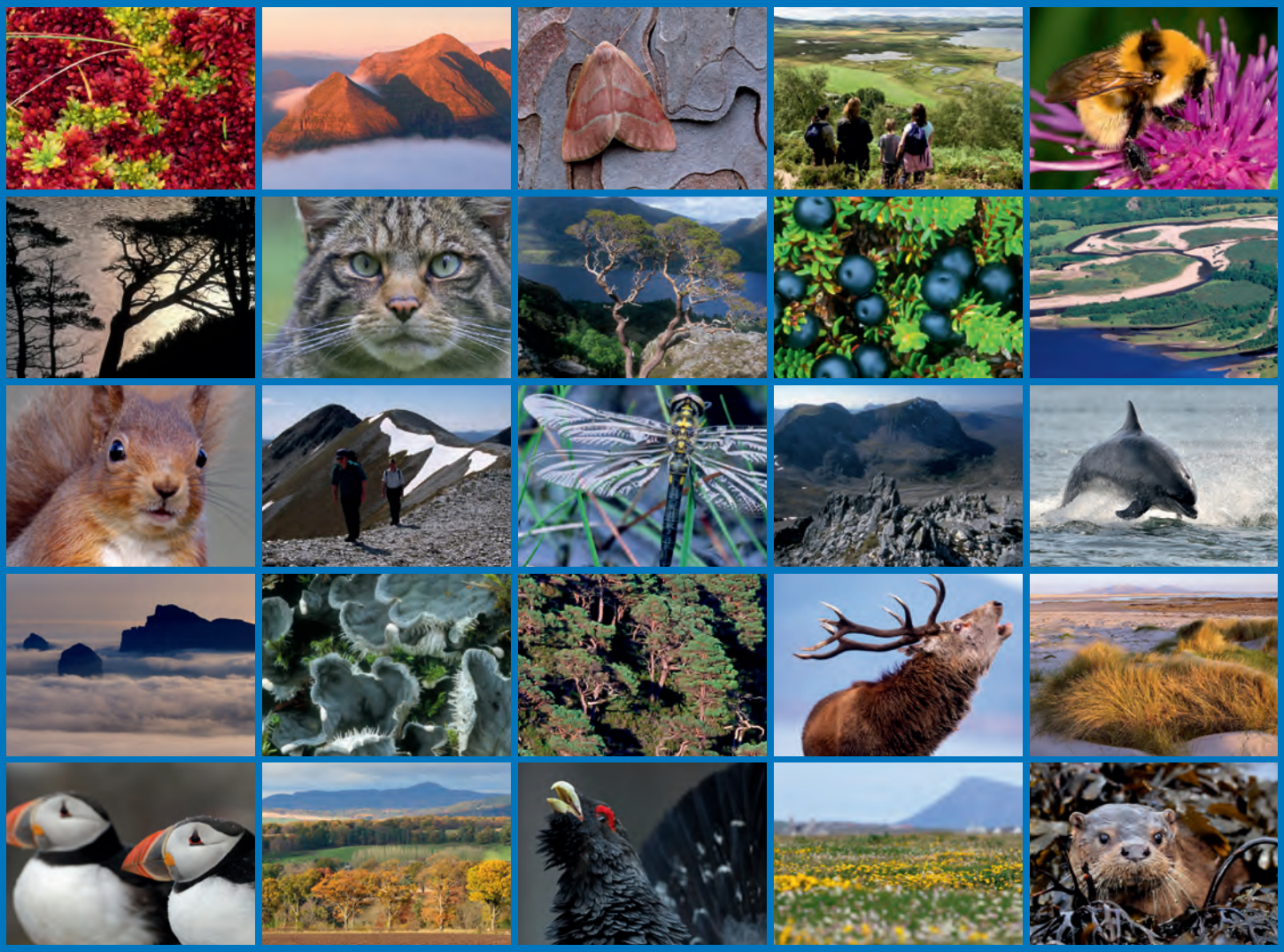
Scottish Natural Heritage
Commissioned Report No. 483

Control of New Zealand pygmyweed (*Crassula helmsii*) at Mochrum Lochs SSSI: phase I, 2007 – 2008



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COMMISSIONED REPORT

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Control of New Zealand pygmyweed (*Crassula helmsii*) at Mochrum Lochs SSSI: phase I, 2007 – 2008

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COMMISSIONED REPORT

Summary

Control of New Zealand pygmyweed (*Crassula helmsii*) at Mochrum Lochs SSSI: phase I, 2007 – 2008

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Background

New Zealand Pygmyweed (*Crassula helmsii*) is an invasive, non-native, aquatic plant species, which is particularly competitive within the drawdown zone of standing water bodies, as it can survive periods of desiccation. It tolerates a wide range of conditions of substrate and water chemistry and is able to regenerate from very small fragments. These attributes have resulted in the rapid colonisation of habitats and dominance of *C. helmsii* over native species in standing water bodies throughout mainland Britain.

C. helmsii was recorded in Mochrum Loch in 2004. The Mochrum Lochs site is designated as a SAC due to the international importance of its bog habitats. Mochrum Lochs SSSI is designated for features of interest which include oligotrophic lochs, blanket bog and breeding bird assemblages. The SSSI includes three water bodies: Castle Loch, Black Loch and Mochrum Loch, along with extensive areas of wetland. The presence of *C. helmsii* in Mochrum Loch means that this SSSI is in unfavourable condition, so a programme of survey and management was instigated, aimed ultimately at eradication of the species from this site. The work is taking place within the Species Action Framework. In phase I of the programme, the three lochs of the SSSI were surveyed, to examine the extent of colonisation by *C. helmsii* and to describe the native flora. Management strategies were considered and shading implemented as the initial control strategy.

Main findings

- A survey of Castle and Black Lochs in September 2007 indicated that these water bodies remain free of *C. helmsii*.
- A variety of native species were recorded in all three lochs of the SSSI.
- Weed control fabric was installed to shade the *C. helmsii* in Mochrum Loch.
- Fixed transects were established at Mochrum Loch and a baseline survey of percentage cover of each species present was undertaken.
- Further measures will be required to continue to control the growth and spread of *C. helmsii* within Mochrum Lochs SSSI.

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Acknowledgements

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1. INTRODUCTION

New Zealand pygmyweed (*Crassula helmsii*) is an invasive, non-native plant, which grows in standing water, marginal and wetland habitats, where it is able to establish and spread rapidly. *C. helmsii* is a monoecious perennial (Preston and Croft, 1997), which regenerates from small fragments, and can rapidly colonise and dominate a plant community. Due to its highly competitive nature and ability to produce dense stands of vegetation, it is believed to be a significant threat to native species of aquatic and riparian vegetation, in the sites to which it is introduced (Kemp and Birkinshaw, 2005). A native of Australia, Tasmania and New Zealand, the species was first sold in Britain as a plant suitable for outdoor ponds in 1927 (Preston and Croft, 1997). The timing of its first release to the wild is unknown, but a naturalised population was recorded in 1956 (Laundon, 1961; in Preston and Croft, 1997). Available records suggest that the distribution of *C. helmsii* increased most rapidly between 1980 and 1990 (Willby, 2008). However, although the rate of spread appears to have decreased in recent years, C. *helmsii* has been recorded from areas of conservation importance, such as Brown Moss, Swanholme Lakes and Hatchet Pond in England (Kemp and Birkinshaw, 2005). In Scotland, there are records for 53 populations, of which it is likely that 45-50 remain extant (Willby, 2008).

C. helmsii is present in Mochrum Lochs Special Area of Conservation (SAC), where it was first recorded during Site Condition Monitoring (SCM) in 2004. This site is situated in south-west Scotland (Figure 1, Appendix 1). It is designated an SAC due to the international importance of its blanket bogs and blanket bog depressions on peat substrates. Mochrum Lochs Site of Special Scientific Interest (SSSI) is of national importance for its standing waters and associated aquatic ecology. Breeding birds and blanket bog are also notified under the SSSI. The standing water feature of interest includes Mochrum Loch, Castle Loch and Black Loch (Figure 2, Appendix 1), as these standing waters were judged to be the best examples of lowland oligotrophic waters in the District.

Mochrum Loch supports macrophyte species typical of oligotrophic to mesotrophic lake types, including *Isoetes lacustris*, *Littorella uniflora* and *Lobelia dortmanna*. In addition to these three isoetid species, Black Loch also supports a fourth plant of this type, *Subularia aquatica*. However, a number of the macrophyte species observed in the loch are more usually associated with eutrophic conditions, e.g. *Lemna minor* and *Potamogeton crispus*. Elevated concentrations of total phosphorus (TP) and algal blooms have been recorded in Mochrum Loch, indicating that nutrient enrichment is occurring within the water body. This may exacerbate the growth of *C. helmsii* in the loch, as invasive non-native plants may become a greater problem in enriched water bodies, if they have strategies for dealing with low or variable levels of CO_2 in the water column (e.g. the ability to use bicarbonate or respiratory CO_2), and/or are able to assimilate nutrients through the leaves. As *C. helmsii* tolerates a variety of conditions, from nutrient-poor and acidic, to eutrophic or calcareous (Preston and Croft, 1997), this suggests that *C. helmsii* may be adapted in such ways.

Due to the presence of *C. helmsii* in Mochrum Loch, the SSSI is in unfavourable condition. It is therefore necessary to attempt to eradicate the species from this site. As *C. helmsii* is a threat to biodiversity, it is included in the Species Action Framework (SAF) (http://www.snh.gov.uk/protecting-scotlands-nature/species-action-framework/).This initiative was developed to support delivery of the requirements of the Nature Conservation (Scotland) Act 2004 and the Scottish Biodiversity Strategy. Since the SAF promotes targeted management of *C. helmsii*, it was appropriate to undertake management of *C. helmsii* under the SAF programme.

The aims of the present project were as follows:

- to determine the distribution and abundance of *C. helmsii* at Mochrum Loch;

- to survey Castle Loch and Black Loch to search for *C. helmsii*;
- to determine the distribution and abundance of native macrophyte species;
- to set up fixed transects to allow collection of data in a repeatable manner during subsequent surveys;
- to consider options for control, and design and implement a plan for management of *C. helmsii*; and
- to make recommendations for future management of *C. helmsii* at this site.

2. METHODS

2.1 Survey methods

Surveys of Mochrum Loch, Black Loch and Castle Loch were undertaken in a manner which was consistent with the Nature Conservancy Council/SNH Scottish Loch Survey Method (Lassiere, 1998), but also included examination of quadrats in fixed transects. As the main aim of the survey was to ensure accurate recording of the presence, abundance and locations of *C. helmsii*, detailed survey of the entire bank and photic zone of each water body was undertaken.

2.2 Aquatic habitats

Aquatic macrophyte survey within Mochrum Loch was undertaken from a rigid inflatable boat (RIB), which was navigated by ECUS ecologists with Royal Yachting Association (RYA) power boat handling qualification, level 2. Two experienced macrophyte surveyors carried out the survey. The boat was manoeuvred around the margins of the entire loch, survey effort focusing on shallow water, marginal shelf areas of up to 1.5 m in water depth, as this is the likely extent of *C. helmsii* colonisation. Surveys extended into deeper water where necessary, to ensure thorough coverage of the site.

Water clarity in all lochs was excellent at the time of survey, enabling the survey to be undertaken on the basis of visual inspection only, without the use of grapnels, which may cause fragments of *C. helmsii* to break off and colonise new areas. The distribution and extent of *C. helmsii* were mapped in the field. Note was made of the presence, location and abundance of other key macrophyte species recorded on the day of survey.

To facilitate future monitoring works, fixed transects were established in *C. helmsii* infested areas throughout Mochrum Loch. Six transects were examined, each incorporating five 2m x 2m quadrats. Thirty quadrats were therefore studied. Where *C. helmsii* extended further than 2-4 m into the main body of the loch, quadrats were arranged as contiguous transects, which extended perpendicular to the lake's margin, from the shoreward limit of *C. helmsii* infestation, to the lakeward limit. Where the gradient of the lake's basin was steep, transects were fixed parallel to the shore. For each quadrat, percentage cover was recorded for each species observed. Locations of transects are illustrated in Figure 3 (Appendix 1) and listed in Table 1 (Appendix 2).

Survey of Castle Loch and Black Loch was undertaken using a combination of wader survey and strandline survey, as these water bodies were too shallow for use of a boat to be practicable. Survey was undertaken by pairs of experienced surveyors. One surveyor walked the strandline, whilst the other waded through the photic zone in a zig-zag pattern. Aquatic and emergent vegetation species present were recorded, along with an indication of their relative abundance.

2.3 Terrestrial habitats

Bankside habitat checks were made on foot and by boat, depending on local site conditions and *C. helmsii* was recorded on maps.

In order to cover terrestrial habitats effectively, surveyors worked in pairs, walking the lake's edge in a zig-zag fashion, covering the likely areas of infestation. Note was made of any wet areas away from the lake's edge that may be subject to infestation by *C. helmsii* and specific checks were made of these sites.

Characteristic bankside vegetation species were noted along with their relative abundances.

2.4 Limitations of survey

The main focus of survey was recording the distribution, abundance and extent of colonisation of Mochrum Loch, Black Loch and Castle Loch, by *C. helmsii*, with additional species information being gathered to facilitate future monitoring of vegetation communities.

However, survey was undertaken in mid/late September 2007, outside the optimal period for vegetation survey, in particular for aquatic macrophyte survey in northern areas. Whilst this time of year represents an ideal time for survey of *C. helmsii*, which persists throughout the winter months, it was noted at the time of survey that much of the aquatic vegetation was experiencing seasonal die-back and it is likely that other macrophyte species were under-recorded. Species records obtained from Mochrum, Castle and Black Lochs should therefore be considered to be indicative.

In addition, access on foot to areas of the bank was restricted over some of Mochrum Loch due to health and safety constraints that prohibited bank access in several areas. However, the affected areas were located well above the water level and did not comprise low-lying or damp habitats likely to be colonised by *C. helmsii*. In addition, banks that were not accessible on foot were inspected from the boat using binoculars.

Whilst access restrictions resulted in some loss of information in recording of bankside communities, it is not considered to have resulted in under-recording of *C. helmsii* present within the site.

3. SURVEY RESULTS

3.1 Mochrum Loch

C. helmsii was recorded as a frequent component of the vegetation community within Mochrum Loch. The species had a scattered distribution around much of the loch's margins. The extent and distribution of *C. helmsii* within Mochrum Loch is shown in Figure 4 (Appendix 1). Grid references of locations at which *C. helmsii* was recorded are included in Table 2 (Appendix 2).

Away from the margins, the banks of the loch are steeply sloping and water depths of over 3 m are present throughout the majority of the water body. Typically, *C. helmsii* does not grow at depths of greater than around 1.5 m and this is reflected in the records of distribution of this species in Mochrum Loch, where it is restricted to shallow margins and bays.

The distribution of *C. helmsii* was focused 'downwind' of the area proximate to the road, which is the only part of the water body that is readily accessible. A high concentration of *C. helmsii* is present in this area and the pattern of distribution of this species suggests that colonisation of the loch may have resulted from introduction of *C. helmsii* to this area.

The patches of *C. helmsii* present were generally restricted in extent and the species did not yet dominate the banks of the loch, to the exclusion of other plant species, in the majority of locations. However, coverage is becoming extensive, particularly in windward bays, where it was starting to dominate the macrophyte community. Aquatic *C. helmsii* was generally absent in areas where bankside woodland communities shaded the adjacent loch.

No *C. helmsii* was recorded in terrestrial habitats around the loch. These habitats were dominated by woodland throughout much of the northern, western and southern shores. With the exception of shallow bay areas, the banks in these sections typically comprised vertical or near-vertical rocks, of between 0.5 and 1.5 m in height. This means that the adjacent terrestrial habitats are not characterised by low-lying marshy areas, which would be more likely to be colonised by *C. helmsii*.

The eastern bank of Mochrum Loch is characterised by more gently-shelving margins, along most of its length, although a bank height of approximately 0.5 m is common in some areas. Comprehensive inspection of this bank was possible and no *C. helmsii* was found to be established above the winter water level.

Based on GPS recording and vegetation mapping undertaken on site, it was estimated that approximately 1 ha of *C. helmsii* was present within the loch's margins, at the time of survey.

Other species forming key components of the aquatic vegetation communities at Mochrum Loch included willow moss (*Fontinalis antipyretica*), quillwort (*Isoetes lacustris*), common duckweed (*Lemna minor*), curled pondweed (*Potamogeton crispus*) and perfoliate pondweed (*Potamogeton perfoliatus*). A list of aquatic, emergent and bankside species recorded at the site is included in Table 3 (Appendix 2), along with the relative abundance of each species throughout the loch as a whole. Quadrat data are included in Table 4 (Appendix 2).

3.2 Castle Loch

Castle Loch is located to the west/north west of Mochrum Loch and is part of the Mochrum Lochs SAC. The centre of the loch is located at approximately NGR NX286 538. The habitats surrounding the loch differ in nature to those at Mochrum Loch, being more exposed, with less shading of the loch's margins by adjacent trees.

No *C. helmsii* was recorded at Castle Loch. The vegetation communities of the loch were characterised by large beds of *I. lacustris*, which is present in the margins and extends for much of the photic zone. Water lobelia (*Lobelia dortmanna*) occurred occasionally within the quillwort beds. Other species present included broad-leaved pondweed (*Potamogeton natans*), amphibious bistort (*Persicaria amphibia*), and *P. crispus*. Full species records are included in Table 3 (Appendix 2).

3.3 Black Loch

Due to the relatively inaccessible nature of the site and shallow nature of the water body, a boat was not used for undertaking survey of Black Loch. However, because the loch is shallow, it is considered that sufficient access was gained using wader survey, to enable the communities present to be recorded and any occurrence of *C. helmsii* to be identified.

The vegetation communities of Black Loch were characterised by quillwort with occasional water lobelia. The other submerged/floating-leaved species recorded were *F. antipyretica*, a stonewort species (*Nitella* species) and bog pondweed (*Potamogeton polygonifolius*). A list of all species recorded from Black Loch and their relative abundance is included within Table 3 (Appendix 2).

No *C. helmsii* was recorded from Black Loch at the time of survey, so this species is not considered to be present at the site.

4. CONSIDERATION OF OPTIONS FOR CONTROL OF *C. HELMSII*

4.1 Chemical control

Chemical control has been found to be effective for treating both terrestrial and aquatic growth forms of *C. helmsii*. Terrestrial and emergent growth forms respond well to treatment with glyphosate-based products, applied with a spray applicator, at temperatures above 5 °C.

Aquatic growth has previously been treated with diquat-based products. However, this chemical has now been banned and is no longer available. In 2007/08, the only available aquatic herbicide suitable for control of *C. helmsii* is dichobenil, which is available under a variety of brand names.

Dichlobenil is effective at controlling *C. helmsii* and is available in a granular form. Using a special applicator, the granules are applied in a net pattern over infested areas. The granules have a dual effect, killing plants that come into contact with them and forming a temporary chemical layer that persists for several months and prevents regrowth of plant material, within the application footprint, for an entire growing season.

Chemical control of aquatic weed species tends to be successful whilst plants are actively growing. As *C. helmsii* continues to grow throughout the winter months, this represents less of a constraint to treatment of this species than with other aquatic plants. Applications of non-persistent aquatic herbicides have been found to be effective when applied in January and February. In addition, the persistent nature of dichlobenil is such that timing of application is less critical than for non-persistent herbicides, as control continues after application.

Where access is available, machinery can be used to remove treated material from water bodies, in order to prevent de-oxygenation of the surrounding environment. However, in view of the localised nature of the infestations at Mochrum Loch and the large size of the water body, mechanical removal is considered unlikely to be necessary or practicable. In addition, access around the loch with heavy machinery has potential to damage habitats for which the area is designated an SAC and, further, ground conditions are largely unsuitable for access with heavy machinery.

An advantage of chemical control is that it is relatively easily achieved, even in large water bodies, as large areas can be covered rapidly and the applicator allows accurate and targeted application of chemical.

Herbicide treatment also minimises the risk of disturbance and subsequent fragmentation of *C. helmsii*, as no direct contact with plant material is required.

However, consent for use of herbicides must be obtained from the appropriate statutory authority (the Scottish Environment Protection Agency (SEPA) in Scotland), prior to works being undertaken and consents may take several weeks to obtain. This can limit the timescales over which works can be undertaken. In addition, use of herbicides can be impractical or unacceptable at some sensitive sites.

Whilst the persistent nature of dichlobenil can be seen as representing an advantage in control of *C. helmsii*, it may also represent a disadvantage at sites where aquatic macrophyte communities of conservation importance co-exist with *C. helmsii*, as is the case at Mochrum Loch. Application of diquat has been undertaken at other sites of conservation importance, during the winter months, enabling treatment of *C. helmsii* and subsequent recolonisation by other aquatic macrophyte species during the following growing season.

However, the persistent nature of dichlobenil will temporarily prevent such regrowth occurring in the areas of treatment and therefore will have greater impacts on the native flora of the water body.

If herbicide treatment were to be progressed at Mochrum Lochs, it would be recommended that an initial treatment be undertaken in winter. The effectiveness of the treatment would then be monitored initially between 2 and 4 weeks following application, once the effects of application could be observed. Further monitoring would then be recommended, once the main growing season commenced, but before other plant species were fully established, for example, in early May. This would allow any need for follow-up applications to be identified and treatment to be undertaken.

4.2 Physical control - shading

Shading *C. helmsii* with heavy-duty polythene or tarpaulin, held *in situ* with heavy rocks, has proven a successful method of control and eradication in a number of locations. The material must be left in place for several months if treatment is to be effective. The Royal Society for the Protection of Birds (RSPB) found that keeping plants covered for 6 months was sufficient to kill *C. helmsii* at a site in the south of England (Wilton-Jones, 2005).

In view of the relatively shallow depths at which *C. helmsii* occurs in Mochrum Loch, it is likely that control using weed control fabric (WCF) could be achieved at the site. Installation of WCF could be undertaken by teams of three people. Corners of fabric could be weighted with stones from within the loch, to prevent introduction of foreign substrates into the water. Alternatively, where softer substrates exist, purpose-made plastic pegs could be used to attach the fabric to the lake bed. These would be removed on completion of works.

Following completion of installation of material, it is recommended that a follow-up monitoring visit would be undertaken approximately 2 months after treatment. This would enable the progress of treatment measures to be checked, along with the condition of the sheeting. Any repairs required would be made as part of this process.

As with chemical control, all works should be carried out in consultation with the local SNH office, landowners and local authorities, with whom close contact should be maintained for the duration of the project.

As physical control is a long-term process, the exact timing of initial installation of sheeting is not critical. The key requirement is that conditions must be good enough to enable patches of *C. helmsii* to be readily identified and sheeting to be installed. Low wind speeds and bright weather conditions are ideal for installation of sheeting.

Assuming that suitable weather conditions occur, it may be preferable to undertake initial control works outside the main macrophyte growing season, for example between October and March. During this period other plant species will have undergone winter die-back and *C. helmsii* should be most readily detected within the water. In addition, whilst *C. helmsii* persists throughout the winter, it grows less readily at this time and there is likely to be less risk of fragmentation of plant material if the works are undertaken during the winter months, as individual vegetation strands will be shorter than during the growing season. In addition, previous works undertaken by ECUS have indicated that small fragments of *C. helmsii* are less likely to become established when works are undertaken during the winter period.

This method has the advantage of not requiring the use of chemicals, which can be unacceptable in some locations. However, the method is likely to be more costly in terms of materials and is labour-intensive to implement. In addition, it will not always be practical to

exclude non-target species from the shaded area. A further drawback is that sheeting is susceptible to damage from both adverse weather conditions and vandalism.

At this site, use of WCF, rather than polythene sheeting would be expected to minimise the risk of damage to the shading material, as WCF is less prone to tearing under physical stress than polythene, for example, if rubbed against rocks, as would be likely to occur through wave action at Mochrum Loch.

Another advantage of physical control is that it would not require licensing by SEPA and therefore can be initiated over a shorter timescale than chemical control.

4.3 No control

If *C. helmsii* is not controlled at Mochrum Loch, it is likely that it will continue to colonise the photic zone and become more dominant in the emergent and marginal vegetation communities. It is likely that the existing botanical interest will decline at the site. In addition, if colonisation is allowed to continue, it is likely to become more difficult to control the species, should management be proposed in future.

As no records were made of *C. helmsii* from Castle Loch or Black Loch, no control methods are required at those locations at this time. However, due to the close proximity of Castle Loch to Mochrum Loch and the presence of livestock, which appear free to move between the banks of the two water bodies, Castle Loch is considered at high risk of colonisation by *C. helmsii* in the future, unless control of *C. helmsii* in Mochrum Loch is achieved.

Should control of *C. helmsii* not be undertaken at Mochrum Lochs at this time, it would be recommended that Castle Loch be re-surveyed, prior to any such works being undertaken in future, to assess whether *C. helmsii* had become established in the intervening period. If future control works are not proposed, it would be recommended that re-survey of Castle Loch would be undertaken at regular intervals, to check for the presence of *C. helmsii*. Ideally, survey intervals should not exceed six years.

Monitoring of Black Loch is also recommended, although this water body is likely to be at lower risk of infestation by *C. helmsii* than Castle Loch, as it is not as closely linked to Mochrum Loch.

5. IMPLEMENTATION OF CONTROL MEASURES AT MOCHRUM LOCH

The risk posed by *C. helmsii*, to the habitat of Mochrum Lochs SSSI, is considered too great to allow selection of the option of taking no action. However, there is normally a presumption against use of herbicide in water bodies constituting standing water features of designated sites. Consequently, physical control was selected as the appropriate action in the first instance. Should that action fail to eradicate *C. helmsii* completely, localised use of herbicide would then be considered, since the risk to the feature from the *C. helmsii* would be considered greater than the risk from herbicide. However, due to use of shading first, the quantity of herbicide required would be expected to be less than if this option were selected in the first instance.

Physical control of *C. helmsii* at Mochrum Loch was begun in February and March 2008. The use of WCF, rather than polythene sheeting, was adopted at Mochrum Loch, to minimise the risk of damage to the shading material. Submerged and marginal areas of *C. helmsii* colonisation were covered with WCF.

Installation of WCF was undertaken by teams of two to six people, depending on the extent of individual infestations. Installation teams included personnel in chest waders, who operated in the shallower areas, and teams in drysuits to enable accurate placing of material in deeper areas. Photographs illustrating the installation process and WCF in place in edge and submerged habitats are presented in Appendix 3.

WCF of 2 m width was utilised during the initial treatment visit. Where infestations of *C. helmsii* of greater than 2 m width were present, lengths of fabric were sewn together on the bank, to create larger sheets of 4 or 6 m width. This approach was preferred, as it was considered that overlaying narrower sections without joining materials increased the risk that layers would separate under adverse weather conditions. It was considered that this could result in either too much light being allowed to penetrate to enable control of *C. helmsii* to be achieved, or individual sheets to come adrift within the loch.

The risk of WCF coming adrift under adverse weather was not considered likely to apply to infestations of *C. helmsii* that were less than 2 m wide. This is because these areas were located within a very narrow band, on the lake's margin and as such, were typically more sheltered and less susceptible to disturbance, than sections of fabric located within the deeper areas, closer to the centre of the loch.

However, sewing of long lengths of fabric (up to 50 m) on site was found to be very labour-intensive and was also considered to represent a health and safety risk to staff undertaking the work, due to the stationary nature of the work and the prolonged exposure of staff undertaking this element of the works to adverse weather conditions.

During subsequent visits, fabric widths of either 2 m or 5 m were utilised, with choice of width of fabric being dependent on the conditions at specific locations. Lengths of fabric were unrolled on the bank and cut to length as appropriate to the size of individual areas of colonisation. Any loose threads along cut edges were removed and edges were folded under to minimise the risk of fraying of material. Fabric sheets were lowered into the water slowly, to minimise disturbance to and potential fragmentation of *C. helmsii*.

Initially, corners of fabric were weighted in place with stones from within the loch, to aid the initial sinking of the material. However, it was discovered during the initial field trials, that material tended to billow when secured solely in this manner. It was considered that this increased the risk of fabric becoming loose in some locations, so where soft substrates exist, WCF control pegs were used to secure the edges of fabric, particularly around the strandline.

Occasionally, during implementation of control measures, patches of free-floating and fragmented *C. helmsii* were noted that had not been evident at the time of the original survey. It is considered likely that adverse weather conditions immediately prior to implementation of control measures had fragmented strands of *C. helmsii* previously contained within identified patches. There is a risk that a proportion of free-floating material may become established within the lake system in the spring.

The locations of the WCF are shown in Figure 5 (Appendix 1) and Table 5 (Appendix 2).

The dates on which works were undertaken and the numbers of people required to undertake the installation work are included in Table 6 (Appendix 2).

6. RECOMMENDATIONS FOR FUTURE WORK

It is recommended that a follow-up monitoring visit be undertaken approximately 2 months after installation of WCF. This would enable both the progress of treatment measures and the condition of the sheeting to be assessed. Any repairs required should be made as part of this process.

Material on windward shores should be checked more frequently if possible, particularly around the lay-by area, as this area is highly susceptible to strong winds and wave action, so material is likely to survive less well than material in more sheltered areas.

The opportunity should be taken as part of this monitoring to resurvey the loch to locate any patches of *C. helmsii* that may have become established from fragments of floating vegetation since the time of treatment. The opportunity could be taken to treat any such patches with WCF, as undertaken previously.

The WCF must be left in place for several months if treatment is to be effective. Work previously undertaken by the RSPB has found that keeping plants covered for 6 months was sufficient to kill *C. helmsii* at a site in the south of England (Wilton-Jones, 2005).

A further visit should be made approximately 6 months after installation of shading material in September 2008. The extent of die-back of areas of *C. helmsii* underneath the sheeting should be checked at a representative sample of treated locations. It is suggested that partial removal of approximately 10 areas of fabric located in different habitat/microclimate types around the loch should be undertaken in order to check the progress of works. Areas subject to partial removal should be replaced prior to leaving the site.

It is important to note that lower stems and roots of *C. helmsii* can remain viable after the visual appearance of the plant suggests that it has died. It would be advisable at this point to remove small samples of 'whole plant' material from the loch and to attempt cultivation prior to removal of shading fabric. Extreme care must be taken in this process, to ensure that fragments of potentially active material are not spread either within the loch, or off site. It is recommended that plant material is transported in sealed containers to minimise such risks.

Removal of WCF from the loch is recommended prior to winter 2008/2009, as winter storms are considered likely to disturb and damage the WCF. As discussed above, this is a particular concern along the windward shore. In addition, the area adjacent to the lay-by is subject to ongoing disturbance, from local user groups and bird watchers, and fishermen were observed standing on areas of installed fabric, during ongoing installation works. This will subject the installed fabric to excessive wear and tear. It is recommended that the opportunity be taken to include signage, detailing the nature and purpose of works, within the lay-by area and requesting that people avoid disturbing the installed fabric.

If *ex situ* cultivation indicates that plant material within the loch is no longer viable, it is likely to be appropriate to remove shading material. If feasible, it is strongly recommended that the opportunity should be taken on completion of removal of shading material to spot treat any areas of remaining *C. helmsii* with an appropriate herbicide approved for aquatic use, such as dichlobenil. Use of dichlobenil would be expected to limit the growth of *C. helmsii* for the entire growing season following application.

Alternatively, the opportunity may be taken to relocate or replace areas of shading WCF in remaining areas of infestation. However, this is less likely to achieve complete control, than combining use of WCF with targeted and localised use of appropriate herbicides.

Whilst removal of WCF will be less labour-intensive than the original installation work, it is important to note that patches of fabric are currently secured with large numbers of stones and rocks, which extend across the entire width and length of each sheet. In order to undertake removal, without compromising health and safety, provision should be made for removal of fabric, by teams comprising a minimum of 4 people. For health and safety purposes, such teams should include a minimum of one person holding RYA or equivalent powerboat handling certificate and one person equipped with a dry suit.

Future works should take account of the high level of wear and tear on the equipment that is associated with undertaking this type of work. Over the course of a two week period, it can be expected that neoprene waders, neoprene gloves, drysuits and boat propellers will require replacement or repair.

As with many invasive weed species, the complete eradication of *C. helmsii* from a site is likely to be a difficult process and only possible over the course of a number of growing seasons. If this target is to be achieved, it may be impractical to avoid herbicide use completely in future. Ongoing monitoring and control is likely to be required over perhaps a three to five year period, although the lack of similar comparable projects means that exact timescales are difficult to specify.

Future monitoring works should have two main aims. The first of these is to check the status of *C. helmsii* within the lake and inform future control works required. This will require full survey of the loch, as undertaken as the initial stage of these works.

The second purpose of monitoring is to investigate the success of recolonisation of treated areas by native aquatic macrophyte species. This element of monitoring should comprise the resurvey of quadrats in fixed transects, recording the percentage cover of macrophyte species present. *C. helmsii* does not reproduce from seed. However, it is anticipated that regeneration of native aquatic and marginal plants from the seed bank will occur, with early-colonising species likely to be most dominant over the first few years following treatment. The communities present are likely to stabilise over time and increasingly resemble the communities present within areas unaffected by *C. helmsii*.

7. REFERENCES

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APPENDIX 1: FIGURES

Figure 1. The location of Mochrum Lochs SSSI

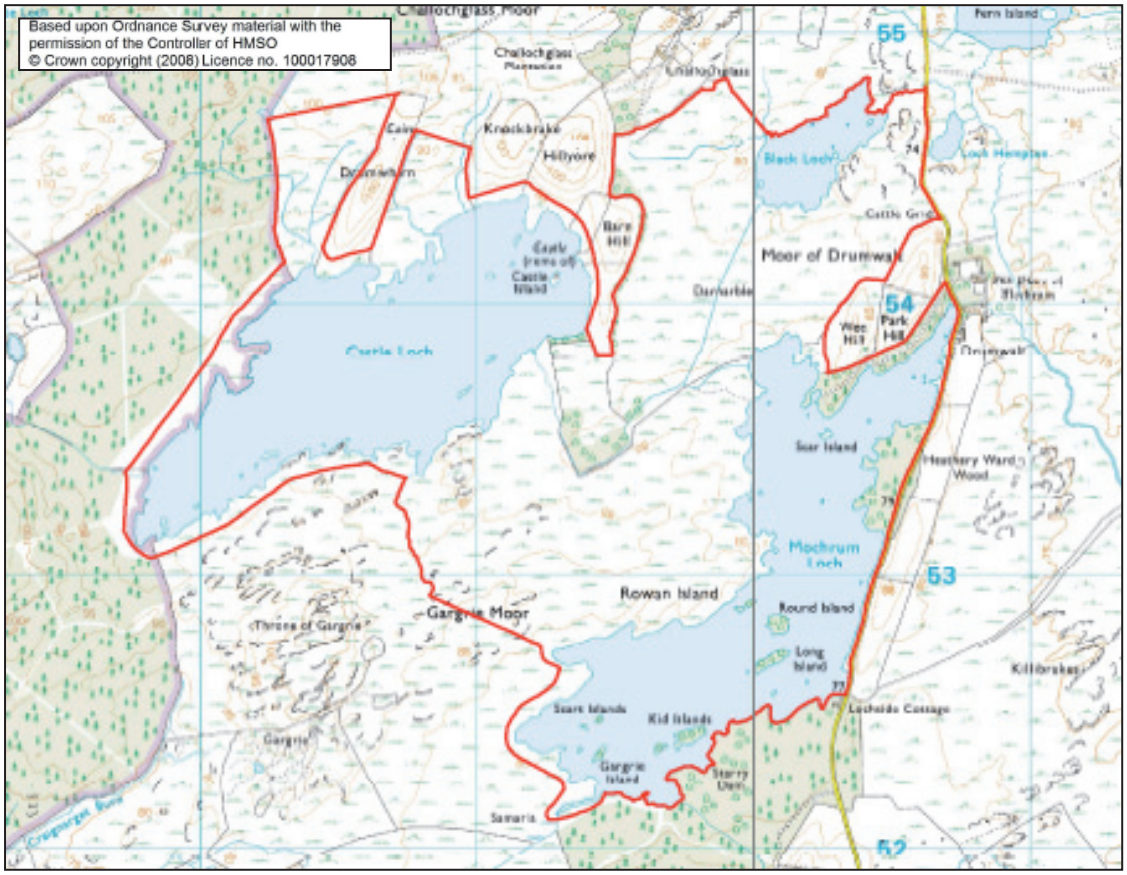

Figure 2. The boundary of Mochrum Lochs SSSI

Figure 3. Locations of transects on Mochrum Loch

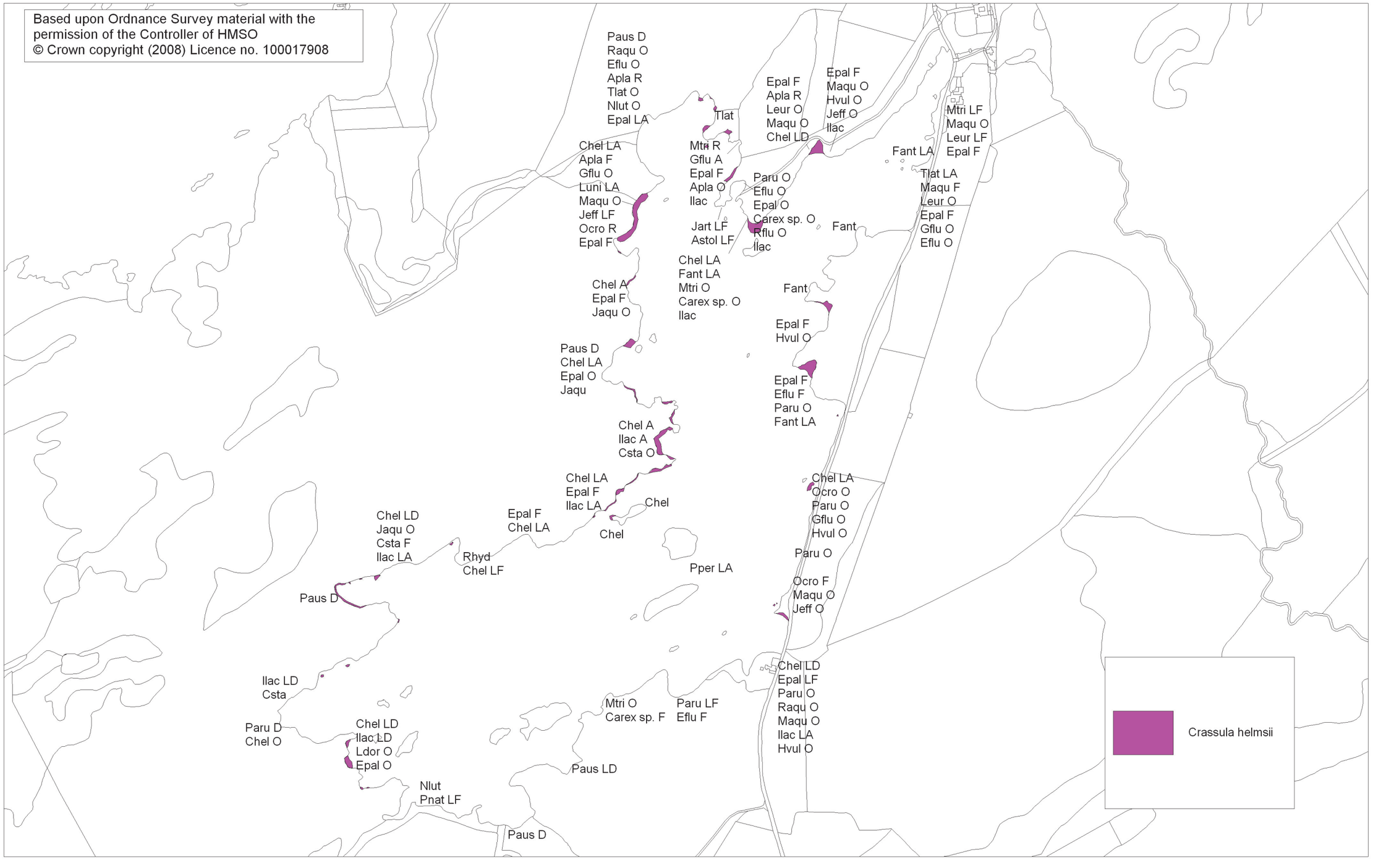

Figure 4. Distribution and abundance of macrophyte species in Mochrum Loch, September 2007.

Key to codes used in Figure 4

Latin Name	Common Name	Code used
Agrostis stolonifera	Creeping bent	Astol
Alisma plantago-aquatica	Water-plantain	Apla
Callitriche stagnalis	Common water-starwort	Csta
Crassula helmsii	New Zealand pigmyweed	Chel
Eleocharis palustris	Common spike-rush	Epal
Equisetum fluviatile	Water horsetail	Eflu
Fontinalis antipyretica	Willow moss	Fant
Hydrocotyle vulgaris	Marsh pennywort	Hvul
Isoetes lacustris	Quillwort	Ilac
Juncus acutiflorus	Sharp flowered rush	Jaqu
Juncus articulatus	Jointed rush	Jart
Lobelia dortmanna	Water lobelia	Ldor
Nuphar lutea	Yellow water-lily	Nlut
Oenanthe crocata	Hemlock water dropwort	Ocro
Phalaris arundinacea	Reed canary-grass	Paru
Potamogeton natans	Broadleaved pondweed	Pnat
Potamogeton perfoliatus	Perfoliate pondweed	Pper
Ranunculus aquatilis	Common water-crowfoot	Raqu
Typha latifolia	Bulrush	Tlat
Juncus effusus	Soft rush	Jeff
Mentha aquatic	Water mint	Maqu
Menyanthes trifoliata	Bog bean	Mtri
Lycopus europeaus	Gypsywort	Leur
Rumex hydrolapthum	Water dock	Rhyd
Littorella uniflora	Shoreweed	Luni
Ranunculus flammula	Lesser spearwort	Rflu
Phragmites australis	Common reed	Paus
Glyceria fluitans	Floating sweet-grass	Gflu

DAFOR scale
D - dominant
A - abundant
F - frequent
O - occasional
R - rare
L - preceding terms in the above scale indicates local distribution, i.e. LA - locally abundant.
DAFOR ratings refer to the areas in which the species were found and are not limited to areas in which *C.helmsii* was present.

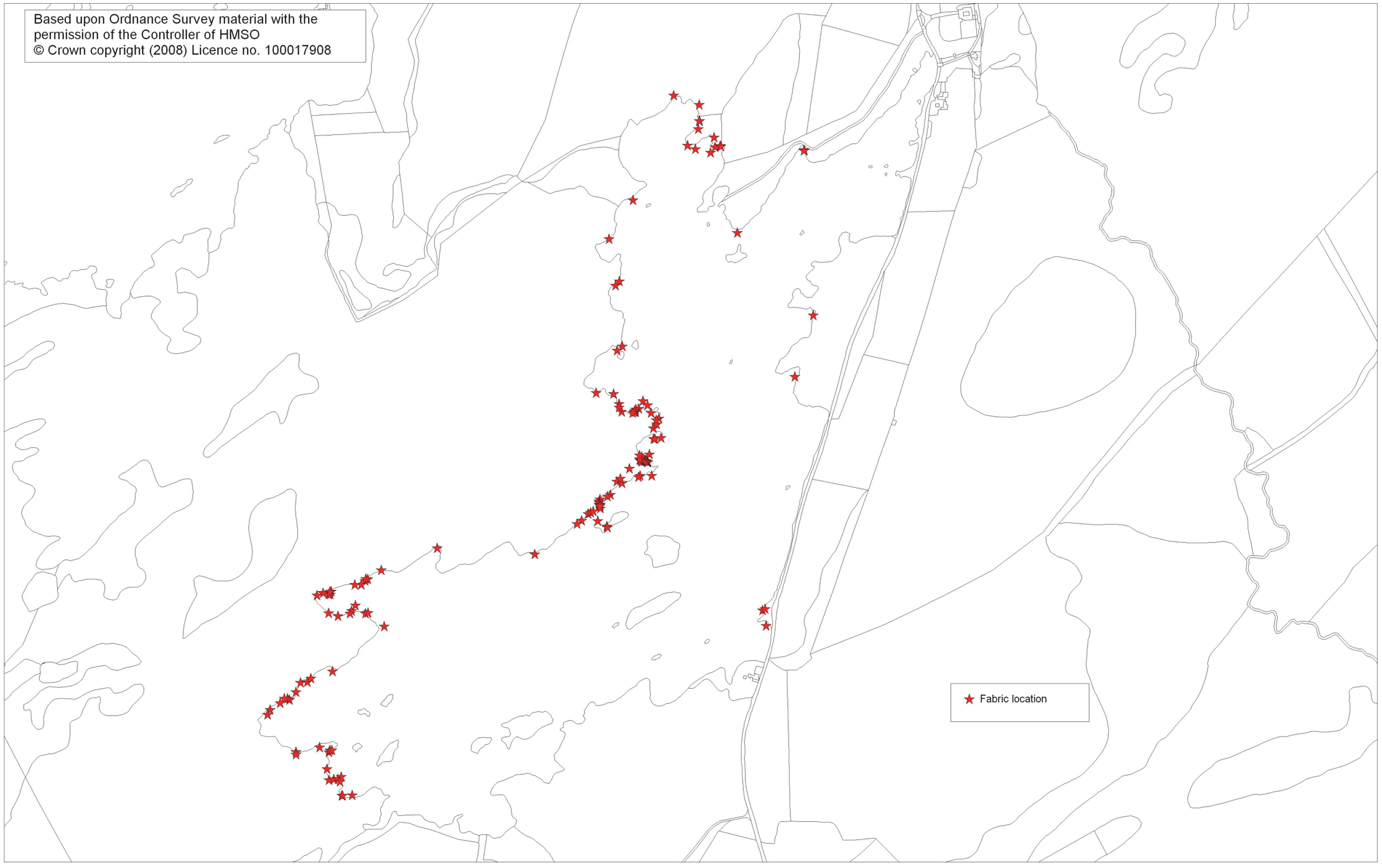

Figure 5. Locations of weed control fabric installed on Mochrum Loch, February to March 2008

APPENDIX 2: TABLES

Table 1. Locations of quadrats in transects in Mochrum Loch, 2007

Transect	Start		End		Centre	
	x	y	x	y	x	y
T1	230418.93	552965.26	230399.58	552970.56	230409.73	552967.73
T2	230410.81	553254.14	230395.20	553241.55	230403.64	553248.23
T3	229987.69	553618.13	229998.73	553634.67	229991.75	553627.53
T4	229992.50	553311.67	230006.05	553296.90	229998.95	553304.70
T5	229309.97	552299.14	229303.71	552313.06	229302.09	552303.98
T6	230327.57	552594.75	230331.86	552614.32	230329.83	552605.04

Table 2. Locations of New Zealand pygmyweed recorded during original survey in September 2007

Waypoint	Position	Elevation	Easting	Northing
3	NX 30401 53235	83 m	230401	553235
4	NX 30444 53380	75 m	230444	553380
5	NX 30423 53769	83 m	230423	553769
6	NX 30422 53768	81 m	230422	553768
7	NX 30265 53574	73 m	230265	553574
9	NX 30166 53772	75 m	230166	553772
10	NX 30019 53651	78 m	230019	553651
11	NX 29969 53552	79 m	229969	553552
12	NX 29987 53460	79 m	229987	553460
13	NX 29978 53450	79 m	229978	553450
14	NX 29994 53307	79 m	229994	553307
15	NX 29982 53297	80 m	229982	553297
16	NX 29973 53195	78 m	229973	553195
17	NX 29986 53171	88 m	229986	553171
18	NX 30025 53152	81 m	230025	553152
19	NX 30043 53178	77 m	230043	553178
20	NX 30080 53137	79 m	230080	553137
21	NX 30075 53123	80 m	230075	553123
22	NX 30068 53089	81 m	230068	553089
23	NX 30040 53047	78 m	230040	553047
24	NX 30058 53052	79 m	230058	553052
25	NX 30063 53002	83 m	230063	553002
26	NX 30036 53002	80 m	230036	553002
27	NX 30032 52999		230032	552999
28	NX 29993 52984	82 m	229993	552984

29	NX 29966 52957	82 m	229966	552957
30	NX 29959 52953	82 m	229959	552953
31	NX 29941 52934	84 m	229941	552934
32	NX 29942 52925	84 m	229942	552925
33	NX 29936 52895	82 m	229936	552895
34	NX 29898 52896	78 m	229898	552896
35	NX 29557 52831	81 m	229557	552831
36	NX 29387 52754	82 m	229387	552754
37	NX 29378 52745	82 m	229378	552745
38	NX 29307 52729	81 m	229307	552729
39	NX 29305 52722	80 m	229305	552722
40	NX 29301 52722	80 m	229301	552722
41	NX 29364 52696	76 m	229364	552696
42	NX 29355 52683	78 m	229355	552683
43	NX 29432 52647	76 m	229432	552647
44	NX 29310 52541	81 m	229310	552541
45	NX 29251 52516	81 m	229251	552516
46	NX 29302 52350	77 m	229302	552350
47	NX 29297 52311	78 m	229297	552311
48	NX 29332 52248	78 m	229332	552248
49	NX 29334 52248	79 m	229334	552248
50	NX 29357 52249	77 m	229357	552249
51	NX 30333 52648	82 m	230333	552648
52	NX 30325 52685	77 m	230325	552685
53	NX 30331 52688	76 m	230331	552688

Table 3. Macrophyte survey data from surveys of Mochrum Loch, Castle Loch and Black Loch

Mochrum Loch

	Scientific name	Common name	Abundance
Submerged /floating aquatic macrophytes	*Alisma plantago-aquatica*	Water-plantain	O
	Callitriche platycarpa	Various-leaved water-starwort	R
	Callitriche stagnalis	Common water-starwort	O
	Crassula helmsii	New Zealand pygmyweed	LA
	Fontinalis antipyretica	Willow moss	LA
	Isoetes lacustris	Quillwort	LD
	Lemna minor	Common duckweed	LF
	Nuphar lutea	Yellow water-lily	R
	Potamogeton natans	Broad-leaved pondweed	R
	Potamogeton perfoliatus	Perfoliate pondweed	LF
	Ranunculus aquatilis	Common water-crowfoot	O
Marginal /emergent species	*Agrostis stolonifera*	Creeping bent	F
	Carex aquatilis	Water sedge	F
	Carex species	Sedge species	LF
	Eleocharis palustris	Common spike-rush	LF
	Epilobium palustre	Marsh willowherb	F
	Equisetum fluviatile	Water horsetail	LF
	Hydrocotyle vulgaris	Marsh pennywort	A
	Juncus acutiflorus	Sharp flowered rush	F
	Juncus articulatus	Jointed rush	F
	Juncus species	Rush species	LF
	Oenanthe crocata	Hemlock water dropwort	O
	Phalaris arundinacea	Reed canary-grass	LF
	Typha latifolia	Bulrush	LF
Bankside species	*Agrostis stolonifera*	Creeping bent	O
	Calluna vulgaris	Common heather	D
	Galium sp	Bedstraw species	O
	Molinia caerulea	Purple moor-grass	LD
	Myrica gale	Bog-myrtle	F
	Pteridium aquilinum	Bracken	LF
	Sphagnum species		LA

Black Loch

	Scientific name	Common name	Abundance
Submerged /floating aquatic macrophytes	*Fontinalis antipyretica*	Willow moss	LD
	Isoetes lacustris	Quillwort	D
	Lobelia dortmanna	Water lobelia	O
	Nitella species	Stonewort species	LA
	Potamogeton polygonifolius	Bog pondweed	LD
Maringal /emergent species	*Alisma* species	Water plantain species	O-F
	Carex aquatilis	Water sedge	LD
	Hydrocotyle vulgaris	Marsh pennywort	LF
	Juncus acutiflorus	Sharp-flowered rush	F-LA
	Juncus articulatus	Jointed rush	O
	Mentha aquatica	Aquatic mint	O
	Phalaris arundinacea	Reed canary grass	LA
	Ranunculus ficaria	Lesser celandine	R
	Ranunculus flammula	Lesser spearwort	O-F
Bankside species	*Calluna vulgaris*	Heather	F
	Erica tetralix	Cross-leaved heath	O
	Eriophorum vaginatum	Hare's-tail cotton grass	LF
	Festuca ovina	Sheep's fescue	LD
	Isolepis setacea	Bristle club-rush	LF
	Molinia caerulea	Purple moor grass	F-LA
	Myrica gale	Bog-myrtle	F
	Potentilla erecta	Tormentil	O
	Pteridium aquilinum	Bracken	LD
	Scabious species	Scabious species	O
	Sphagnum cuspidatum		O
	Sphagnum fallax		O
	Sphagnum palustre		O
	Sphagnum papilosum		O

Castle Loch

	Scientific name	Common name	Abundance
Submerged /floating aquatic macrophytes	*Callitriche hamulata*	Intermediate water-starwort	O
	Callitriche stagnalis	Common water-starwort	F
	Fontinalis antipyretica	Willow moss	LA
	Galium species	bedstraw species	O
	Isoetes lacustris	Quillwort	D
	Lemna minor	Common duckweed	A
	Lobelia dortmanna	Water lobelia	R
	Persicaria amphibia	Amphibious bistort	O
	Potamogeton crispus	Curled pondweed	A
	Potamogeton natans	Broad-leaved pondweed	A
	Potamogeton obtusifolius	Blunt-leaved pondweed	O
	Potamogeton perfoliatus	Perfoliate pondweed	A
	Potamogeton polygonifolius	Bog pondweed	LD
	Ranunculus aquatilis	Common water-crowfoot	O
Maringal /emergent species	*Caltha palustris*	Marsh marigold	R
	Hydrocotyle vulgaris	Marsh penny wort	LA
	Juncus acutiflorus	Sharp flowered rush	LD
	Juncus articulatus	Jointed rush	LD
	Mentha aquatica	Water mint	LA
	Menyanthes trifoliata	Bogbean	M
	Oenanthe crocata	Hemlock water dropwort	O
	Ranunculus flammula	Lesser spearwort	F-LA
Bankside species	*Agrostis stolonifera*	Creeping bent	O
	Deschampsia cespitosa	Tufted hair grass	O
	Eriophorum vaginatum	Hare's-tail Cottongrass	F
	Filipendula ulmaria	Meadowsweet	LF
	Holcus lanatus	Yorkshire fog	LA
	Juncus effusus	Soft rush	LA
	Juncus species	Rush species	LF
	Lythrum salicaria	Purple-loosestrife	O
	Molinia caerulea	Purple moor grass	LA
	Myrica gale	Bog myrtle	O
	Potentilla anserina	Silver weed	O
	Pteridium aquilinum	Bracken	LA
	Rumex acetosella	Sheep's sorrel	F
	Sphagnum cuspidatum		LA

Sphagnum fallax		O
Sphagnum palustre		O
Sphagnum papilosum		O
Vaccinium myrtillus	Bilberry	LF
Vicia species	Vetch species	O

Table 4. Percentage cover by macrophytes, information on substrate and water depth in transects in Mochrum Loch

Transect 1					
Transect type	Boat Transect				
	Quadrat				
Species	**1**	**2**	**3**	**4**	**5**
Crassula helmsii	60	35	5	0	0
Hydrocotyle vulgaris	15	15	0	0	0
Galium palustre		8			
Oenanthe crocata	5	0	0	0	0
Phalaris arundinacea	10	0	0	0	0
Mentha aquatica	15	10	5		
Fontinalis antipyretica	0	5	65	20	5
Bare substrate	0	30	25	80	95
Water depth	0.5 m	0.9 m	1.4 m	> 2 m	> 2 m
Substrate type	Cobble with some humus	Cobble	Cobble	Large cobble/ bedrock	Large cobble/ bedrock

Transect 2					
Transect type	Boat Transect				
	Quadrat				
Species	**1**	**2**	**3**	**4**	**5**
Eleocharis palustris	25	1	0	15	0
Mentha aquatica	10	1	1	0	5
Phalaris arundinacea	15	0	5	0	0
Glyceria fluitans	10	0	0	0	10
Crassula helmsii	90	90	70	35	20
Typha latifolia	0	0	1	0	0
Carex species	0	0	0	10	0
Alisma plantago-aquatica	0	0	0	2	2
Potamogeton crispus	0	0	0	0	5
Potamogeton perfoliatus	0	0	0	0	5
Fontinalis antipyretica				35	40
Bare substrate	0	0	5	10	25
Water depth	0.5 m	0.6 m	0.8 m	1.4 m	1.7 m
Substrate type	Humus/ leaf litter	Humus/ leaf litter	Humus/ leaf litter	Cobble	Cobble

Transect 3					
Transect type	Shore Transect				
	Quadrat				
Species	**1**	**2**	**3**	**4**	**5**
Glyceria fluitans					
Alisma plantago-aquatica	2	8	8	5	5
Epilobium palustre	8	8	10	8	10
Mentha aquatica					
Crassula helmsii	85	95	95	85	75
Oenanthe crocata	2				2
Juncus effusus		5		5	10
Equisetum fluviatile	5		2		2
Ranunculus flammula	2				2
Hydrocotyle vulgaris	5			5	
Water depth	0.55	0.6 m	0.65	0.6	0.6
Substrate type	cobble/ gravel	cobble/ gravel	cobble/ gravel	cobble/ gravel	cobble/ gravel

Transect 4					
Transect type	Boat Transect				
	Quadrat				
Species	**1**	**2**	**3**	**4**	**5**
Callitriche stagnalis	25	10	0	0	0
Crassula helmsii	90	90	75	10	0
Eleocharis palustris	10	10	8	0	0
Ranunculus flammula	2	0	0	0	0
Carex species	5	2	0	0	0
Alisma plantago-aquatica	10	10	2	0	0
Fontinalis antipyretica			5	45	45
Bare subtrate			15	50	55
Water depth	0.4 m	0.7 m	0.9 m	1.5 m	> 2 m
Substrate type	cobble/ gravel	cobble/ gravel	large cobble	large cobble/ rock	large cobble/ rock

Transect 5					
Transect type	Shore Transect				
	Quadrat				
Species	**1**	**2**	**3**	**4**	**5**
Crassula helmsii	75	55	70	65	45
Eleocharis palustris	10	15	15	10	15
Carex species		5			
Hypericum elodes	5			5	
Isoetes lacustris	35	55	35	35	65
Lobelia dortmanna	1	2	1	1	2
Potamogeton natans		5			
Bare substrate			15	50	55
Water depth	0.4 m	0.7 m	0.9 m	1.5 m	> 2 m
Substrate type	cobble/ gravel	cobble/ gravel	large cobble	large cobble/ rock	large cobble/ rock

Transect 6					
Transect type		Shore Transect			
	Quadrat				
Species	**1**	**2**	**3**	**4**	**5**
Crassula helmsii	45	45	65	25	25
Eleocharis palustris	5	5	0	15	10
Phalaris arundinacea	8	5	10	45	45
Ranunculus aquatilis	3	0	3	10	5
Mentha aquatica	4	4	0	0	10
Hydrocotyle vulgaris	5	5	2	0	0
Isoetes lacustris	65	65	45	0	0
Bare substrate	0	0	0	5	5
Water depth	0.4 m	0.7 m	0.9 m	1.5 m	> 2 m
Substrate type	cobble/ gravel	cobble/ gravel	large cobble	large cobble/ rock	large cobble/ rock

Table 5. Locations of weed control fabric covering New Zealand pygmyweed

Waypoint	Position	Elevation	Easting	Northing
16	NX 30115 53898	80 m	230115	553898
17	NX 30175 53876	74 m	230175	553876
18	NX 30176 53838	77 m	230176	553838
19	NX 30175 53838	77 m	230175	553838
20	NX 30173 53819	76 m	230173	553819
21	NX 30148 53780	72 m	230148	553780
22	NX 30210 53799	74 m	230210	553799
23	NX 30213 53776	77 m	230213	553776
24	NX 30225 53779	76 m	230225	553779
25	NX 30226 53778	77 m	230226	553778
26	NX 30202 53763	75 m	230202	553763
27	NX 29425 52779	65 m	229425	552779
28	NX 29393 52758	72 m	229393	552758
29	NX 29389 52759	76 m	229389	552759
30	NX 29363 52745	79 m	229363	552745
31	NX 29304 52728	77 m	229304	552728
32	NX 29288 52725	77 m	229288	552725
33	NX 29274 52720	77 m	229274	552720
34	NX 29301 52678	76 m	229301	552678
35	NX 29321 52660	74 m	229321	552660
36	NX 29353 52666	74 m	229353	552666
37	NX 29388 52677	78 m	229388	552677
38	NX 29394 52679	77 m	229394	552679
39	NX 29259 52524	76 m	229259	552524
40	NX 29235 52514	74 m	229235	552514
41	NX 29224	74 m	229224	552492

Waypoint	Position	Elevation	Easting	Northing
	52492			
42	NX 29209 52474	75 m	229209	552474
43	NX 29204 52477	74 m	229204	552477
44	NX 29197 52477	74 m	229197	552477
45	NX 29187 52466	76 m	229187	552466
46	NX 29163 52450	76 m	229163	552450
47	NX 29157 52439	77 m	229157	552439
48	NX 29224 52351	77 m	229224	552351
49	NX 29224 52345	74 m	229224	552345
50	NX 29280 52362	76 m	229280	552362
51	NX 29304 52355	75 m	229304	552355
52	NX 29309 52355	75 m	229309	552355
53	NX 29302 52285	76 m	229302	552285
54	NX 29313 52286	76 m	229313	552286
55	NX 29323 52287	77 m	229323	552287
56	NX 29331 52292	77 m	229331	552292
57	NX 29328 52281	77 m	229328	552281
58	NX 29887 52888	78 m	229887	552888
59	NX 29787 52817	77 m	229787	552817
60	NX 29913 52912	73 m	229913	552912
61	NX 29919 52915	76 m	229919	552915
62	NX 29925 52918	76 m	229925	552918
63	NX 29941 52946	76 m	229941	552946
64	NX 29941 52946	76 m	229941	552946
65	NX 29939 52942	76 m	229939	552942
66	NX 29939 52939	76 m	229939	552939
67	NX 29939	76 m	229939	552934

Waypoint	Position	Elevation	Easting	Northing
	52934			
68	NX 29941 52933	75 m	229941	552933
69	NX 29941 52930	75 m	229941	552930
70	NX 29941 52930	75 m	229941	552930
71	NX 29957 52882	56 m	229957	552882
72	NX 29959 52880	56 m	229959	552880
73	NX 29981 52988	79 m	229981	552988
74	NX 29989 52995	80 m	229989	552995
75	NX 30011 53019	79 m	230011	553019
76	NX 30054 53034	80 m	230054	553034
77	NX 30053 53033	80 m	230053	553033
78	NX 30051 53036	79 m	230051	553036
79	NX 30050 53036	78 m	230050	553036
80	NX 30048 53037	78 m	230048	553037
81	NX 30046 53036	78 m	230046	553036
82	NX 30040 53035	77 m	230040	553035
83	NX 30037 53037	77 m	230037	553037
84	NX 30035 53039	77 m	230035	553039
85	NX 30035 53041	77 m	230035	553041
86	NX 30034 53050	78 m	230034	553050
87	NX 30071 53089	47 m	230071	553089
88	NX 30085 53091	60 m	230085	553091
89	NX 30067 53114	69 m	230067	553114
90	NX 30074 53133	74 m	230074	553133
91	NX 30062 53150	73 m	230062	553150
92	NX 30053 53168	78 m	230053	553168
93	NX 30033	76 m	230033	553160

Waypoint	Position	Elevation	Easting	Northing
	53160			
94	NX 30025 53158	76 m	230025	553158
95	NX 30023 53154	76 m	230023	553154
96	NX 30022 53152	75 m	230022	553152
97	NX 30018 53150	74 m	230018	553150
98	NX 29992 53153	76 m	229992	553153
99	NX 29986 53163	74 m	229986	553163
100	NX 29932 53197	77 m	229932	553197

Table 6. Timing of installation of WCF and number of person-days taken

Date	**Number of workers**
19th February 2008	4
20th February 2008	4
21st February 2008	4
17th March 2008	6
18th March 2008	6
19th March 2008	6
20th March 2008	6
25th March 2008	5
26th March 2008	4
27th March 2008	4
28th March 2008	4
11 days in total	**53 person-days in total**

Note
Table 5 does not include travel time, but represents the number of full person-days on site, which were required to install the WCF.

APPENDIX 3: PHOTOS

Plate 1. Installation of WCF at Drumwalt Plantation/Scar Islands

Plate 2. WCF installed at the bay adjacent to Park Hill

Plate 3. Installation of WCF at Heathery Ward Wood, south bay

Plate 4. WCF installed over Wee Hill Cove strand line

Plate 5. A small patch of WCF on the west shore/Gargrie Moor

Plate 6. Installation of WCF on west shore, opposite Rowan Island

Plate 7. Rock placement at bay on west shore north of Rowan Island

Plate 8. Boulder placement and folded edge of WCF

Plate 9. Weighting the join between two lengths of fabric

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