Lye Valley SSSI North Fen

Vegetation Transect investigation of the drying effect of brook bank erosion

North Fen SSSI unit 1

(Natural England condition assessment ‘Unfavourable Recovering’)

Data recorded on 14.06.2013, 21.06.2013 and 04.07.2013

Collected by Dr Judith A Webb

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Contents

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Aim:
To investigate the effect of drying of the brook marginal zone on the composition of fen vegetation. Adjacent to the fen, flash-flooding has caused erosion and lowering of the brook bed by at least 1 metre. This will have lowered the water table in the adjacent peat, resulting in drier conditions at the surface and a change in plant community. This study should provide evidence of the width of the zone of plant community change.

1.0 Introduction and Background

This site (1.8 ha, site centre SP 548057) is in the ownership of Oxford City Council. The North Fen contains 19 plants which are on the draft Rare Plants Register for the county (see Appendix 1 for list). The Register is currently in production by the Ashmolean Natural History Society of Oxfordshire (ANHSO). Full species lists for the site can be obtained from the Thames Valley Environmental Records Centre (TVERC). A full report for Oxford City Council on the possible effect of housing on nearby land on the wildlife of the SSSI is presented in Webb (2007). I have also completed two further botanical and invertebrate reports on the site for Oxford City Council (Webb, 2008 & 2009). Some of the information below is from an unpublished Draft Management Plan for the site produced in about 1986 by Oxford City Council.

Calcareous fens are spring-fed ecosystems where the water level is maintained at the peat surface by flow from an aquifer. In this case the aquifer is the Jurassic Corallian limestone and the springs emerge on both east-facing and west-facing slopes at the junction of this permeable limestone with the impervious Oxford Clay below.

Just over 1m of peat and tufa exists under the current vegetation on the east side. It is presumed that this represents the early post glacial only, subsequent peat accumulation having been removed for fuel. Tufa (calcite) formation is known to remove and lock up phosphate, so that plant growth is restricted.

Historically, since the cessation of rough grazing in the early 1900s the margins of the fen site had become colonised by dense reed or scrub. By the early 1980s, a short, biodiverse, fen community was restricted to the central area, approximately 20m in length and situated in the middle of the east side, with devil's bit scabious, marsh lousewort, marsh helleborine, bog pimpernel, grass of Parnassus, few-flowered spike rush, cotton grasses, tawny sedge, marsh

arrowgrass and dioecious sedge. In this short central area sundew was last seen in about 1964 and butterwort in 1994. This is still the area where most plants show nutrient deprivation, being short and yellowed. Much tufa formation is visible here, as the high calcium spring water will have locked away phosphate in the limey deposit. This explains how this valuable community was able to survive in the absence of grazing for approximately 90-100 years. Photographs taken by Henry Taunt in about 1910 show no trees and very little reed.

Whilst allotments remained at the very head of the valley, housing development started on the higher land around either side of the valley slopes from the 1930s. The valley sides were steepened from their natural shallow slopes by the pushing of material from the level ground of the housing areas into the valley, resulting in very steep slopes (tipped embankments) above the spring lines on each side at the top end of the valley. Road surface drainage was directed into the Lye Brook at the head of the valley. Sewers were routed through the valley, including through the most valuable area of fen on the east side.

The site was the target of much fly tipping in the years to 1978, when it was all cleared. However, this tipping left the site with a problem population of Japanese knotweed on the west side above the actual SSSI area. This patch is now much reduced from the extensive patch which was once present.

East side fen after cutting and raking in autumn

The newly set-up Countryside Service of Oxford City Council began management in the North Fen area in 1985, starting with the removal of willow scrub that surrounded the small open area that remained on the east side. In addition, reed mowing and raking happened every year on the whole area of the level part of the east side, which has had more than 20 years of such management. The winching out of willow trees has left valuable warm shallow pools, which are now important breeding sites for darter dragonflies and scarce-to-rare soldierflies, craneflies and water beetles. The very local marsh whorl snail *Vertigo antivertigo* is found throughout the site, as are glow-worms. Lizards and grass snakes are occasionally found basking in the fen.

East side, volunteers raking and removing reed, 2012

On the steeper west slopes, cutting was more difficult and only a firebreak set of corridors were mown through the reed, which was otherwise left alone. Arson attacks happened

regularly on the reed that was adjacent to the footpath on this west side and the breaks prevented it all burning at once. Arson attacks (usually in late spring to dry old reed before new growth) have had the effect of stimulating reed growth on this side, so that with a history of no cutting it is a virtual monoculture except in the firebreak areas. Some previously burnt areas now have reed with an understory of nettle, a species known to be encouraged by nutrient release.

The northern end of the West side has an excellent tufa-producing spring, so is now undergoing reed cutting and raking twice yearly to remediate it to the short fen that would have been here under grazing. So far, three of the rare plants have recurred here from buried seed: marsh lousewort, parsley water-dropwort and marsh valerian. A big flush of commoner desirable species such as hemp agrimony and yellow flag iris is also noticeable following this management.

West side of fen, ex-arson area adjacent to path, uncut for many years and progressed to reed monoculture

Remedial cutting and raking to previously reed-dominated west side fen, 2013.

1.1 Current management regime

An early cut and rake of the most reed-dominated areas only happens sometime from the end of June to mid-July. This deprives the reed's underground rhizome of nutrition, thus resulting in shorter reed the following year and reduction of its shading, so a more biodiverse community of short fen species can thrive.

Sometime in October a cut and rake of the whole of the level east side is carried out. Cut material is raked by volunteers to habitat piles adjacent to the stream. This second cut removes tall, shading, vegetation, removes nutrients and gets light down to the peat surface to stimulate seed germination. The poaching from the footprints of the rakers assists in bringing buried seed to the surface, so it can germinate.

Cutting and raking of reed and tall vegetation twice a year has been extended to the north end of the west side of the fen for the last 2 years in order to remediate the fen. Historic vegetation maps in NE records indicate past presence of short diverse fen in this area and the plan is to bring this back.

There is annual Japanese Knotweed herbicide treatment by rhizome injection.

1.2 Hydrological damage and historical information on this site

Flash-flooding from road run-off from the Thames Water surface water drain at the head of the valley is a known problem. Stream-bed lowering affects the water table in the nearby banks. As the stream bed lowers, the water table closest to the stream will be pulled down by hydrostatic pressure. Eventually the water table further away from the stream in the fen vegetation will also drop, causing unfavourable dry conditions.

A draft management plan for the Lye Valley produced about 1986 by Oxford City Council contains historical information on the cause of the erosion of the banks of the Lye Brook, quoting data from an undergraduate project completed by Alistair Sandels, a student at Oxford Brookes University, which measured bank losses in 1979. It has not been possible to locate a copy of this original project, but a summary of the author's findings is in the management plan. A photocopy of the relevant page of the management plan is presented in Appendix 2, along with details from the management plan of remediation for the erosion which was carried out in the North Fen area in 1985.

1.3 Previous plant survey data

Brian Smith, an undergraduate at Oxford Brookes University, carried out a north-south vegetation transect across the valley in 1975 but did not state its exact location. His study shows a short fen with cotton grasses, blunt-flowered rush, sedges and mosses occupying a 10m-wide zone on the east-side fen. His pollen and seed study of the peat deposit indicates that Hydroseral succession started in an aquatic pool or small lake environment and progressed to a peat-forming community.

A survey in 1989 by Anita Diaz, also an undergraduate at Oxford Brookes University, presents plant lists and a vegetation map. This is useful to some degree (it shows where scrub used to be in areas that are now remediated to short fen) but a poor photocopy does not enable accurate identification of her vegetation zones, as they were apparently coloured in the original. It does enable the pinpointing of the position butterworts last existed, however.

Student identification skills will be variable and the time of year when a survey is undertaken may make things difficult. A number of key plant species are absent from their lists e.g. neither person found: *Carex dioica*, *Eleocharis quinqueflora*, *Triglochin palustre*, *Carex rostrata*, *Eriophorum angustifolium*, *Carex disticha,* all of which are present and important in the vegetation today. Maybe with improved management they have become more noticeable today.

Surveys by fen expert Wanda Fojt of EN (species list and one quadrat) in 1990, published 1991, identify the valuable vegetation present as NVC M13b black bog rush *Schoenus nigricans* - blunt flowered rush *Juncus subnodulosus* mire, quaking grass *Briza media* , butterwort, *Pinguicula vulgaris* sub-community (Rodwell, 1991). Butterwort was present in her quadrat but lasted for only a few more years on site (*Schoenus* no longer exists here today). I first started my surveys and research on site in 2003.

2.0 Methods

It was considered that belt transects were the most appropriate method for assessing the vegetation where there is an obvious gradual change in the plant community as the distance from the spring line to the brook edge increases. Levelling the transects might have been of use to determine the topography, but lack of time precluded this. The east side fen has only a very gentle slope towards the edge of the brook, but the west side fen has a much steeper slope.

Plant percentage cover was estimated. The accuracy of these estimates varies with the plant species involved. Broad-leaved species were fairly easily estimated, but those with similar long, narrow, leaves (marsh arrowgrass, few-flowered spike-rush, dioecious sedge, flea sedge) were very difficult to distinguish and the cover values for these cannot be very accurate.

The rough degree of wetness of the surface peat was recorded, as well as whether there was evident tufa formation or iron oxide deposition. An accurate assessment of soil water content would have been useful, but as what M13b vegetation and the rare invertebrates present need is almost constant water at surface level with shallow pools or runnels, the rough wetness score is adequate as an indicator of health of the habitat. At least a film of standing water at the surface is the key requirement. Tufa formation is an important guide as to whether the phosphate levels will be appropriately low, due to it being locked away in calcite precipitation.

As previous studies could not be accurately re-located, detailed descriptions of the current

transect positions are given in order that they might be fairly accurately re-located in the future for repeat assessment of vegetation condition.

2.1 East side

Just looking at the site, it is obvious that shorter vegetation is in the centre, where it is wetter and there are small pools. It is suggested this is because here is the biggest impact of emerging low-nutrient water. As the brook is approached the vegetation gets taller, as drier peat means in this area will mean more mineralisation with oxidising conditions and liberation of plant nutrients, stimulating growth. Vegetation height might have been a useful observation to record, but lack of time precluded this.

On the east side fen, spring flow is variable; some areas have a strong flow and others only a weak flow. Two areas were chosen that had what was judged to be average wetness for the site. The vegetation is patchy rather than uniform, so two different areas were chosen to reflect the range of fen plants.

Two transect lines were laid out running from the south-east bank base (upslope) to the north west (brook margin). In total both transects stretched for 16m of gently sloping fen surface on peat, roughly at right angles to the line of the brook.

Contiguous 1m x 1m quadrats were placed to the north of the line in both cases.

The end of each transect was on the bank at the point where there was approximately a 1m drop from the top of the bank to the stream water below. The 1m bank exposed in the stream channel at this point was composed mostly of an organic, dark, peat with whitish tufa areas .

Site 1 was chosen because it went through an area with few-flowered spike rush and good amounts of marsh lousewort, with the scarce tufa forming moss *Palustriella falcata*. It is thus probably in an area that was originally still open before scrub work started (personal observation that the scarce specialist mosses are very slow to colonise newly-cleared areas). The transect line ran from just north of a concrete lump at the spring line (SP54770 05822) to a point on the bank opposite a pollarded willow (SP54758 05827). Data collected in sunny dry weather on 14.06.2013.

Lye Valley North Fen, East side: Transect at site 1, data collected on 14.06.2013, photographs taken a couple of weeks later.

Site 1 transect position in centre of photo. Looking from brook across fen to spring line at edge of reeds and dry valley side with trees above

Start of transect 0m next to concrete lump at spring line, reed and blunt-flowered rush

Middle section of transect. Wet area with marsh lousewort prominent in vegetation.

End of transect 16m at brook bank. Tall herb vegetation on dry peat in front of pollard willow.

Site 2 was chosen in a contrasting area that was known to have gone to willow scrub before 1989 (Anita Diaz vegetation map and pers. comm. Anthony Roberts, ranger at the time). The pool in the centre will have been produced from winching out a willow tree. This transect went through patches of bottle sedge and marsh pennywort, not found in site 1 and thus presenting a contrasting wetland assemblage. The transect line ran from the base of a recently pollarded young grey willow (SP54795 05864) at the spring line, across the fen through a pool area to the stream bank opposite a young ash on the opposite side (SP54781 05871). Data was collected in dry weather on 04.07.2013. This transect had to be carried out after a marginal remediating cut had taken place to knock back the strong vegetation on the site margins, so no percentage data is available for the 2m and 14m positions.

Lye Valley North Fen, East side: Transect at site 2, 04.07.2013

Transect start 0m at break of slope just in front of willow stump

Middle of transect at 7m, short low nutrient fen vegetation and mossy tufa pool with stoneworts.

Approaching brook-side at 11-12m, recording in drier peat, vegetation here tall reed and dense blunt-flowered rush.

End of transect at 15-16m, cut path and tall herb vegetation and dry land plants opposite young ash tree.

2.2 West side

On this side, fen vegetation exists on a steeper slope, the spring flow is strong and tufa formation evident right down to the edge of the boardwalk. The sampling was done on 21.06.2013 before the first remedial reed cut, which happened on 30.06.2013.

A transect line was laid out from the base of a coppiced ash tree at the top of the slope to the north-west (SP54753 05878) in a strong spring area. The line was taken down diagonally south-east, through the best section of recovering fen to the boardwalk path by the stream, 5m before the bend in the path (SP54767 05853).

A 1m x 1m quadrat was laid down at 5m intervals down the slope to the north of the line. Plant percentage cover was estimated. There were few species due to previous reed dominance. The centre of the transect went through a shorter, more diverse, area, which had been cut for some previous years as a fire break. The bottom section of the transect was burnt-over in 2006 in an arson attack and thus has a more damaged flora, being reed dominated.

North Fen West side transect photos, 21.06.2013

Start of transect top of slope at Newly-coppiced ash tree 0m

Looking down transect from start at ash tree, dense reed dominated area, no previous cutting and raking history.

Middle section of transect, more open and diverse, tufa area, not reed-dominated, previous cutting as fire-break

Bottom end of transect, looking up from boardwalk through reed-dominated area (arson attack in 2006).

3.0 North Fen Area Results – East Side

Transect data is presented in the accompanying MS Word versions of Excel spreadsheets:

- East side, Site 1 (towards the southern end) - Appendix 5
- East side, Site 2 (towards the northern end) - Appendix 6.

3.1 At the East side, Site 1, it can be seen from the table that for the first 7m the surface of the fen peat was wet and from 3-5m and at 7m there were small open-water pools. Between 8 and 9m the surface of the fen peat became merely moist or actually dry and continued in this state to the brook margin at 16m. There were two areas where there was a sudden change in surface topography to a level some 30-40cm approx. lower ('step down' in the table). It is not known why this sudden change in topography happens, but one possibility is past peat slumping in sections, when erosion was most active before the 1985 remediation actions. Levelling the transect would have made this clear, but lack of time precluded this.

3.1.1 East side, Site 1: Discussion and Conclusions

When looking at the distance along the transect from the start at the spring line, rarer rich fen species (e.g. long-stalked yellow sedge, few-flowered spike rush, marsh helleborine, marsh arrow grass, claw-leaved hook-moss *Palustriella falcata*, yellow starry feather moss *Campylium stellatum*) disappear after 8-9m and more dry-tolerant plants of moist meadows (rough meadow grass, false oat grass, bugle) are seen for the first time. This can be interpreted as an indication that conditions, at least for some part of each year, are too dry for these specialist fen species. Marsh lousewort is an exception, in that it does continue beyond 9m but at very low levels. These were all small seedlings and it is possible that these might never mature to full-grown plants next year (this is a biennial species). Blunt-flowered rush exhibits its greater tolerance to dry conditions by continuing further to the brook edge

These results show that the rare flowering plants and bryophytes of rich fen (M13b) are restricted to the first 8m of the transect. From 8m to the brook edge a drier community exists, possibly fen meadow, or transitional to meadow. As water is at the surface for only the first 8m, active peat/tufa formation is restricted to this zone. This is the only zone where phosphate will be kept low by being bound in tufa precipitation. Beyond 8-9m to 16m, a distance of 7-8m, the peat is merely moist or dry, thus no new peat accumulation is happening. This dry peat will be vulnerable to oxidation in dry weather conditions. As tufa is not forming here and oxidation of peat will be occurring, more plant mineral nutrients (N and P) will be available. Visual inspection shows that common plants growing here are taller and more vigorous (e.g. reed), which probably reflects this higher level of nutrients available to them.

3.2 At the East side, Site 2 it can be seen from the table that for the first 9m the surface of the fen peat was wet and from 7-10m there was a substantial pool occupied by *Chara* stonewort. Between 10m and the brook edge at 16m the surface of the peat became merely moist or dry.

3.2.1 East side - Site 2: Discussion and conclusions

At this position, when looking at the distance along the transect from the start at the spring line, rarer rich fen species (e.g. marsh pennywort, marsh lousewort, parsley water dropwort, long-stalked yellow sedge, marsh helleborine, marsh arrow grass and bottle sedge) disappear after 11m and are replaced by more dry-tolerant common plants of moist meadows (fen bedstraw, meadow buttercup, marsh thistle, wild angelica, rough meadow grass, false oat grass, yorkshire fog, bugle), which are seen for the first time. The centre of the transect is occupied by a shallow pool with much bare peat, so all species are scarce except Chara stonewort algae. Near the brook edge at 15m even fairly tolerant blunt-flowered rush is lost and replaced by species tolerant of dry conditions and typical of hedgerows (hedge woundwort, garlic mustard, blackberry). The extreme bank edge is dominated by dense pendulous sedge tussocks. This last is known to favour watercourse edges and has tolerance to temporarily dry conditions. No rare bryophytes are present at this transect position, possibly because this area is one that had been colonised by willow scrub in the past and remediated from this state by scrub removal starting in the 1980s. The rarer bryophyte species are extremely slow colonisers (personal observation).

These results show that the rare flowering plants of rich fen (M13b) are restricted to the first 11m of the transect. From 11m to the brook edge a drier community exists, like fen meadow or meadow. As water is at the surface for only the first 10m, active peat/tufa formation is restricted to this zone. This is the only zone where phosphate will be kept low by being bound in tufa precipitation. Beyond 12m, up to the bank edge at 16m, for a distance of 5-6m, the peat is merely moist or dry, thus no new peat is accumulating. This dry peat will be vulnerable to oxidation in dry weather conditions. As tufa is not forming here and oxidation of peat will be occurring, more plant mineral nutrients (N and P) will be available. Visual inspection shows that plants growing here are taller and more vigorous (especially reed), which probably reflects this higher level of nutrients available to them.

4.0 North Fen Area Results - West side

Transect data is presented in the accompanying MS Word version of an Excel spreadsheet - Appendix 7.

On the West side, it is obvious from the transect observations that a very good spring flow exists from the top to the bottom of the slope. Water was evident at the surface in all parts and tufa formation was seen from 15-20m. The transect recording was stopped at the path (boardwalk) but, in fact, level peat continues on the other side of the boardwalk for one metre to the brook edge. This was not sampled because it actually consisted of bramble with tall reed with some other tall herbs. This margin is cut only occasionally. The presence of bramble indicates the peat here is drier, as bramble is unable to invade waterlogged soil.
On the North Fen West side there is no evidence of drying along the recorded part of the transect. The variation in plant abundances is due to a past history of cutting and raking or no cutting and raking (combined with arson). The start point could really be described as being in scrub, with bramble and reed not quite suppressing drier land plants such as false oat and rough meadow grass. Historically this is the edge zone of the tipped embankment to the housing on higher land and has typical disturbance species like cleavers. Reed then immediately dominates in a monoculture until 10m, where shorter vegetation is reached.

This shorter centre area of the transect was historically cut annually as a fire break and shows the presence of carnation sedge, purple moor grass, water mint and the rarer species marsh lousewort, parsley water dropwort and marsh valerian. Beyond this middle, reed again dominates with few other species. This end of the transect area was burnt in 2006 which explains the lack of diversity. At the very end, it is possible that the board walk (old wooden sleepers) acts a like a dam holding back water. On the far side of the boardwalk (not sampled) the level peat margin to the brook looks drier and hosts bramble indication drying of this level area.

This vegetation data from the west side of the SSSI was collected mainly to act as a baseline survey:

- Firstly, in order to compare with results a few years from now, when the increased frequency of cutting and raking is expected to have restored more of the original valuable short fen community. Hopefully more species will be able to return from the seed bank with the reduction in reed domination.

- Secondly, this will act as a baseline data set to compare with the future vegetation with regard to the proposed housing development at nearby Warren Crescent at the top of the slope. If this housing development goes ahead, the proposed mitigation measures will be implemented to re-infiltrate roof and paved surface water, so that the springs are not deprived. A repeat of this transect in the future should give information useful in understanding if the mitigation structure (swale) has worked.

5. General Conclusions and Discussion

5.1 North Fen East side

Shallow pools with stoneworts (so important as invertebrate breeding sites) never occur on the peat near to the brook edge, being only in the centre of the east side. The most important clear finding is that regarding the calcareous fen community, at Site 1 botanical indicators show a detrimental change for 8m from the brook edge and for Site 2 the detrimental vegetation change was for 5-6m from the brook edge. A peat forming (waterlogged) environment used to exist in these marginal zones, but no longer does so.

Thus the botanical data from these transects indicate that flash-flooding erosion at this site has damaged the community of plants by changing it from rich calcareous fen community to a moist meadow or scrub for an average of 7m into the SSSI on the east side of the stream.

Damage may extend further towards the spring line in dry years (the springs are flowing very well in 2013, after the wet year of 2012). Effects may be subtle and not detectable by crude cover of adult plants. Seed production may fail due to flowerheads shrivelling or seedlings may die shortly after germination.

Invertebrates dependent on waterlogged moss mat or shallow tufa forming pools may have been more seriously impacted, but this would be much more difficult to assess.

References

'***A Draft Management Plan for the Lye Valley***' produced by Oxford City Council. Unpublished, undated and no authors stated, but probably produced shortly after 1986. Document supplied by Oxford City Council Countryside Service

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Rodwell, J. S. (ed) (1991) '***British Plant Communities Volume 2: Mires and Heaths'*** Cambridge University Press

The draft ***Rare Plants Register for Oxon***, produced by the Ashmolean Natural History Society of Oxfordshire, viewable at www.oxfordrareplants.org.uk

Records of species surveys in the Lye Valley held by the Thames Valley Environmental Records Centre (TVERC) www.**tverc**.org

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Appendix 1

Plants on the Oxfordshire Draft Rare Plants Register found in the North Fen (majority on the East side) and known plant losses

Anagallis tenella, bog pimpernel (only 3 other sites)

Carex dioica, dioecious sedge (only 2 other sites)

Carex distans, distant sedge

Carex hostiana, tawny sedge

Carex lepidocarpa, long-stalked yellow sedge

Carex paniculata, greater tussock sedge (may end up having more than 10 sites)

Carex rostrata, bottle sedge

Eleocharis quinqueflora, few-flowered spike rush (only 1 other site – South Fen)

Epipactis palustris, marsh helleborine (usually about 1000 every year)

Eriophorum angustifolium, common cotton grass (only 5 other sites)

Eriophorum latifolium, broad leaved cotton grass (only 3 other sites)

Hottonia palustris, water violet

Hydrocotyle vulgaris , marsh pennywort,

Oenanthe lachenalii, parsley water-dropwort

Parnassia palustris, grass-of –Parnassus (only 3 other sites)

Pedicularis palustris, marsh lousewort (only 4 other sites)

Salix aurita, eared willow (only 1 other site)

Triglochin palustre, marsh arrow grass

Valeriana dioica, marsh valerian (may end up with more than 10 sites)

Apart from these rarer species there are numerous common spotted orchids, and some twayblades. Four species of scarce moss present – *Scorpidium cossonii, Campylium stellatum, Plagiomnium elatum and Climacium dendroides.* One scarce liverwort *Chiloscyphus pallescens.*

Known Losses and date last seen:

Schoenus nigricans, Black bog rush (1790)

Pinguicula vulgaris, butterwort (after 1994)

Drosera rotundifolia, Round leaved sundew (1964)

Appendix 2 (i)

Extract from draft management plan produced c. 1986 by Oxford City Council (unpublished) quoting data from an undergraduate project completed by Alistair Sandels, a student at Oxford Brookes University, which measured bank losses in 1979.

Stream bank erosion can be caused by runoff, scouring, and undercutting below the water surface. These can be seen in both valleys. In addition, the processes of seepage and runoff over the Oxford Clay lead to lubrication of the clay particles causing subsidence of large clay or peat masses from the bank. This also occurs in the Lye Valley.

Sandels (1979) noted three distinct phases in the erosion of the stream bed within his study period:

i) A rapid lowering of the base and upstream erosion from July to September.

ii) A less rapid period of erosion, especially of the stream bed between September and November.

iii) An increase in both, from November to December.

Within the period of study, stream-bed erosion lowered the base by 1.25 metres and the width increased by 0.9 metres followed by a further 1.5 metres between January and March. Upstream cutting of the bed was approximately 1 metre over the study period.

The effect of stream bed lowering has the greatest effect on the water table. As the stream bed drops, the water table closest to the stream will be pulled down by hydrostatic pressure. Eventually the water table further away from the stream will also drop threatening the fen vegetation.

Measures were taken by the Oxford City Council in January/ February 1985 to prevent further erosion and thereby prevent the possible loss of the fen vegetation. The O.C.C. laid down several hundred tons of limestone rubble over a 40-50m stretch of the stream bed adjacent to the Sandels (1979) study area. Limestone was used to maintain the alkaline pH of the area. The rubble was stabilized using wire netting. In addition concrete rubble was dumped at the end of the stretch to prevent undercutting. As yet it is unknown whether the work has had the desired effect of raising the water table to its former level. Unfortunately one possible side effect of the work could be in shifting and concentrating the erosional problems elsewhere, either upstream or downstream of the raised section.

The erosional capability of the stream has probably increased due to the construction of housing estates around the Lye Valley over the last three or four decades. The gradual increases in waste water and surface runoff probably surpassed the threshold capacity of the Lye Brook in the 1970's, resulting in accelerated erosion.

Appendix 2 (ii)

Extract from draft management plan produced c. 1986 by Oxford City Council (unpublished)

1.2.3.3 Past Management by BBONT/Oxford City Council (OCC)

c1930 Development of the housing estates to the east of the Lye Valley.

1930-50 Continuation and completion of the housing estates around the Lye Valley.

1975-84 Occasional mowing of the unofficial path down the Lye Valley by the OCC.

1978 Substantial rubbish clearance both at the Lye Valley (removal via Peat Moors) and at Warren Crescent. Fifteen skip loads of non-combustible material removed and approximately the same quantity burned on site (about 50 tons). This work was carried out by OCC and a MSC team.

1979 Fencing along the top of the valley sides erected at both Peat Moors, the playing fields and Warren Crescent with 'No Tipping signs along the fences (OCC).

1979 About 6 willows pollarded at the lower end of the valley. work carried out by an MSC team.

1980 Hedging plants placed alongside the erected fences, (OCC).

1982 Two scrub clearing tasks on the Bullingdon Bog BBONT reserve. Organized by A Smith and carried out by Oxford Polytechnic Students.

1983 About 15 willows were pollarded at the lower end of the valley. (Work carried out by contractors).

1983 Further rubbish clearance at the Heath Close entrance (OCV task force).

1985 Limestone chippings were put down in the stream bed, to maintain the pH level and raise the stream bed by 1.5 m. This work was carried out to prevent the stream bed erosion next to the BBONT reserve. The chippings were put down along a 40-50 m stretch and covered in wire netting to stabilize them. Associated with the work was the stripping of top soil from the acess point, the Churchill Hospital Field, and an artificial surface was put down so that heavy machinery could travel to the work area without damaging the surface beyond repair. The work was carried out by OCC and the Drainage Department of the OCC, grant aided by the Thames Water Authority, cost £40 000.

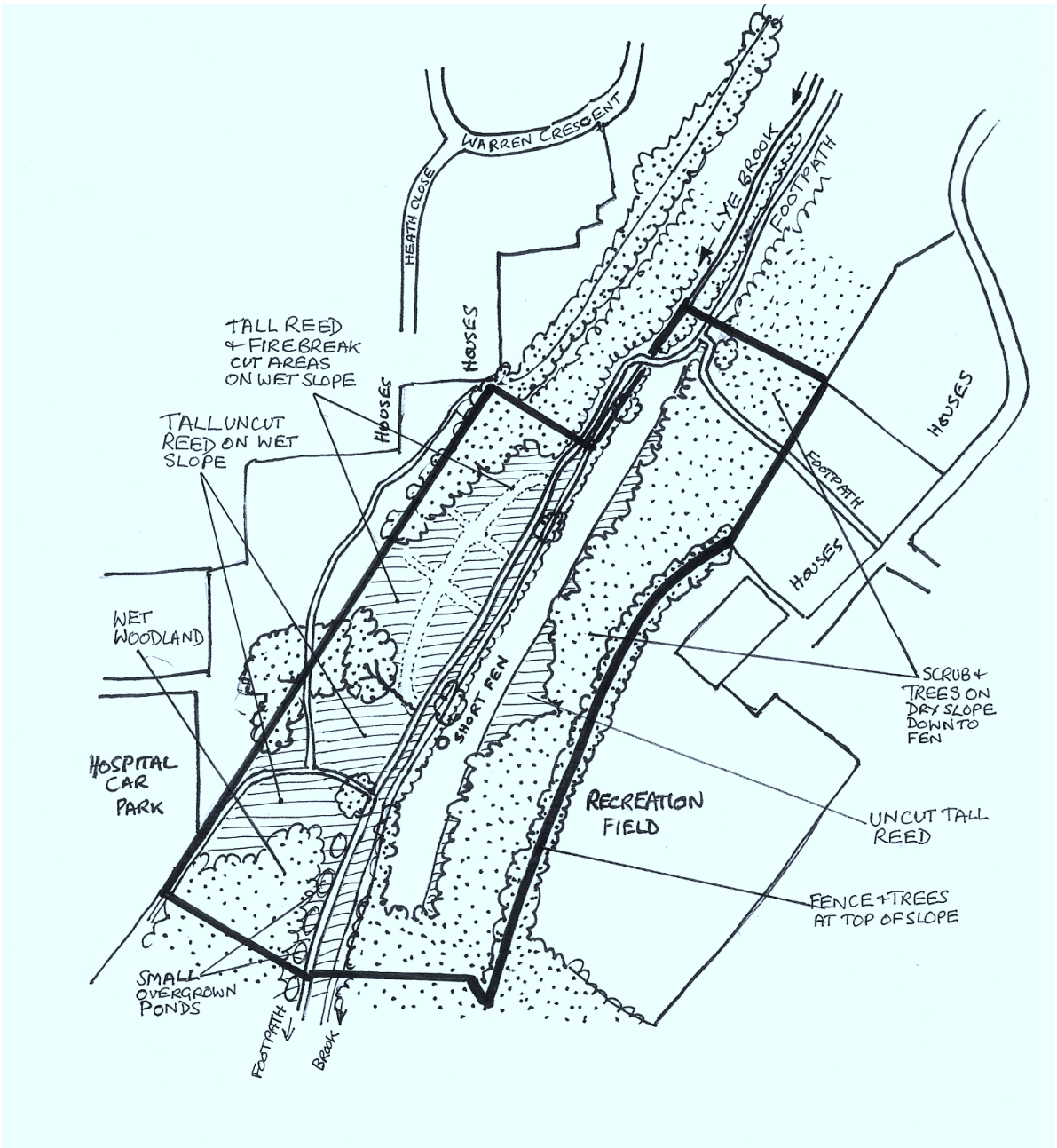
1985 Small scale cutting of Phragmites reeds on the Bullingdon Bog reserve.

1985 Experimental treatment of Japanese Knot - grass (Reynoutria japonica) by cutting and painting with Round-Up (OCC).

1986 Some scrub clearance within the Salix spp. carr including the clearing of two glades. Erection of a raised boardwalk across the wetter parts of the valley to improve its accessibility to the public.

Appendix 3:

Vegetation map of Lye Valley North Fen Area prior to management undertaken since 2009



Appendix 4:

Vegetation map of Lye Valley North Fen Area in July 2013, with transect positions.