OXFORD FLOOD ATTENUATION SCHEME SOIL RESOURCES REPORT AND MANAGEMENT RECOMMENDATIONS

Report 1345/2

27th February, 2017

Land Research ASSOCIATES

OXFORD FLOOD ATTENUATION SCHEME

SOIL RESOURCES REPORT

AND MANAGEMENT RECOMMENDATIONS

M.W. Worsley, BSc., MSc.
L. Thomas, BSc., MSc.
M. Palmer, MSc., PhD.

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Land Research Associates Ltd
Lockington Hall,
Lockington,
Derby
DE74 2RH

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1.0 Introduction

1.1 This report provides information on the soils of agricultural land which will form the site of the Oxford Flood Relief Scheme.

1.2 As part of the soils strategy, soil resources have been assessed for suitability for reuse in habitat restoration as part of the development.

1.3 The report addresses the suitability of the soils as a growing medium for a variety of habitats within the development and the nature reserve to the north including:

- Species rich floodplain meadow grassland
- Floodplain grazing marsh
- Woodland (tree pit) planting
- Wetland mosaic
- Wetland backwaters/scrapes
- Shrub areas
- Amenity grassland

1.4 It also considers soil handling/management during construction in order to ensure the resource is not damaged.

2.0 Soils investigation

SITE ENVIRONMENT

2.1 The site was visited in October/November 2017. During this visit a walkover was conducted to assess vegetative indicators of previous management which may affect soil suitability for different reuses. Tenant farmers were also contacted prior to the site visit to determine previous management.

2.2 The site was visited in October/November 2017. The following soil resources were observed. Full details of soil investigations are included in a separate report (1345/1).

HEAVY SOILS

2.3 The dominant soils have relatively thin calcareous clay or heavy silty clay loam topsoils typically 150-200 mm thick. The topsoil is generally underlain by stiff poorly structured clay showing evidence of seasonal waterlogging (grey mottled colours). The clay is underlain by calcareous groundwater affected gravel, although in other places the clay extends to over 100 cm below the land surface. This variability in depth to gravel apparently reflects the deposition of clayey alluvium over an earlier uneven braided channel deposit.

2.4 Similar soils formed in Oxford clay are found on the lower slopes east of land east of the A34.

LIGHTER SOILS OVER ROCK

2.5 These soils found to the east of the A34 are formed over limestone or calcareous sandstone. The loamy calcareous topsoils are slightly deeper than the rest of the site (250-300 mm) reflecting the arable use of this land. Subsoils are of variable depth to rock (400-1200 mm).[1]

[1] This area has been excluded from the scheme since the time of survey.

3.0 Laboratory analysis

3.1. A total of twenty four topsoil 'unit' samples were collected from within the proposed floodplain corridor, as well as from proposed adjacent habitat mitigation areas. The selection of sample areas was based on 'management units' which often included more than one field. Each sample comprises a representative sample bulked from a minimum of twelve sample points collected from 0-150 mm depth across the management unit. These samples were submitted for nutrient testing at a UKAS accredited laboratory. Samples were analysed for available nutrients (N, P, K, Mg) organic matter content (Loss on Ignition), pH and electrical conductivity.

3.2. In addition to the sampling described above, fourteen point samples were collected from areas of interest defined by the Environment Agency. At each of these points duplicate samples were collected from 50-150 mm depth using bulk density rings. The bulk density of each sample was recorded, before the duplicate samples were bulked and submitted for laboratory testing.

3.3. The location of sample areas is shown by Map 1 in an appendix to this report.

UNIT SAMPLES

3.4. There is significant variability in the availability of phosphate within topsoils in different parts of the site: Low nutrient areas (MAFF index 0[2]) are limited to northern and southern parts of the site, probably due to lower intensity of grazing. Some areas in the centre of the site are moderately low in P status (index 1). Elsewhere P status is moderate to high (index 2-4) with regard to habitat creation.

3.5. The heavy alluvial soils under grassland management are relatively high in organic matter content and total nitrogen (which are closely correlated). Arable soils to the west of the A34 (and disturbed/artificial soils in non-agricultural areas in the north and south) are much lower in organic matter.

[2] MAFF indices are a simplified measure of crop/plant nutrient availability. Optimum crop growth (including grass) usually requires index values of 2 or above. Phosphate is generally considered the key limiting soil nutrient in natural ecosystems . For semi-natural species-rich grassland to flourish low phosphate index values (0 or 1) are required because at higher values productive agricultural grasses dominate at the expense of grass species diversity and wildflowers.

Table 1: Unit sample analysis (mg/l unless stated)

Sample no.	pH	P	K	Mg	texture class	cond. uS/cm[1]	LOI%[2]	N%
1	7.3	8.2(0)	99.5	67	Clay loam	2160	7.8	0.27
3	7.4	36.8	162	123	Clay	2332	17.3	0.61
4	7.7	27.8	93.1	85.2	Sandy clay loam	2118	17.3	0.52
6	7	7.8(0)	75.8	77.3	Clay	2234	23.5	0.72
7	6.9	12.6	124	129	Clay	2331	21.7	0.73
8	7.1	15(1)	125	133	Clay	2435	22.3	0.78
9A	7.4	46.6	135	84.7	Clay loam	2264	18.7	0.69
9B	7.7	10(1)	125	92.2	Clay loam	2193	19.9	0.7
9C	7.3	11.6	136	89.8	Clay loam	2252	19.7	0.66
10A	7.4	12	141	99.6	Clay	2184	19.9	0.64
10B	7.1	18	142	91.7	Clay	2315	21.7	0.7
11	7.6	18	142	91.7	Clay	2315	13.8	0.43
12	7.2	17.2	144	115	Clay	2450	20.1	0.63
13	7.1	22.4	127	117	Clay	2448	17.9	0.59
14	7.1	22.4	156	117	Clay	2422	15.7	0.5
15	7.2	16.4	127	84.4	Clay	2464	19.1	0.69
16	6.8	31.8	149	113	Clay loam	2748	19.5	0.72
17A	6.9	30.8	147	122	Clay	2545	20.6	0.73
17B	7.4	13.4	135	120	Clay	2448	17.5	0.6
18	6.9	11.8	112	85.1	Clay loam	2234	10.7	0.39
19	7.7	48	124	54.2	Sandy loam	2201	8.3	0.32
20	7.7	20	436	110	Sandy clay loam	2259	10	0.32
21A	7.1	22.6	189	131	Sandy clay loam	2096	4.6	0.2
21B	7.9	21.8	344	80.5	Sandy loam	2172	5.4	0.23

POINT SAMPLES

3.6. The point sample target areas are generally low in phosphate status (MAFF index 0 to 1). The samples in the south of the site (23-25, see Map 1) are an exception.

3.7. Bulk densities were found to vary significantly across the site, but with low variation between replicate samples (indicating genuine differences). A strong correlation between organic matter content and bulk density (see Figure 1) indicates these soils are generally not severely compacted. However, samples 8, 14 & 15 have relatively high bulk densities for clay topsoils (above 1.6) and their deviation from the general trend suggests them to be compacted. The sample taken from the proposed MG4 habitat creation area (sample 11) is regarded as 'very porous' according the Soil Survey of England and Wales classification scheme (see page 6 for details).

Figure 1: organic matter content (Loss On Ignition) Vs bulk density

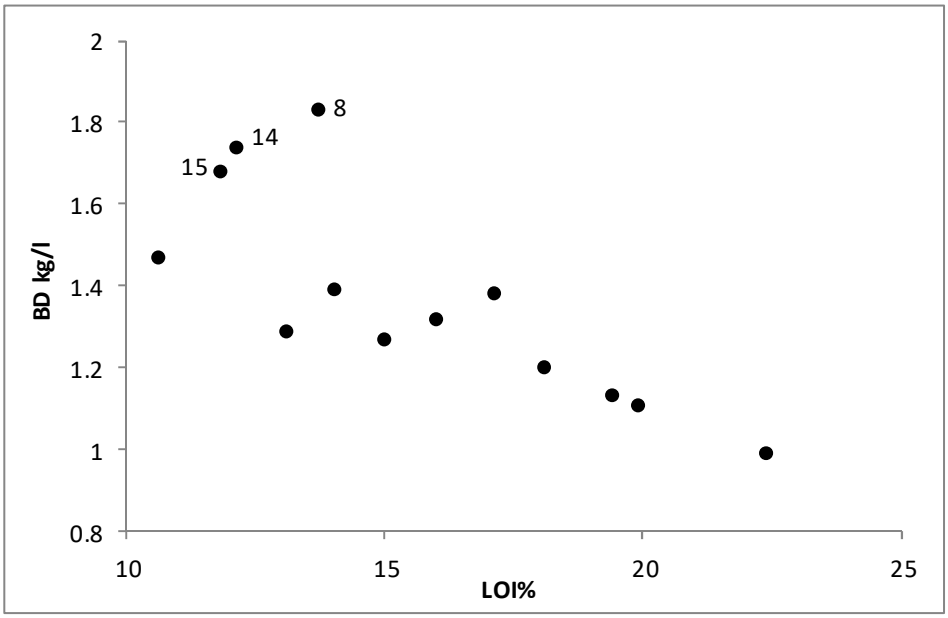


Table 2: point sample analysis (mg/l unless stated)

Sample no.	pH	P[1]	K	Mg	texture class[2]	cond. uS/cm[3]	LOI%[4]	N%	B.D. kg/l[5]	air-filled porosity%[6]
1	7	10.2(1)	120	140	C	2082	13.1	0.46	1.29	15-20
6	7.4	14.8(1)	157	148	C	2269	22.4	0.83	0.99	15-20
7	7.6	15.4	189	181	C	2318	19.9	0.71	1.11	15-20
8	7.6	9.6(0)	94.7	71.6	SCL	2127	13.7	0.84	1.83	<5
11	7.4	11.2	120	66.3	C	2173	18.1	0.66	1.2	15-20
14	7.3	6.2(0)	102	101	CL	2233	12.1	0.44	1.74	5.0-9.9
15	7.6	5.2(0)	114	82.7	CL	2102	11.8	0.44	1.68	5.0-9.10
16	7.9	9.2(0)	138	74.6	CL	2101	14	0.53	1.39	10-14.9
17	7.5	6(0)	131	95.8	C	2179	15	0.56	1.27	15-20
18	7.6	8.6(0)	97.9	90.3	CL	2305	19.4	0.78	1.13	10-14.9
19	7.6	6.8(0)	92.7	69.3	CL	2093	16	0.63	1.32	10-14.9
23	6.7	27.2	178	148	CL	2335	17.1	0.68	1.38	10-14.9
24	6.4	17	234	136	CL	2457	25.8	1.04	1.03	10-14.9
25	6	19.6	208	141	SL	2118	10.6	0.51	1.47	>20

[1]MAFF index value in brackets

[2]C=clay; CL= clay loam; SCL = sandy clay loam; SL=sandy loam

[3]Electrical conductivity

[4]Loss on ignition (an estimate of organic matter concentration)

[5]Bulk density

[6]Calculated from Soil Survey of England and Wales porosity classes after Hall et al. (1977) Water retention, porosity and density of field soils. Soil Survey Technical Monograph No.9, Harpenden.

4.0 Available soil resources

4.1. The distribution of soil resources is shown in Map 2 in the appendix to this report respectively. The available resources are described below.

TOPSOIL

TS1

4.2. These are the dominant topsoils at the site, approximately 200 mm in thickness on average, mainly clay or silty clay loam textured and of moderate to high nutrient status.

Estimated yield (stripped from construction area): 35,000 m^3

TS2

4.3. These topsoils occur in areas of lower agricultural intensity, particularly in the north and south of the site. They are approximately 200 mm in thickness on average, mainly clay or silty clay loam textured and of moderate nutrient status.

Estimated yield (stripped from floodplain area): 46,000 m^3

SUBSOIL

SS1

4.4. The subsoils of the construction area are clay textured, dense and poorly structured. They do not comprise a reuseable resource for habitat creation (i.e. use as topsoil). The surface is very likely to be compacted and sealed by construction activities. This property is favourable with regard to wetland/backwater scrape habitats. It is recommended that excess clay excavated during lowering of the channel surface be discarded.

SS2

4.5. This resource comprises the calcareous gravel which underlies the clay upper subsoil. Whether stripping to reduce levels will expose the gravel at the land surface is very difficult to predict, but where it is exposed it would form an appropriate medium for wildflower planting, or for use as permeable fill for tree pit planting.

5.0 Soil suitability assessment

5.1. The suitability of on-site soil resources for reuse in landscaping and habitat creation is summarised in Table 3 and described below.

Table 3: soil suitability assessment

After use	Soil resource			
	TS1	TS2	SS1	SS2
Tree pit planting	✓[1]	✓[1]	✗	✓
Transplants	✓[1]	✓[1]	✗	✓
Shrubs	✓[1]	✓[1]	✗	✓
MG4 grassland	✓[1,2]	✓	✓[3]	✓
Grazing marsh	✓	✓	✓[3]	✓
Wetland mozaic	✓[2]	✓	✓[3]	✓
Amenity grassland	✓	✓	✓	✓

✓ well suited ✓ moderately suitable ✗ not suitable

[1]High clay content makes soil handling difficult. Soils used for this purposes must be maintained in good structural condition and carefully replaced without compaction.

[2]High nutrient availability may introduce excess weed competition.

[3]Used in situ (not emplaced by machinery)

MG4 GRASSLAND

5.2. MG4 grassland requires soils of low nutrient status (phosphate index 1 or below, preferably index 0) with sufficient topsoil porosity to prevent persistent waterlogging which leads to a high proportion of undesirable wetness tolerant species (e.g. rush infestation). The creation/recreation of MG4 grassland would be best undertaken on existing low nutrient soils TS2 (see Map 2). The topsoils of target habitat creation areas are also of low fertility and adequate aeration (low bulk density) making them well suited to MG4 habitat creation provided the sward can be improved (diversified).

GRAZING MARSH

5.3. Floodplain grazing marsh is not a well-defined habitat, but is typically characterised by a low diversity of grasses. The composition of species is controlled primarily by prolonged wet conditions. Marshy grassland vegetation is less sensitive to higher nutrient levels, and either topsoil resource is suitable

for this purpose. Lowering the ground level of the secondary channel is likely to create suitable marshy conditions.

WETLAND FEATURES

Wetland mosaic

5.4. The subsoils in the north of the site are well suited to the creation of open water areas, being naturally poorly-structured clays which can easily be 'puddled' to create an impermeable base. Topsoils should be stripped from the wetland cells and at least 1 m around the perimeter (to prevent eroded topsoil from re-entering the wetland). Topsoils are not suitable for use as a growing medium for submerged planting, as they are likely to result in eutrophicaton of the water column. Reed plugs or rhizomes can be planted directly into the subsoil base. Underlying gravel (resource SS2) may be used as a planting medium for emergent vegetation such as yellow flag (*Iris pseudacorus*).

TREES AND SHRUBS

5.5. TS1 and TS2 are suitable for reuse as topsoils for tree pit planting, provided they are handled carefully to prevent compaction damage.

5.6. Machine digging of pits for standards should take place when soils are not wet, to avoid smearing of the perimeter structure which will increase incidence of waterlogging. Early spring plantings are less likely to be affected by prolonged waterlogging. The clay subsoils (SS1) are likely to be compacted by machinery operations and are unsuitable for use as backfill; SS2 is suitable for this purpose. The base and sides of planting holes should be broken with a fork to reduce the risk of the pit becoming waterlogged. The top of the root ball should be raised 50-100 mm above the surrounding ground level to improve drainage.

5.7. Shrub and hedgerow planting would be best performed by backfilling with topsoil (TS1 or TS2) to a depth of up to 450 mm.

LANDSCAPING

Amenity grassland

5.8. Amenity grassland (e.g. on new flood embankments) has relatively low demands, for which all of the topsoils at the site are suitable. Soil stripping/stockpiling needs to be performed carefully, ensuring soils are in a friable state (see paragraph 6.2) to avoid soil which will affect the ease with which a seedbed can be obtained.

6.0 Soil handling

6.1 Both topsoil and subsoil should be stripped and emplaced using the loose-tip method described in Sheets 1 & 4 of the MAFF Good Practice Guide for Handling Soils (2000)[3].

6.2 The soils at the site have high clay content and are easily compacted by machine handling. Soil handling should not take place when these soils are in a plastic state. This can be assessed with a simple field test to establish whether the soil can be rolled into a thread 3 mm in diameter. If this is the case, soils should not be handled with machinery and drier conditions should be awaited before repeating the test. Soils to be used to form the core of embankments need not be subject to this condition.

6.3 The location of stockpiles of different resources (i.e. TS1-2; SS1-2) should be recorded and retained to avoid mixing or loss during extended construction works.

TOPSOILS

6.4 Topsoils should be stripped and stockpiled from designated roadways prior to the commencement of groundworks. Vehicle traffic should be kept to designated roadways as far as possible to avoid damage to soil resources. Topsoil should be stripped from areas to be used for subsoil stockpiles. Topsoils should be stripped and stored separately according to resources Map 2 in the appendix to this report. Care should be taken to ensure that the soils are stripped to the correct depth to prevent dilution with underlying subsoil. Average topsoil resource thicknesses are indicated in section 4.0 of this report, but in all cases stripping depth should be checked carefully (e.g. by a banksman).

6.5 Topsoil resources should be stockpiled in windrows no more than 3 m in height to minimise settling damage to structure and to facilitate drying prior to reinstatement. Stockpiles to be left in-situ for greater than six months should be seeded with grass to increase stability.

[3]http://webarchive.nationalarchives.gov.uk/20090317221756/http://www.defra.gov.uk/farm/environment/land-use/soilguid/index.htm

SUBSOILS

6.6 Subsoil resource SS2 is moderately well structured (friable) and is a higher quality resource than the overlying clay. It is essential that the two materials are carefully separated if SS2 is to be reused.

6.7 Subsoil resource SS2 should be stockpiled in windrows no more than 5 m in height to minimise settling damage to structure and to facilitate drying prior to reinstatement.

6.8 In-situ subsoils compacted during construction should be loosened/ripped prior to topsoil reinstatement to improve drainage and aeration.

7.0 Summary and conclusions

7.1 The site has heavy soils with restricted drainage that are difficult to handle with machinery without causing physical damage.

7.2 The topsoils in the north and south of the channel construction area are of low nutrient status. The remaining topsoils are of moderate to high nutrient status.

7.3 The soils are well suited to wetland and marsh planting schemes.

7.4 Planting of standard trees is likely to result in structural damage to the subsoil. To mitigate resultant waterlogging/aeration problems, this should be performed outside of wet periods and holes should be backfilled with permeable material (SS2).

7.5 Areas proposed as MG4 grassland creation areas have moderately low nutrient status and bulk density and appear well suited to this purpose.

7.6 Overall the existing topsoils on site are of sufficient quality and volume for all landscaping requirements, with the possible exception of standard tree planting.

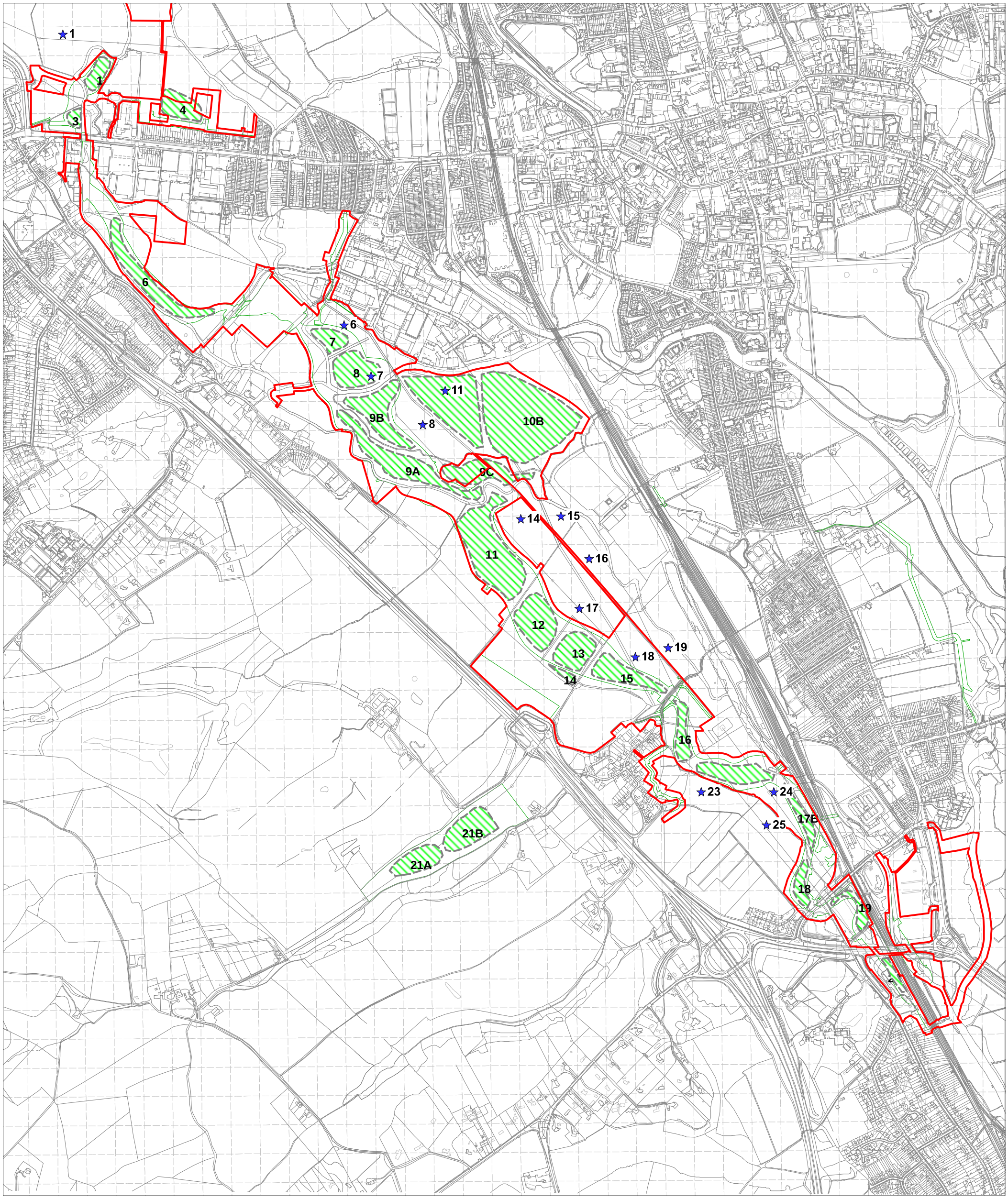
SUMMARY OF RECOMMENDATIONS

After use	Recommended soil resources	Recommendations
Tree pit planting (standards and heavy standards)	**TS1 or TS2/SS2**	Use SS2 to backfill pits where possible. Pits need to be relatively large, with the margins broken, to avoid filling with water. Root balls should be slightly elevated above the surrounding ground level . Use up to 300 mm of topsoil topdressing.
Transplants	**TS1/TS2**	Planted by hand on undisturbed land, transplants may be backfilled with the in-situ topsoil (TS1 or TS2).
Shrubs	**TS1/TS2**	Planted by hand on undisturbed land, shrubs may be backfilled with the in-situ topsoil (TS1 or TS2). Ouse up to 450 mm of topsoil.
MG4 grassland	**TS1/SS1**	Strip turf layer of in-situ soils and reseed with desired seed mix in summer or early autumn.
Grazing marsh	**TS1/SS1**	Replace topsoil on lowered land surface to minimum 150 mm thickness.

After use	Recommended soil resources	Recommendations
Open water wetland	**SS1**	Scrape away topsoil within 1 m of the margin. The permeability of the base may be reduced by smearing with an excavator bucket. Reed plugs and rhizomes can be planted directly into subsoil. Topsoil should not be used in aquatic planting schemes.
Amenity grassland	**TS1/TS2**	This planting has low demands and can use any excess topsoil resources. Emplacement to a minimum of 300 mm will reduce surface wetness.

APPENDIX

DETAILS OF SURVEY OBSERVATIONS
RESOURCE AREAS
AND LABORATORY ANALYSIS



Client:

ch2m.

Project:

Oxford Flood Alleviation Scheme

Title:

Map 1 - Sample areas

Key

Revised site boundary (Feb 2018)

Sample units

EA sample point

Scale - 1 : 12,500 at A3

Date 01/03/2018

Land Research ASSOCIATES

Lockington Hall
Lockington
Derby
DE74 2RH

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ch2m

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Oxford Flood Alleviation Scheme

Title:

Map 2 - Topsoil resources

Key

- Revised site boundary (Feb 2018)
- TS1
- TS2
- Unsurveyed areas (added to scheme since survey date)

Scale - 1 : 12,500 at A3

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Land Research ASSOCIATES

Lockington Hall
Lockington
Derby
DE74 2RH