200 023)	**150**	**7.2**
Brithdir Ponds (Pond 2) (SJ 200 023)	**180**	**7.6**
Glanhafren Bridge (SO 169 969)	200	6.6
Freestone Lock (SO 137 927) Newtown	250	7.1
River Severn feeder, Penarth, (SO 139 926)	200	6.8

The Weston Arm

This is a 100metre long reserve at the end of a side-arm which, in total, is approximately 200metres long (Map 1). The side arm is approximately 1km from the Frankton Junction with the Llangollen Canal where the water is very turbid with a Secchi disc of only 40cms. The water is also probably hypertrophic since the conductivity was 500 microsiemens and the pH recorded was 8.6 at 10.00hrs at an ambient temperature of 20C. The water at the reserve had the same pH and conductivity. The flora of the reserve was dominated by *Elodea nuttallii* with occasional dominant overgrowths of the filamentous algal genera *Mougeotia/Spyrogyra* (Maps 2 and 3). Despite extensive searching no other submerged species could be found. Species such as *Ceratophyllum demersum* might have been present. *Lemna minor* occurred occasionally mainly at the extreme end of the reserve. The emergent species *Typha latifolia* and *Glyceria maxima* were found in roughly equal amounts on the northern side only. The inner landward zone of these species was dominated by *Carex acutiformis, Phalaris arundinacea* and *Juncus effusus.* The full assemblage of the aquatic and bankside species is given on Maps 2 and 3 and on the spreadsheet (Appendix 1).

Whilst the Weston Arm contained a limited number of species, this was to be expected as the nearby main canal contained only small amounts of *Elodea nuttallii, Persicaria amphibia* and a very small amount of *Ranunculus circinatus* when surveyed in September 2001 (Newbold 2001). These species were found again in the canal in 2003 in approximately the same areas. The pH and conductivity of the water within the reserve suggest the canal is greatly influenced by the hypertrophic water found in the Llangollen Canal. In many ways the flora of the reserve is representative of the nearby Montgomery Canal but it has a greater abundance of *Elodea nuttallii* than that of the canal. The absence of species such as *Persicaria amphibia* and *Ranunculus circinatus* may be the result of spatial competition from the totally dominant *Elodea nuttallii.*

Rednal Basin

Rednal Basin is found approximately 4.825km away from Frankton Junction. The water quality is considered to be eutrophic having a lower conductivity of 275 microsiemens but a pH of 8.7 was recorded at 14.00hrs at an ambient temperature of 26C. The increase in pH over that of the Weston reserve could reflect the increasing ambient temperature as the day progressed with increasing algal activity increasing the pH.

The aquatic flora within the reserve was diverse with species such as *Ceratophyllum demersum*, *Elodea nuttallii*, *Hydrocharis morsus-ranae, Myriophyllum spicatum, Nuphar lutea, Persicaria amphibia, Potamogeton alpinus, Potamogeton obtusifolius,* and *Potamogeton natans* being found. The abundant species were *Potamogeton obtusifolius, Potamogeton natans,*and *Elodea nuttallii.* The remainder were only occasionally found except for *Ceratophyllum demersum* which was rare (Maps 5,6 and 7). The edge species along the channel were not very diverse due to intense shading with occasional growths of *Carex paniculata, Glyceria maxima, Iris* *pseudacorus* and *Rumex hydrolapathum* (Maps 5 and 6). The old quay was dominated in the western corner by *Glyceria maxima* and occasional growths of *Phalaris arundinacea* and *Caltha palustris.* Growing under the *Salix* along the western edge were occasional growths of *Iris pseudacorus, Sparganium erectum* and *Alisma plantago-aquatica* (Map 7).

The diversity of Rednal Basin is not reflected in the generally impoverished nearby canal (Map 4) where only *Elodea nuttallii, Nuphar lutea* and *Potamogeton alpinus* were found in this survey. The latter two species were growing abundantly along the far edge (the non towpath side). In September, 2001 only *Nuphar lutea* was found in the immediate vicinity on the main canal. *Potamogeton alpinus* was not found in the reserve in 2001. Clearly the diversity found in the reserve suggests that it is more than representative of this section of the canal. Introductions were made in the mid 1980's of several of the presently found recorded species (see Discussion).

The Aston Lock Nature Reserve

The Aston Locks Nature Reserve is 7kms from the Frankton Junction and they comprise of five interlinked ponds (Map 8) with a through-flow of water. This is fed by gravity using the fall of the Aston locks. Another three ponds are separated from this source and appear to be fed by rain water and leakage from the canal. All the five main ponds are butyl lined. The water is eutrophic having a pH of 8.0 and a conductivity of 220 microsiemens at the inflow. As the water flows through the five ponds so the pH gradually reduces from pH 8.0 to pH 7.8 to pH 7.6 to pH 7.5 with the conductivity remaining the same until the final pond where 200 microsiemens was recorded (Maps 9 to 13). Ponds six, seven and eight were situated on mildly acid soils of pH 6.5. Pond 6 had a 1cm depth of water and Pond 7 had a 10-20cm depth of water. In Pond 7 the pH was 9.5 which reflected the high oxygen production from the *Chara globularis* during the afternoon of the 28th June with an ambient temperature of 28C.

The aquatic flora in Pond 1 is locally dominated by surface growths of *Hydrocharis morsus-ranae* and *Nuphar lutea. Elodea nuttallii, Ceratophyllum demersum, Myriophyllum spicatum, Persicaria amphibia, Potamogeton natans* and *Zannichellia palustris* were found occasionally and *Potamogeton compressus* was found being rare in only one location (Map 9). The edge of this pond was dominated by *Carex acutiformis, Glyceria maxima* and *Typha latifolia. Iris pseudacorus* and *Alisma plantago-aquatica* were found occasionally (Map 9).

Pond 2 was less diverse with the possible hybrid *Elodea Canadensis x nuttallii* being frequently found alongside *Hydrocharis morsus-ranae. Potamogeton alpinus* was found rarely. Parts of the pond and the edge were dominated by *Typha latifolia* and occasional growths of *Nasturtium aquaticum* and *Sparganium erectum* (Map 10).

Pond 3 had more open water in it but *Elodea canadensis* was the only frequently found plant with *Potamogeton alpinus* and *Hydrocharis morsus-ranae* being locally dominant. *Typha latifolia* dominated the edge with occasional growths of *Alisma plantago-aquatica* and *Alisma lanceolatum* (Map 11).

Pond 4 was dominated by *Potamogeton alpinus* with *Hydrocharis morsus-ranae* being locally dominant. The edge was again dominated by *Typha latifolia* (Map 12).

Pond 5 was more diverse but again was dominated by *Potamogeton alpinus. Hydrocharis morsus-ranae Nuphar lutea* and *Sparganium emersum* were locally dominant. *Elodea canadensis* was the only frequently found plant and *Hottonia palustris* and *Ranunculus circinatus* were occasionally found. The edge was dominated by *Typha latifolia* and *Sparganium erectum* with small areas of *Nasturtium aquaticum* and *Butomus umbellatus* and one tussosk of *Carex paniculata* (Map 13). The narrowing of the pond towards the outflow had three small wettish depressions which were the only areas where *Juncus sub-nodulosus* and *Carex rostrata* were found

Pond 6 was dominated by *Chara globularis* and *Ranunculus flammula* with occasional growths of *Hydrocotyle vulgaris.* The last two species reflect the acid nature of the soil (Map 14).

Pond 7 was dominated in the dry area by sparse growths of *Phragmites australis* and stunted growths of *Typha latifolia.* The small area of shallow water (10 –20cm depth) was dominated by *Chara globularis.* The acid loving *Juncus bulbosus* was the dominat plant found around the edge of this water. It was also the main component of the understorey to the *Phragmites* growth. *Ranunculus flammula* was locally dominant. (Map 14).

Pond 8 was a deeper water body approximately 60 to 80cms deep but one which was totally overgrown with Chara globularis which in turn was 70% covered by filamentous algal growths of the genera *Mougeotia* and *Spirogyra. Phragmites australis* dominated the eastern side whilst on the more open western side *Juncus effusus* was dominant. In the corner, between these stands, a small area of *Sparganium erectum* was recorded. To the north the pond narrowed down and was overgrown by carr of *Alnus glutinosa, Salix sp.* and *Betula sp..* The shading and potentially toxic leaf litter precluded any plant growth. In the poor fen surrounding this pond, *Anagallis tenella* the bog pimpernel was found in one small area (Map 15). This again reflected the acidity of the soil in this corner of the reserve but no such acidity was reflected by the true aquatic flora found in any of the ponds 6, 7 and 8.

The Aston Ponds have an introduced flora but they are nevertheless representative of what might be found in the nearby canal. However the first pond is suffering from the effects of both highly eutrophic canal water and the effects of swan grazing and this is the only pond in which *Potamogeton compressus* was found. The leaves of this species were stressed by coverings of algae and diatoms and its long term survival must be questioned if the pollution is not addressed. Remedial measures are considered in the Discussion (Blockage of Inflow by Emergent Plants).

The Guilsfield Arm

The Guilsfield Arm shown at a scale of 1:2500(Maps 16) is approximately 26kms from Frankton Junction and approximately 8kms “downstream” of the Tanat feeder**.** This feeder gives the canal a mildly acid mesotrophic water of pH 6.7 with a low conductivity of 120 microsiemens (Newbold 2001). By the time this water has reached the junction with the Guilsfield Arm it is again eutrophic with a pH of 7.6 and a conductivity of 175 microsiemens. Additionally the stagnant water in the overgrown disused Guilsfield Arm attracts nutrients from the surrounding fields which although sheep and cattle grazed do nevertheless receive fertiliser treatments. The water in this section has a pH of 7.7 and a conductivity of 275 microsiemens.

There are two sections to the Guilsfield Arm. One is connected to the Montgomery Canal and is approximately 115metres long (Map 17). The other, the main arm of the Guilsfield Canal is a disused overgrown section 1650metres long starting at Springbank and ending at Varchoel. It is cut off from the first section by a “control paddle” and a culverted bridge (Maps 18 to 23). At the junction with the Montgomery Canal the Guilsfield Arm contains *Elodea nutalli* as the only aquatic plant but it does have occasional stands of *Glyceria maxima* and *Sparganium erectum. Acorus calamus* is present at the far end near to the “control paddle” and there are occasional growths of *Berula erecta.* **The flora in the disused section of the canal contains some remnants of its former diversity, *Oenanthe fistulosa* (Map 21) and *Luronium natans* (Map 22)** were both recorded but in reality the canal was overgrown by *Glyceria maxima* or shaded by trees up to the end of the “Deep Cutting” (Map 25). There were occasional “stands” of *Berula erecta, Iris pseudacorus, Juncus effusus, Juncus inflexus, Lycopus europaeus, Myosotis scorpioides, Oenanthe crocata, Rumex hydrolapathum, Sparganium erectum, Equiseteum palustre* and *Equiseteum litorale.* In general a narrow ribbon of open water meandered through the middle of the *Glyceria maxima*. Occasionally the ribbon of water was totally cut off and small pools were formed. The water in general was either dominated by *Lemna minor,* contained occasional growths of *Elodea nuttallii* or was void of any aquatic vegetation. Maps 20 to 25 accurately depict these pools, the ribbon of water and the flora found. Beyond the “Deep Cutting” (Maps 25 and 26) cattle had grazed and puddled the edge growth and muddied the water in the much reduced canal width. Notwithstanding this, the edge flora was diverse and contained the following; *Alisma plantago- aquatica, Berula ercta, Carex acutiformis, Cirsium palustre, Filipendula ulmaria, Glyceria maxima, Iris pseudacorus, Juncus effusus, Juncus inflexus, Lycopus europaeus, Mimulus guttatus, Myosotis scorpioides, Oenanthe crocata, Rumex hydrolapathum, Sparganium erectum, Typha latifolia, Equiseteum palustre* and *Equiseteum fluviatile.* The aquatic flora was dominated by *Lemna minor* with occasional growths of *Elodea nuttallii.*

The efforts made in restoring this section of the canal in 1986 have now been negated. It is much as it was in 1985 except that the Deep Cutting then had a diverse flora.

The Wern Reserve

The Wern Reserve (Map 24) has been constructed with a feeder pond and weir, another pond, four meanders and a final arm. All have one conjoined through-flow of water. The reserve is approximately 26.5kms from Frankton Junction. There are two main problems with the Wern Reserve, one is the lack of management with an overgrowth of *Salix* carr shading out any potential growths of aquatic plants. In places the Salix has been cut back and is some 5 to 10 metres distant from the edge. Here shade does not limit plant growth and as such there is an overgrowth of emergent macrophytes. The second but lesser issue is one of water quality. This is at the lowest point, "the sump", of the canal. Although only 8.5kms from the Tanat feeder the water has a pH of 8.2 and a conductivity of 375 microsiemens. It also should receive reasonably clean water from the Severn feeder (Table 1) but both supplies seem to be enriched from fertiliser run-off and the use of slurries on the surrounding farmland. At this low point of the canal the farmland is mainly re-seeded grassland used for cattle, sheep, hay and silage production. Additionally cattle have access to the canal as a source of drinking water and have been observed defaecating in the canal (Newbold, 2001). Not withstanding these water quality issues the though-flow of water reduces the residence time of algal species common in the canal, such as *Spirogyra sp.* and *Mougeotia sp.* and other species such as *Lemna minor* such that where there are areas of open water (Maps 30 and 31) these nuisance species are only occasionally found. It is also possible that the blockage of *Glyceria maxima* in the first pond and first meander is removing a lot of nitrogen due both to denitrification processes and it being locked up in the biomass of the *Glyceria* (Table 1 and Maps 26, 27). Although macrophytes in general are "poor removers" of phosphorus it is suggested the blockage of *Glyceria* in the pond and in part of the first meander is not removed (see Discussion, Blockage of Inflow by Emergent Plants).

The flora of the reserve is considered in several sections. The first section is the feeder pond and weir. This is mainly dominated by *Elodea nuttallii* with occasional growths of *Berula erecta.* The edge is dominated by *Oenanthe crocata* (Map 25).

The first pond is dominated by *Elodea nuttallii* with occasional growths of *Lemna minor* and an edge of *Glyceria maxima*. There are occasional growths of *Berula erecta*, *Rumex hydrolapathum* and *Solanum dulcamara* (Map 26).
The first meander is not shaded at first and *Glyceria maxima* is again dominant with abundant growths of *Phalaris arundinacea* and *Sparganium erectum*. In the channel growing to the channel depth of 0.9metre are abundant growths of *Elodea nuttallii.* The water is remarkedly clear. Eventually *Elodea nuttallii* and *Elodea nuttallii x canadensis* and *Lemna minor* are only occasionally found in the turbid leaf litter stained water as shading from the *Salix* carr precludes most plant growth in the second and third meanders (Maps 27 and 28 and 29).

The fourth meander and the final arm are the most diverse sections due to the absence of shading. There is a diverse marsh (Map 30) containing species such as *Carex pseudocyperus, Filipendula ulmaria, Galium palustre, Glyceria maxima, Juncus effusus, Iris pseudacorus, Oenanthe crocata, Oenanthe fistulosa, Phalaris arundinacea, Rumex hydrolapathum, Solanum dulcamara and Typha latifolia*. There are two species of note here *Carex pseudocyperus* and *Oenanthe fistulosa*. The open water contains occasional growths of *Potamogeton natans*, *Elodea canadensis* and rarely *Luronium natans.* The latter two species are a sign that the water quality is improving as it passes though the reserve.

Clearly the reserve is not in a favourable condition. Water quality issues need to be addressed outside the reserve, within the canal. In 1986 the canal and the old clay pit contained species such as *Potamogeton compressus* and abundant growths of *Luronium natans*. Whilst the water quality issues are difficult to rectify as they are mainly diffuse pollution problems, tree removal could do much to improve the diversity of the aquatic and bankside flora (see Discussion).

Whitehouse Bridge Reserve

The Whitehouse Bridge Reserve is just below Welshpool, and is approximately 37kms from Frankton Junction. The reserve comprises of one large pond approximately 160metres long and a smaller one with culverted water passing under the A 490 (Map 32). The water is fed through the reserve but the shallow gradient means the water flow is hardly noticeable. A conductivity reading of 125 microsiemens and a pH of 7.8 were recorded in the large pond but the smaller pond had a conductivity of 140 microsiemens and a pH of 8.0. This small increase may be due to the increased production of macrophytes presumably due to accumulated sediments.

The large pond was surveyed by boat and it contained a diverse assemblage of plants. Species such as *Callitriche stagnalis, Ceratophyllum demersum, Elodea nuttallii, Lemna minor, Luronium natans, Myriophyllum spicatum, Nuphar lutea, Potamogeton compressus, Potamogeton natans, Potamogeton obtusilfolius, Potamogeton perfoliatus* and *Sparganium emersum* were recorded. Some idea of their relative abundance is given in Maps 33, 34, 35 and 36. One oddity, was two very small specimens of *Callitrche hermaphroditica* found at the inflow end (Map 33). This is a mesotrophic species being found only in the area of the Vyrnwy Aqueduct close to the Tanat feeder. Its presence here is aberrant and cannot be explained. The two species of note here are *Luronium natans* and *Potamogeton compressus.*

The emergent flora was nowhere dominant containing species such as *Acorus calamus, Filipendula ulmaria, Glyceria maxima, Oenanthe crocata, Scrophularia auriculata* and *Sparganium erectum* (Maps 33 and 34).

It should be noted that the only areas of open water were where the anglers had cleared their “swims”. This practice could be of benefit to the management of the pond if it could be targeted at the “less desirable” species such as *Elodea nuttallii* and *Ceratophyllum demersum.*

The smaller pond was dominated by *Potamogeton natans* and *Elodea nuttallii* with occasional growths of *Ceratophyllum demersum, Lemna minor* and *Lemna trisulca.* At the inflow was found a small amount of *Potamogeton compress*us and *Potamogeton obtusifolius*. These had presumably entered from the large pond through the culvert (Maps 37 and 38).

The southern edge of the pond was dominated by *Glyceria maxima* whereas the northern edge was dominated by *Juncus effusus*. Occasional growths of *Persicaria amphibia, Sparganium erectum* and *Typha latifolia* were also recorded.

The flora within the reserve is affected by a water quality which is stressing those species less able to tolerate the obvious nutrient enrichment. Overgrowth of *Elodea nuttallii* could in time exclude the more desirable species such as *Luronium natans* and *Potamogeton compressus.* Remedial measures are suggested in the (Discussion, Blockage of Inflow by Emergent Plants).

Brithdir Ponds

The Brithdir Ponds reserve contains two ponds but the old quay now the inflow area was also surveyed (Map 39). Both ponds are approximately 41.25kms from Frankton Junction. The old quay was very overgrown with *Glyceria maxima* and this contained frequent growths of *Berula erecta* (Map 40). It is suggested this might act as a nutrient trap and filter for the pond water and as such should be left. A conductivity reading of 150 microsiemens and a pH of 7.2 were recorded in the smaller pond but the lower larger pond had a conductivity of 180 microsiemens and a pH of 7.6. This small increase may be due to accumulated sediments.

The first pond was only 25metres long and approximately 1.25metres deep but it was dominated by *Potamogeton compress*us and *Luronium natans*. There were occasional growths of *Nuphar lutea* and *Sparganium emersum.* There were occasional edge growths of *Glyceria maxima*, *Berula erecta*, *Galium palustre, Lycopus europaeus, Oenanthe crocata and Solanum dulcamara* (Map 41).

The second pond again contained dominant growths of *Potamogeton compress*us and *Luronium natans*. There were occasional growths of *Nuphar lutea* but *Elodea canadensis x nuttallii* had occasional to abundant growths. *Lemna minor* was also evident particularly in a "backwater" by the outflow where the algal species *Mougeotia sp.* and *Spirogyra sp.* were abundant. As the pond is longer and deeper (approximately 1.75 metres deep) than the first pond sediment accretion may have occurred resulting in a potentially more nutrient rich water. The north western edge contained a large linear stand of *Glyceria maxima* with occasional growths of *Typha latifolia* whereas the opposite side had a narrow sparse edge of *Glyceria maxima.* Other species were recorded here namely *Berula erecta, Galium palustre, Glyceria fluitans, Lycopus europaeus, Oenanthe crocata, Ranunculus flammula, Solanum dulcamara* and *Sparganium erectum.*

The Brithdir Ponds are in a favourable condition. The only design fault is the angled outflow culvert which gives "dead" water at the end of the second pond resulting in algal growth.

Discussion

Historical Comparisons with the Present Day Survey.

In 1997 (British Waterways 1999) the whole canal was surveyed and this report included five of the seven reserves surveyed in the present study. These reserves were the Rednal Basin, the Aston Locks Nature Reserve, the Guilsfield Canal, the Wern Reserve and the Whitehouse Bridge Reserve. There appear to be no comparative surveys for the Weston Arm and the Brithdir Reserve. The species list given in 1997 is not as comprehensive as that used in the present survey so for direct comparisons in this section of the report the 1997 species list is used. The full species list found in the reserves is presented on a spreadsheet (Appendix 2). In summary the Wern Reserve and the Guilsfield Arm (Table 2) have lost species since 1997 and the greatest loss has occurred in the Guilsfield Arm which is now a derelict unmanaged overgrown side arm. The losses are of greater importance than appears.

Many of the species lost were aquatic species and the replacement species found in 2003 were all emergent species (Appendix 2). In all reserves the original complement of species has been manipulated by attempting to introduce species once found in the area. This strategy has largely failed and the reserves are a mix of both introduced species, species that have naturally colonised and their original floras. The reserves best documented for their introductions are the Rednal Basin, the Guilsfield Arm and the Wern Reserve (Briggs 1989). However possible introductions to the Aston Locks Nature Reserve and the Brithdir Ponds seem to have been mostly successful. These two ponds represent a large component of the flora found within the canal.

Table 2. A Comparison between the Number of Species found in the Present Day Survey with that of 1997

Number of species	Rednal Basin	Aston Locks Nature Reserve	Wern Reserve	Whitehouse Bridge Reserve	Guilsfield Arm
1997	19	31	35	16	34
2003	29	55	34	31	28

N.B. Bryophytes, Charophytes, Nitellids and Algal species have been excluded from the comparison

Rednal Basin. *Butomus umbellatus, Cerotophyllum demersum, Elodea canadensis, Ranunculus circinatus* and *Spirodela polyrhiza* were all introduced into the Rednal Basin in 1985 whilst they were found in 1997 they could not be found in the present survey. Other species introduced into the Rednal Reserve in 1985 such as *Caltha palustris, Callitriche obtusangula, Hottonia palustris, Luronium natans, Oenanthe fistulosa, Potamogeton compressus* and *Potamogeton praelongus* were not found in both the 1997 survey and only one of these *Caltha palustris* was found in the present survey. Successful introductions were made of *Hydrocharis morsus ranae* and *Nuphar lutea. Potamogeton obtusifolius* now abundant in the reserve grew naturally following management of the reserve in 1986 (Briggs 1989). *Potamogeton natans* is not mentioned in the Briggs (1989) report but it was recorded in 1997 and now forms an abundant component of the community. Ironically great efforts were made to introduce *Potamogeton alpinus* into the reserve in 1985 and 1986, these failed but it was recorded in the inflow area of the reserve for the first time this year. This may reflect its increasing abundance in the canal in this area, with a large bed growing almost opposite the entrance to the reserve. Such a bed was not recorded here in the 2001 survey but a large bed was found approximately 600 metres away towards Frankton Junction.

Guilsfield Arm. In 1985 a range of interesting species were found from Springbank to Deep Cutting although it was only in the Deep Cutting that the following were found; *Potamogeton berchtoldii, P. crispus, P. friesii, P. natans, P. obtusifolius, P. pectinatus, Luronium natans* and *Riccia fluitans.* From the Deep Cutting to Varchoel cattle trampling had produced a rich emergent fringing vegetation. From Springbank to Deep Cutting the canal was heavily shaded and overgrown with *Glyceria maxima.* In 1986 restoration work started with tree thinning along the Deep Cutting and tree clearance and shallow dredging from Spring Bank to Deep Cutting. In this latter section *Potamogeton crispus, P. natans, P. obtusifolius, P. pectinatus* "appeared in quantity" with *Lemna trisulca, L. minor* and *Riccia fluitans* frequent in the shallow water at the margins. *Potamogeton alpinus, P. compressus, P. friesii, P. praelongus* and *Luronium natans* were all introduced. By 1997 only *Potamogeton berchtoldii, P. crispus, P. obtusifolius, L. minor* and *Lemna trisulca* were recorded amongst a channel containing emergent species similar to the present day. In 2003 the channel was again overgrown by *Glyceria maxima* with occasional pools and linear channels of open water mainly dominated by *Lemna minor* and *Elodea nuttallii.* In one recently cleared area possibly by the landowner wanting to keep the cattle drinking area as open water a small amount of *Luronium natans* was found. Additionally in a section of the fringing vegetation mainly dominated by *Berula erecta* a few plants of *Oenanthe fistulosa* were recorded. The Deep Cutting was very heavily shaded in the present survey and the lack of light precluded the growth of any plants. From the Deep Cutting to Varchoel cattle trampling had produced a rich but very overgrazed emergent fringing vegetation and these results mirrored the observations made in 1985. A linear uninterrupted strip of muddy water in 2003 only contained *Lemna minor* and *Elodea nuttallii.*

The Wern Reserve. Following the construction of the reserve in April 1987 Briggs reported that colonisation was rapid and apparently natural. As the puddled clay base was lined with 2-3 year old dredgings it is logical to assume that most of the rapid colonisation came from these dredgings. Species such as *Alisma plantago-aquatica, Butomus umbellatus, Callitriche hamulata, Elodea canadensis, Lemna gibba, L. minor, L. trisulca, Persicaria amphibia, Potamogeton berchtoldii, P. crispus, P. natans, P. obtusifolius, P. pectinatus, Spirodela polyrhiza, Sparganium erectum* and *Glyceria maxima* "had appeared by mid-summer". *Sparganium emersum, Potamogeton compressus* and *P. praelongus* were all introduced. *Luronium natans* was also introduced but this had been previously recorded in the old overgrown clay pit from which the site was built around.

By 1997 only *Alisma plantago-aquatica, Elodea canadensis, Lemna gibba, L. minor, Potamogeton natans, P. praelongus, P. obtusifolius,* and *Glyceria maxima* survived with losses of *Butomus umbellatus, Callitriche hamulata, Lemna trisulca, Luronium natans, Potamogeton berchtoldii, P. compressus, P. crispus, P. pectinatus, Spirodela polyrhiza* and *Sparganium erectum.* In the present survey *Luronium natans* was re-found but the past site for *P. praelongus* had been heavily shaded and only leaf litter could be found on the bottom sediments. Likewise *Potamogeton obtusifolius* and *Lemna gibba* were not found but the more open habitat and water quality seemed suitable for their survival. Thus of all the "introductions" only *Elodea canadensis, Lemna minor, Luronium natans, Potamogeton natans* and *Glyceria maxima* survived.

The Aston Ponds Nature Reserve. In the report by Briggs (1989) the Aston Ponds had not yet been constructed. Information on any introductions is therefore not available but it is thought that *Potamogeton alpinus, Hottonia palustris, Hydrocharis morsus-ranae, Ranunculus circinatus* and *Butomus umbellatus* were introduced to the reserve. All five species were recorded in 1997 and all were recorded in 2003. In two areas of this pond young growths of *Potamogeton crispus* were found. This species was abundant in September 2001. The floral assemblage for the reserve appears to remain the same today as it did in 1997 despite the apparent increase in species number from 31 to 55 plant species. It is thought that the recorder failed to visit the area around Ponds 6, 7 and 8 since *Phragmits australis* dominates the eastern side of Pond 8 and this species was not recorded in 1997. The flora in the peaty area around Ponds 6, 7 and 8 is very diverse and unique to the reserve and must have been a wet mildly acid flush before the reserve was built. Briggs (1989) certainly mentions the need to conserve the floral importance of areas of the land prior to the construction of the Aston Ponds.

The Whitehouse Bridge Reserve. In 1989 the site had yet to be constructed but the canal in this section was noted for the amount of *Luronium natans* and *Potamogeton compressus* it supported. In 1988 *P. compressus* was mysteriously replaced by *Nitella flexilis* the implication being that it had re-appeared in 1989 (Briggs 1989). *Potamogeton compressus* was recorded in 1997 but *Luronium natans* was not found. In the present 2003 survey both species were found with *P. compressus* abundant to locally dominant. At the outflow to the first pond *Potamogeton obtusifolius* was recorded and this was not mentioned by Briggs (1989) nor was it recorded in 1997.

Species found in the Reserves compared with those Species found in the Canal during the 2001 Survey.

The spreadsheet gives all those species found in the canal as a whole during the September 2001 survey (Appendix 1). This easily facilitates comparison when assessing the reserves as potentially representing the flora found in the canal. Overall 128 species were found in the reserves against a possible total for the canal of 153 species (Newbold 2001). **Appendix 1 however does give species which are not considered to be "wetland" species in the list compiled by Williams et. al (1996). Thus the recorded flora was divided into wetland species using the lists compiled by Willams et. al. (1996).**

The wetland species have been further split into three, aquatic macrophytes and emergent species, with the remainder of the wetland flora being classified as bankside species. This split has been necessary in order that comparisons can be made with the results of two previous surveys in 1988 and 1997 (Briggs, 1988 and British Waterways, 1999). It is accepted that the divisions for some species are subjective and arbitrary particularly those found on the bankside. However, it was considered that if a species is assigned to an identified category, even if not fully in agreement with other researchers, valuable comparisons can be made on the impact or otherwise of future restoration. Table 3 gives the aquatic species recorded, in total, for both the canal and the reserves.

Overall, a total of 26 aquatic macrophytes were recorded for the reserves which included one macrophyte namely *Hottonia palustris* not recorded in the canal. In addition one charophyte namely *Chara globularis* was found (Table 3). Overall 39 aquatic macrophyte species, no *Chara* species and 2 species of Nitellid were recorded for the canal in 2001. Thus the reserves have a shortfall of 14 aquatic species (16 if the *Nitellids* are included in the total). In addition, 1 aquatic bryophyte and two genera of algae were recorded in the reserves as against 2 species of bryophyte and two genera of algae and two species of algae recorded in the canal in 2001.

Table 3. The aquatic flora found in the Montgomery Canal and in the Seven Side Reserves, Weston Arm (1), Rednal Basin (2), Aston Reserve (3), Guilsfield Arm (4), Wern Reserve (5), Whitehouse Bridge (6), and the Brithdir Ponds (7).

Code	Species	Reserve	Code	Species	Reserve
Az fi	Azolla filliculoides	Absent	P cri	Potamogeton crispus	3
Cal ham	Callitriche hamulata	Absent	P. fri	Potamogeton friesii	Absent
Cal her	Callitriche hermaphroditica	6	P nat	Potamogeton natans	2,3,5,6.
Cal obt	Callitriche obtusangula	Absent	P obt	Potamogeton obtusifolius	2,6.
Cal pl	Callitriche platycarpa	Absent	P. pect	Potamogeton pectinatus	Absent
Cal stag	Callitriche stagnalis	7	P perf	Potamogeton perfoliatus	6
C dem	Ceratophyllum demersum	1,2,3,6.	P pra	Potamogeton praelongus	Absent
E can	Elodea canadensis	3,5.	P pus	Potamogeton pusillus	Absent
E nut	Elodea nuttallii	All,1 to 7.	P tri	Potamogeton trichoides	Absent
En x Ec	Elodea canadensis x Elodea nuttallii	2,3,5.	R cir	Ranunculus circinatus	3
Gl fl	Glyceria fluitans	7	R flam	Ranunculus flammula	3,7.
Hot p	Hottonia palustris	3	Sp em	Sparganium emersum	3,6,7
H mra	Hydrocharis morsus-ranae	2,3.	Sp pol	Spirodela polyrhiza	Absent
J bul	Juncus bulbosus var. fluitans	3	Za pa	Zannichellia palustris	3
L gib	Lemna gibba	Absent		**Charophytes**	
L min	Lemna minor	All, 1to7.	C glob	Chara globularis	3
L. m	Lemna minuta	All, 1 to 7.	Ni fl	Nitella flexilis agg.	Absent
L tri	Lemna trisulca	2,3,4,5,6,7.	N m g	Nitella mucronata var. gracillima	Absent
L nat	Luronium natans	4,5,6,7.		**Algae**	
M alt	Myriophyllum alterniflorum	Absent	C glom	Cladophora glomerata	Absent
M spi	M. spicatum	2,6.	Mou	Mougeotia sp.	123467
N lut	Nuphar lutea	2,36,7.	Spi	Spirogyra sp.	123467
N alb	Nymphaea alba	Absent	Hyd	Hydrodictium reticulatum	Absent
P alp	Potamogeton alpinus	2,3.		**Bryophytes**	
P ber	Potamogeton berchtoldii	Absent	Fo an	Fontinalis antipyretica	3
P com	Potamogeton compressus	3,6,7.	Ri fl	Riccia fluitans	Absent

Table 4. The Emergent Species growing in the Montgomery Canal and in the Seven Side Reserves, Weston Arm (1), Rednal Basin (2), Aston Reserve (3), Guilsfield Arm (4), Wern Reserve (5), Whitehouse Bridge (6), and the Brithdir Ponds (7).

Code	Species	Reserve	Code	Species	Reserve
A cal	Acorus calamus	3,4,6	G max	Glyceria maxima	All, 1-7.
A lan	Alisma lanceolatum	3	I ps	Iris pseudacorus	2,3,4,5.
A nod	Apium nodiflorum	3	J e	Juncus effusus	1,2,3,4,5,6.
A paq	Alisma plantago-aquatica	2,3,4,6,7.	M aq	Mentha aquatica	1,3,4,7.
B er	Berula erecta	2,3,4,5,7.	My sc	Myosotis scorpioides	2,3,5,7.
B umb	Butomus umbellatus	3	N aq	Nasturtium aquaticum	3
C pal	Caltha palustris	2,3.	**O fist**	**Oenanthe fistulosa**	**4,5.**
C ac	Carex acutiformis	1,3.	P amp	Persicaria amphibia	2,36.
C el	**Carex elata**	**3**	Phal	Phalaris arundinacea	1,3,5.
C pan	Carex paniculata	2,3,4.	Phrag	Phragmites australis	3
C rip	Carex riparia	3	Ru hy	Rumex hydrolapathum	2,3,4,5,6.
Eq fl	Equiseteum fluviatile	4	Sp er	Sparganium erectum	3,4,5,6,7.
Eq pa	Equiseteum palustre	4	Sc lac	Schoenoplectus lacustris	Absent
Eq l	Equiseteum x litorale	3,4.	Ty lat	Typha latifolia	1,3,4,5,6,7.
			V bec	Veronica beccabunga	Absent

The emergent species recorded for the reserves and the canal are presented in Table 4. **Overall 27 emergent species were recorded in the reserves** and 29 emergent species were recorded for the canal as a whole. One species found in the reserves but not in the main canal was *Oenanthe fistulosa.*

Overall 42 bankside species thought to be associated with water were recorded as against 38 species recorded for the canal as a whole (Table 5). Eleven species were recorded in the reserves but not in the canal. These were *Anagallis tenella, Carex pseudocyperus, Carex rostrata, Dactylorchis fuchsii, Dactylorchis purpurella, Eleocharis palustris, Galium saxatile, Hydrocotyle vulgaris, Juncus acutiflorus, Juncus sub-nodulosus* and *Myosotis secunda.*

The two orchis species are associated with marshes and were only recorded in the Aston Reserve. The other nine species except one are all associated with more acid soils and were only found in the boggy ground in the Aston Reserve by ponds 7, 8 and 9. *Carex pseudocyperus* was found in the Wern Reserve.

Table 5. The Bankside Species found in the Montgomery Canal and in the Seven Side Reserves, Weston Arm (1), Rednal Basin (2), Aston Reserve (3), Guilsfield (4), Wern Reserve (5), Whitehouse Bridge (6), and the Brithdir Ponds (7).

Code	Species	Reserve	Code	Species	Reserve
An te	**Anagallis tenella**	**3**	**J acu**	**Juncus acutiflorus**	**3**
Ag st	Agrostis stolonifera	123467	J art	Juncus articulatus	3
Al gl	Alnus glutinosa	234567	J in	Juncus inflexus	1,34.
An sy	Angelica sylvestris	5	**J sub**	**Juncus sub-nodulosus**	**3**
A f f	Athryium felix femina	Absent	L eur	Lycopus europaeus	123467.
Bi ce	Bidens cernua	Absent	Ly sal	Lythrum salicaria	3,4,7.
Bi tr	Bidens tripartita	Absent	Ly f c	Lychnis flos cuculi	3
Br mol	Bromus mollis	3	Mim g	Mimulus guttatus	3,4.
Ca ps	**Carex pseudocyperus**	5	My sc	Myosotis scorpioides	2,35,7.
Ca ro	**Carex rostrata**	3	**My sec**	**Myosotis secunda**	**3**
Ca re	Carex remota	Absent	My aq	Myosoton aquaticum	3,4,5.
Ch a	Chamaenerium angustifolium	2,3,4.	Oe cr	Oenanthe crocata	3,4,5,6,7.
Ci pal	Cirsium palustre	2,3,4.	P hy	Persicaria hydropiper	4,5.
D fu	**Dactylorchis fuchsii**	**3**	Pet hy	Petasites hybridus	1,2,3,4,6.
D pur	**Dactylorchis purpurella**	**3**	Ra sc	Ranunculus sceleratus	1,3,4,5,6,7
De ca	Deschampsia caespitosa	3,5	Ro my	Rorippa microphylla	Absent
El pal	**Eleocharis palustris**	**3**	Ro sy	Rorippa sylvestris	Absent
Ep hi	Epilobium hirsutum	123567	Sc au	Scrophularia auriculata	1,6.
Eu ca	Eupatorium cannabium	3	Sc gal	Scutellaria galericulata	Absent
Eq te	Equiseteum telmateia	Absent	Se aq	Senecio aquaticus	Absent
Fi ul	Filipendula ulmaria	123567	So dul	Solanum dulcamara	2,3,4,5,6.
Ga pa	Galium palustre	1234567	St pa	Stachys palustris	1,3,4.
Ga sa	**Galium saxatile**	3	Urt di	Urtica dioica	1,2,3,4,6,7
H vul	**Hydrocotyle vulgaris**	**3**	Va of	Valeriana officinalis	5
I gl	Impatiens glandulifera	Absent			

The emergent and the bankside species when combined become the **marginal plants** as recorded in the 1988 and 1997 surveys. **Thus in total 69 marginal plants were recorded in the reserves in 2003** and 67 for the canal as a whole in 2001.

With the 26 aquatic plant species, 95 plant species found in or by water were recorded in the reserves (see Discussion). This compares with the 39 aquatic plant species and two species of *Nitellid* found in the canal as a whole in 2001 when an overall total of 108 plant species were recorded.

The highest number of and most noteworthy omissions in the reserves were those representing the true aquatic species (Table 6). *Callitriche hermaphoditica* has been included in Table 6 as it is considered to be aberrant record for the Whitehouse Bridge reserve. The two specimens found were small and seemingly stressed.

Table 6. Aquatic Plants Species not found in the Reserves

Code	Species	Reserve	Code	Species	Reserve
Az fi	Azolla filiculoides	Absent	P pus	Potamogeton pusillus	Absent
Cal ham	Callitriche hamulata	Absent	P tri	Potamogeton trichoides	Absent
Cal her	Callitriche hermaphroditica	6	Sp pol	Spirodela polyrhiza	Absent
Cal obt	Callitriche obtusangula	Absent		**Charophytes**	
Cal pl	Callitriche platycarpa	Absent	Ni fl	Nitella flexilis agg.	Absent
L gib	Lemna gibba	Absent	N m g	Nitella mucronata var. gracillima	Absent
M alt	Myriophyllum alterniflorum	Absent		**Algae**	
N alb	Nymphaea alba	Absent	C glom	Cladophora glomerata	Absent
P ber	Potamogeton berchtoldii	Absent	Hyd	Hydrodictium reticulatum	Absent
P. fri	Potamogeton friesii	Absent		**Liverworts**	
P. pect	Potamogeton pectinatus	Absent	Ri fl	Riccia fluitans	Absent
P pra	Potamogeton praelongus	Absent			

Some species have little conservation value as they are species of tolerant of pollution or are aggressive colonists. Both categories can dominate communities to the exclusion of other species and are often found in the canal in polluted sections. One species not to be encouraged is *Azolla filiculoides* whereas others as part of a community are acceptable species worthy of conservation effort namely; *Potamogeton pectinatus* and *Nitella flexilis agg.*

In all 14 aquatic plant species and two species of *Nitellid* are absent from the reserves. Some of these 14 (16) species are more important than others either as locally important or nationally important species and efforts should be made to conserve these species either by providing additional reserves or more controversially, possibly purposefully introducing them into the most suitable existing reserve.

Generally there are two groups of species absent from the ponds which need to be conserved. These are those species only tolerant of a mesotrophic water quality and those representative of eutrophic conditions. The former group is best found in the canal 200 metres east of Carreghofa Locks and thence westwards from the Tanat feeder to the Vyrnwy aqueduct. Four mesotrophic species, absent from the reserves, were recorded in the canal in this section; *Callitriche platycarpa, Myriophyllum alterniflorum, Nymphaea alba* and *Potamogeton praelongus.* This is also the best area for *Callitriche hermaphroditica* and this species does need a reserve having the appropriate water quality.

A section of canal on the English side by Maesbury Marsh in September, 2001 contained small amounts of *Potamogeton friesii.* The latter is an important eutrophic species to conserve. In 1988 it was recorded in abundance here *"in the spring survey (June) but not at all in the survey during September-October"*(Briggs, Ed.,1988). This section could well contain the densest populations of this species on the canal.

A section of canal between Pool Quay and Welshpool contained the following species missing from the reserves namely; *Potamogeton berchtoldii, Potamogeton friesii, Potamogeton pectinatus, Nitella flexilis agg,* and *Nitella mucronata var. gracillima.*

Three relatively discrete sections of canal thus contain 9 of the 16 species. If *Azolla filiculoides* is not considered worthy of conservation effort then in reality this total becomes 9 of the 15 desirable species not found on the reserves. The remaining species not represented excluding *Azolla filiculoides* are *Callitriche hamulata, Callitriche obtusangula, Lemna gibba, Potamogeton pusillus, Potamogeton trichoides* and *Spirodela polyrhiza.*

However between kilometres 18 and 19 several "missing species" were recorded namely three of the aquatic species; *Lemna gibba, Potamogeton pusillus* and *Spirodela polyrhiza.*

Callitriche obtusangula was recorded in September, 2001 just north east of Queen's Head, around kilometre 6, close to the Aston Reserve. *Potamogeton trichoides* was recorded September, 2001 in the centre of Welshpool. *Callitriche hamulata* was found commonly at the extreme south western end of the canal close to the River Severn feeder in September 2001.

There is only one emergent species, not found in the reserves worthy of conservation effort that of *Veronica beccabunga* but it is possible that it was missed in the present survey. *Veronica beccabunga* was only recorded in kilometres 37,40 and 43 in September 2001 geographically far removed from any reserve. The other unrepresented species is *Schoenoplectus lacustris.* This is a commonplace species and it can be aggressive and it could jeopardise diverse aquatic communities

In summary there are four areas where new reserves might be targeted to allow an almost complete representation of the aquatic flora and the best of the emergent species. These are;

- An area 200 metres east of Carreghofa Locks and thence westwards from the Tanat feeder to the Vyrnwy aqueduct.
- A section of canal between Pool Quay and Welshpool.
- A representative section between kilometres 18 and 19.
- A section of canal on the English side by Maesbury Marsh

Reserve Design

Through-flow of Water and Gradient.

All the reserves have a water quality which is either eutrophic or suggestive of hypertrophy (Table 1). Hypertrophic water feeds the side arm reserve at Weston. Eutrophic water feeds the Rednal Basin, the Aston Locks Reserve, Whitehouse Bridge and probably the Wern Reserve although the water could be bordering on hypertrophy. Low eutrophy water seems to feed the Brithdir Ponds. The most successful of the reserves in terms of their overall plant diversity are those having a through-flow of water. These are the Aston Locks Reserve, the Brithdir Ponds, Whitehouse Bridge and the Wern Reserve, although the last two reserves seem to have some design faults. Through-flow prevents any marked dominance by algae or *Lemna minor* but where there is a shallow gradient between the inflow point and the outflow, as at Whitehouse Bridge the flora can become dominated by pollution tolerant species such as *Elodea nuttallii* or *Ceratophyllum demersum.*

Recommendation: A through flow of water seems an essential pre-requisite to good reserve design but a gradient of one lock depth between inflow and outflow is desirable.

Blockage of the Inflow by Emergent Plants

Emergent plant or any aquatic macrophyte can lock up plant nutrients in their biomass and so improve water quality. Nitrogen can also be lost into the atmosphere as gaseous nitrogen through denitrification processes when oxygen levels at the mud-water interface are high. The reverse conditions release phosphorus from the particulate matter making up the sediments. This can be “scavenged” by plant roots for their growth. However there is a limit to plant root uptake and some phosphate phosphorus will escape into the water column to be scavenged by floating macrophytes or algal species. None is released into the atmosphere. Thus the only net loss of phosphorus is that bound up in the biomass of plants whether they are algae or higher plants. Only approximately 2.5% of the plants **dry weight** is made up of phosphorus but some 25% of this weight will be nitrogen. Thus the benefits of a blockage by plants at the inflow are three fold. First the blockage locks up nutrients in its biomass, secondly, during the day time some denitrification will occur when oxygen is leaked through the root hairs and thirdly and very importantly, it acts as a sediment trap. The dis-benefit of a blockage is that the biomass will result in lowered oxygen levels particularly during night-time respiration resulting in phosphorus release. It should be emphasised that nutrient removal will only occur if the plants are removed when still actively growing in August as their natural decay in September will release any locked up nutrients back into the water for use next spring. However if such a strategy of total plant removal were adopted this would negate the benefits of a winter time sediment trap. **Ideally some plants, up to 25% of the biomass and hence nutrients should be removed annually preferably during August when the plants have reached peak biomass and are not beginning to decay.**

The Aston Reserve might have benefited from a narrow feeder channel "blocked" with emergent species to help remove some nutrients. At present the first pond in the Aston Reserve is acting as a sediment trap and hence nutrient "sump". The water quality gradually improves as it flows through the reserve (Maps 9 to 13). There is a fall in pH and conductivity from pH 8.0 at the entrance to the reserve to pH 7.5 in the final pond and a conductivity fall from 240 to 200 microsiemens. One element of a Management Plan for this reserve might be to allow a "blockage" of emergents to grow at the inflow point. It is also recommended that the blockage of emergents at the entrance to the second and third ponds are not removed but controlled to cover around 25% of the pond surface.

The Wern Reserve seems to be benefiting from a blockage of *Glyceria* at the first pond and part of the first meander (see section on the Wern Reserve)

The Whitehouse Bridge Reserve might benefit from creating and managing a blockage of *Glyceria* in the canal by the inflow to the reserve.

Recommendations: It is recommended that the potential benefits caused by a blockage of emergent plants is explored for the following reserves, the Aston Nature Reserve and the Whitehouse Bridge Reserve.

The blockage at the inflow in the Wern reserve is retained but managed from spreading any further into the reserve.

Meanders

Meanders create "dead" stagnant water and this is more marked if they are greater than a 6 to 8 metre canal width and the gradient between inflow and outflow is limited. Thus the 20 metre wide "gentle" meanders at the Aston Reserve in Ponds 1 and 5 have "dead" water but the gradient between inflow and outflow is one lock depth. As a consequence plants such as *Nuphar lutea* or *Hydrocharis* still grow in the corners of the meanders.

The Wern Reserve could be argued as suffering from three "design" errors but in reality only "suffers" from one major management problem. First the reserve does not seem to have the fall of a reserve situated by a lock. Second the meandering design is extreme but this is understandable as it makes best use of the ground available. The meanders for the most part are only a canal width, 6 to 8 metres wide but this could still create "dead" stagnant water but thirdly the most important factor preventing greater plant diversity is the shading caused by the overgrowth of Salix (willow) carr (see next section). The meanders at Wern where narrow should mitigate against any dead water but there are three broad and extreme meanders (Maps 28, 29 and 30) which would create "dead" water and sediment accretion.

However the effects of these extreme meanders on the ecology of this reserve is difficult to judge due to effects of shading.

Recommendation: Meanders should be avoided if possible in future reserve design or if necessary should only be incorporated where there is a "lock depth" gradient between inflow and outflow. They should be no wider than 6 to 8 metres.

Shading

Shading is one the major reasons for lack of plant growth on the canal as a whole and within the Rednal Basin Reserve and the Wern Reserve. The Wern Reserve will never reach its full potential until upwards of 75% of the overgrowth of *Salix* at least one tree height from the edge is removed. Additionally too much leaf litter can result in a sterile detritus covered mud layer.

Recommendation: Avoid areas where shading by trees cannot be controlled and avoid over-planting. Retain approximately 75% of the edge as open areas of water.

Width and Linearity

A long linear reserve divided into a series of linear ponds preferably no wider than 6 to 8 metres such as at the Aston Reserve has yielded the greatest plant diversity. A long narrow linear design seems preferable to that of a meander, rectilinear or square pond. First, linearity visually simulates a canal. Secondly, the through flow of water can spread across most if not the whole width. "Dead areas" would be created if the design was rectilinear or square. This happens naturally in many lakes for example at Derwent Water or Bassenthwaite Lake, where there are many bays cut off from the central through-flow of water. Here the bays are protected from the effects of wind and the water quality is so good that macrophyte diversity is not affected by the increased water retention time. The water quality, in general, in the present Montgomery Canal Reserves is so close to being hypertrophic that any increase in retention time should be avoided. A square design would create "dead" areas not reached by any through-flow water thus increasing nutrient retention times in these areas and this in turn would exacerbate algal and *Lemna* growth. A square design also could increase exposure to wind effects pushing algal and *Lemna* growth into the wind exposed emergents plants and stifling aquatic plant growth in these zones. Also the larger the open water area the more is the danger of it being an attractive habitat to *Branta canadensis* (Canada geese). These birds can be extremely damaging to plant growth through the effects of grazing and to water quality through enrichment from their droppings.

In summary it is suggested that the best design for a reserve is encapsulated in that of the Aston Ponds save that the first pond may too square as it suffers from grazing and pollution by Cygnus olor (Mute swans).

Anglers as Management Tools

At the Whitehouse Bridge Reserve anglers have removed both *Elodea nuttallii* and a species of high conservation importance that of *Potamogeton compressus* to create their fish “swims”. Ecologically this has the advantage of creating some open water potentially allowing the re-growth of desirable species such as *Potamogeton compressus* or undesirable species such as *Elodea nuttallii* or *Ceratophyllum demersum.* The practice of creating “swims” could be put to good conservation use if targeted only at pollution tolerant species such as *Elodea nuttallii* or *Ceratophyllum demersum.* Some informal training of the anglers is suggested.

Recommendation: Anglers could be trained to remove pollution tolerant plants to create their “swims” and to leave behind the more desirable plant species.

Some Criteria for a Possible Ideal Reserve Design

It is suggested that the ideal reserve might contain the following design features;

1. A source of water appropriate to the survival of the target community of plants.
2. A through-flow of water.
3. The reserve preferably sited by a lock giving a gradient between inflow and outflow of one lock depth.
4. A linear design no greater than 6 to 8 metres in width and avoiding where possible meanders.
5. A narrow channel at the inflow point blocked by emergent plants. These will act both as a sediment trap and retain some nutrients in their biomass. The design should allow for the easy management of the plants.
6. Shaded sites should be avoided if at all possible and tree planting should be set at least one mature tree height away from the water’s edge. Up to 25% of the edge could be shaded.

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Species	1	2	3	4	5	6	7
Acer pseudoplatanus							
Achille millefolium	o	o	o				o
Acorus calamus			o	o		o	
Aesculus hippocastanum							
Agrostis stolonifera	f	f	f	f	o	f	f
Alisma lanceolatum			r				
Alisma plantago aquatica		r	o	o	o	o	o
Alnus glutinosa		a	o	l/d	f	f	f
Anagallis tenella			r				
Angelica sylvestris					f		
Anthriscus sylvestris			o	o		o	o
Apium nodiflorum			r		o		
Artemisia vulgaris							
Athyrium felix femina							
Betula sp.		o	o	o		o	
Bidens cernua							
Bidens tripartita							
Berula erecta		o	o	f-l/a	l/a		o
Bromus mollis			o				
Butomus umbellatus			o				
Callitriche hamulata							
Callitriche hermaphroditica						r	

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Appendix 1. Plants found in the Montgomery Canal Reserves June/July, 2003

Species	1	2	3	4	5	6	7
Callitriche stagnalis							o
Caltha palustris		r	o				o
Calystegia sepium	f	o	o	o		o	
Carex acutiformis	a		l/a				
Carex elata			r				
Carex paniculata		o	r	r			
Carex pseudocyperus					r		
Carex remota			r				
Carex riparia			r				
Carex rostrata			r				
Centaurea nigra	f	o	o	o			
Cerastium fontanum			o	o			
Ceratophyllum demersum	r	o	o			f	
Chamaenerion angustifolium		r	r	r			
Cirsium palustre		f	l/f	o			
Clematis vit-alba							
Corylus aveliana		r	r			o	
Crataegus monogyna	f	o	o	l/a	o	f	
Dactylorchis fuchsii			l/a				
Dactylorchis purpurella			r				
Dactylis glomerata			o				
Deschampsia caesipitosa			o		o		

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Eleocharis palustris			o				
Elodea canadensis			l/a		o		
Elodea nuttallii	d	a	l/d	o	a-d	l/d	a
Elodea canadensis x nuttallii		o	l/f		l/d		a
Epilobium hirsutum	f	f	f		o	o	l/d
Equiseteum fluviatile				o			
Equiseteum litorale			o	o			
Equiseteum palustre				o			
Equiseteum telmatia							
Fagus sylvatica							
Filipendula ulmaria	a	o	f		f	f	o
Fraxinus excelsior		o				o	
Galium palustre	o	r	o	o	o	o	o
Galium saxatile			r				
Glyceria fluitans							o
Glyceria maxima	a	f	l/d	d	l/d	l/a	l/a
Heracleum spondylium		o	o	f	o	o	l/a
Hottonia palustris			o				
Hydrocharis morsus-ranae		f	l/a				
Hydrocotyle vulgaris			l/a				
Impatiens glandulifera							
Iris pseudacorus		o	o	o	o	o	

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Juncus acutiflorus			o				
Juncus articulatus			o	o			
Juncus bulbosus var. fluitans			l/a				
Juncus conglomeratus			o	o			
Juncus effusus	a	o	o	l/a	l/f	r	
Juncus inflexus	f		o	o	o		o
Juncus sub-nodulosus			r				
Lemna gibba							
Lemna minor	o	o	o	l/d	l/d	o	l/a
Lemna minuta							
Lemna trisulca		o	o	o	o	o	o
Lotus corniculatus	f		o				
Luronium natans				**r**	**r**	**o**	**o/f**
Lycopus europaeus	o	o	o	o	o	o	o
Lychnis-flos-cuculi			o				
Lythrum salicaria			o	o			o
Mentha aquatica	o	o	o	o			o
Mimulus guttatus			o	o			
Myosotis scorpioides		o	o		o		o
Myosotis secunda			r				
Myosoton aquaticum			o	o	o		
Myriophyllum alterniflorum							

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Myriophyllum spicatum		o				o	
Nasturtium officinale			l/a				
Nymphaea alba							
Nuphar lutea		f	l/a			l/a	l/a
Oenanthe crocata			o	o	f	o	o
Oenanthe fistulosa				**r**	**r**		
Peplis portula			o				
Persicaria amphibia		o				o	
Persicaria hydropiper				o	o		
Petasites hybridus	r	o	o	o		o	
Phalaris arundinacea	f		o		l/a		
Phragmites australis			l/a				
Phyllitis (Asplenium) scolopendrium							
Plantago lanceolata		o	o	o		o	o
Plantago major	o	o	o	o		o	o
Populus alba							
Potamogeton alpinus		o	l/a				
Potamogeton berchtoldii							
Potamogeton crispus			o				
Potmogeton compressus						**l/a**	**d**
Potamogeton friesii							
Potamogeton natans		a	r		l/f	o	

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Potamogeton obtusifolius		a				f	
Potamogeton pectinatus							
Potamogeton perfoliatus						o	
Potamogeton praelongus							
Potamogeton pusillus							
Potamogeton trichoides							
Pteridium aquilinum		r					
Quercus sp.		o		o			
Ranunculus circinatus			o				
Ranunculus flammula			l/d				o
Ranunculus repens							
Ranunculus sceleratus				o	o		
Rorippa microphylla							
Rorippa sylvestris							
Rosa canina			r	r		r	
Rubus fruticosus agg.	r	a	o	o		o	o
Rumex conglomeratus		o	o				
Rumex hydrolapathum		o	o	l/f	l/f	o	
Rumex obtusifolius			r				
Salix alba	r	o			l/d		
Salix aurita							

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Salix cinerea		o	o	o	l/d	o	
Salix fragilis							
Sambucus nigra		o	o	o			
Sarothamnus scaparius							
Schoenoplectus lacustris							
Scrophularia auriculata		o			o	o	
Scutellaria galericulata							
Senecio aquaticus							
Senecio jacobea			o				
Sonchus arvensis	r	o	o	o		o	o
Solanum dulcamara		o	o	o	l/a	o	
Sparganium emersum			l/f			o	o
Sparganium erectum			f/a	l/f	l/a	f	f
Spirodela polyrhiza							
Stachys palustris	o		o	o	o	o	
Symphytum officinale			o	o	l/a	o	
Taraxacum officinale agg.	o	o	o	o		o	o
Tussilago farfara			o			o	
Typha latifolia	a		l/a	l/a	l/a	o	l/f
Ulmus glabra						r	
Ulex europaeus			l/a				l/a

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Urtica dioica	o	o	o	o		o	o
Vicia cracca	f	o	o	o		o	
Valeriana officinalis					r		
Veronica beccabunga							
Zannichellia palustris			o				
Charophytes							
Chara globularis			l/d				
Nitellids							
Nitella flexilis							
Nitella mucronata var. gracillima							
Mosses/Bryophytes							
Fontinalis antipyretica			r				
Liverworts							
Riccia fluitans							
Algae							
Mougeotia/Spirogyra	a/ ld	r	l/d	o		o	l/a
Cladophera glomerata agg.							
Hydrodictium reticulatum							
Blue green alga	o						

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