

Appendix A

Geotechnical Study

Adwick washlands habitat creation – planning application supporting information

4. PHYSIOGRAPHY AND SUBSTRATE CONDITIONS

4.1 Physiography

The project area lies beside the northern bank of the River Dearne, approximately 4.5 km west of its confluence with the River Don. The area covers the entire floodplain on this bank, which is levelled at c.12.5-15.5 m AOD, and occupies the south-facing slopes of a ridge of high ground between Dearne and Barnburgh. This includes the valley side footslopes, some of which lie at a moderate angle (5-7°) rising from c.15.5 m to 18 m AOD. The mid-slopes of the valleysides rise quite evenly above this break of slope.

Drainage from the valley slopes is effected by a partly natural dike network, centred on West Moor Dike, with developed ground surface concavities evident as both West Moor and Crane Well Dikes enter the floodplain. The upland slopes are gently undulating northwards in the vicinity of West Moor Closes Dike, and continue to rise northwards beyond the boundary of the project area to a height of c.90 m AOD on the catchment boundaries. Similar small streams also rise from the slopes further up- and downstream.

The River Dearne meanders in a fixed channel along the southern boundary of the site. An earth/colliery spoil flood embankment runs along the northern edge of the river, with a foreshore of up to c.10m wide. A soak dike runs approximately 25 m north of the flood embankment.

The width of the floodplain is variable across the site, and often indeterminate. It is c.520 m broad in the vicinity of Crane Well Lane, while downstream it narrows to c.240 m. The historic extent of the floodplain is difficult to assess, as it has been modified by the extent of surface mining. Part of the northern margin of the natural floodplain was probably marked by the area once known as Barnbrough Gorse, which was an area of rough grassland and gorse scrub extant and well developed in 1892 alongside West Moor Dike. It is unlikely that this habitat has developed on an active floodplain, and may represent the toeslope of the upland. The area of the habitat was reduced by 1956, and had been cleared by 1962. This suggests that the historic floodplain was smaller than its current extent.

The disruption to the physiography of the project area caused by surface mining begun in the 1950s is scarcely discernable. The area affected by excavation is shown in Figure 6 as the restored soil zone. The spoil materials produced by opencast mining were backfilled in the 1990s (UK Coal 2003). Although the shape of the original floodplain within the affected area is not clear, it is considered that the disruption to local physiography was minimised during regrading of the backfill. It is likely, however, that some 'smoothing' of the contours has occurred, to produce a more even slope between the level of the former floodplain and the mid slopes. The soil surveys undertaken within the project area suggest that grading of the backfill has not only mimicked the natural floodplain to the south of the main slopes, but that spoil materials have

been scraped above the margin of the opencast area to restore the natural lines of the slope profile.

Surface features discernable from the ground within the floodplain include three large but shallow depressions immediately to the north of Lowfield Lane (shown clearly in Figure 5), very shallow depressions in the floodplain to the extreme east and west of the project area, gentle swales along the foot of the river embankment, and a rather marked hollow and swale topography to the west of the modern course of the West Moor Dike.

These features correspond to changes in the courses of dikes and the river, of historic deposition of sand bars by the river, and of subsidence caused either by backfill settlement within the area of former opencast mining, or of settlements of spoils used to infill the natural course of Well Crane Dike. It is also possible that the area of depressions north of Lowfield Lane may indicate the destabilization of underground mine workings by the infiltration of ground- or floodwater. These ground surface features act as indications of the distribution and characters of soils within the floodplain, and are discussed in section 4.3.2.2.

4.1.1 Physiography – effect on potential size of wetland

Size is an important consideration when designing wet grassland for breeding and wintering birds. Both groups require large open areas devoid of trees and overhead obstructions, such as powerlines (see section 6.6). The presence of mature trees or tall hedges in areas used by ground- nesting birds can greatly reduce breeding productivity in their immediate vicinity, as they provide lookouts and nest sites for predators such as carrion crows. Larger areas allow colonies of breeding waders to establish, which collectively may be more able to deter predators and are also much more economically managed.

At Adwick, the potential size of wet grassland is limited by the extent of the floodplain. Accounts of field visits to the project area have revealed that the lie of the land is deceptive in suggesting that the shallow slopes over large areas of the site are currently suitable for the establishment of wet grassland. In fact, the gently sloping character of the land above the River Dearne floodplain would act to restrict the potential size of the wetland.

Accurate topographical leveling is therefore a crucial aspect of scheme design.

4.1.2 ELP Levelling survey

A topographical survey of the site was conducted on the 28th-29th September 2006 using a Trimble 5700 Base and Receiver kit (with an accuracy of 1 cm in all directions). Levels were taken by walking along transects (spaced approximately 70m apart) running perpendicular to the river, with a spot height recorded every 20 m. Additional spot heights were also taken to capture local ridges and hollows, water and ditch bed levels, water control structures, path surfaces and temporary benchmarks. The data gathered was then combined with Lidar data provided by the Environment Agency. The software package "Vertical Mapper" was used to generate contour lines at 25 cm intervals across

the site, which were then examined and, in some cases, corrected manually to fit with observations made in the field.

Results are presented in Figure 5, which illustrates:

1. The absence of extensive level areas, even within the floodplain, which includes areas of subsidence.
2. The modern floodplain is larger than the historic one, as it includes landshaped low-lying areas of the restored surface mine.
3. The Scheduled Monument lies on the lower slopes of a sandstone outcrop, rather than in the floodplain, though the scheduled track crosses the floodplain to Lowfield Lane.
4. Lowfield Lane itself runs across the lowest parts of the project area, and is certain to be at least partly buried by any cut-and-fill landshaping.
5. The Coal Measures produce steep slopes where the sandstone aquifer outcrops and mudstone produces long, shallow slopes.
6. The most efficient landshaping to produce a level surface for wet grassland is to cut into the shallow mudstone slopes, rather than the steep sandstone ones. This would necessitate subdividing the marsh into two levels, within a similar footprint to that defined as the washland reservoir.

4.2 Geological materials

The British Geological Survey (BGS) map of the area, Sheet 87 (Barnsley) Solid and Drift Edition, indicates that the site is underlain by the Middle Coal Measures (Westphalian C). The Coal Measures are overlain by river alluvium in the vicinity of the River Dearne.

The distribution and extent of geological materials presented by Sheet 87 was found by Babbie et al (2004) to be in general agreement with the archive geological logs they obtained from the British Geological Survey National Records Data Centre. In addition to these logs, the BGS hold records of three boreholes sunk on West Moor Closes by British Coal in the 1980s. These logs are confidential, but the geological sequence they encountered is summarised in the UK Coal Environmental Statement (2003).

4.2.1 Coal Measures

The Coal Measures consist of thin bands of sandstone, mudstone, siltstone and seatearths, with coal seams.

Coal was recorded at 3.75-4.5 m depth in borehole 221/6 on the southeastern corner of the site. Detailed coal seam exploration in the area by British Coal in the 1980s, described by UK Coal (2003), indicates that this is the Highgate Rider Seam, outcropping approximately in line with West Moor Lane. The Highgate Rider Seam is almost immediately underlain by the Highgate Seam. The Shaffton Seam outcrops between Lowfield Lane and the River Dearne, 300 m west of Adwick Bridge. This seam was also encountered at 38.4 - 40.1 m depth in the southeastern corner of the site. The three seams encountered outcrop NW-SE across the site and that the strata dip to the east and northeast at 1:10 to 1:30.

The majority of these seams have now been extracted by opencast methods across the central part of the site.

The archive logs for the area indicate that the upper levels of the Coal Measures tend to be weathered to a non-calcareous firm clay for a thickness of between 0.6-2.4 m. This confirms the view of the BGS, which describes this material as a dark grey silty mudstone. This material was extensively proved by soil survey (see section 4.3) and outcrops in a broad swathe mainly on the mid slopes above the former surface mine. It is also noted that a very similar material was proved as the subsoil of the restored opencast area. Weathered mudstone naturally breaks down to a silty clay or silty clay loam, and is a key constituent of the river alluvium found on the floodplain.

In addition to the mudstone and associated siltstone, beds of sandstone are an integral part of the Coal Measures rocks. Weathered sandstone rubble is also a constituent of the river alluvium, but is apparently in situ as outcrops at four locations on the margins of the project area. The BGS map these outcrops as Ackworth, Mexborough and Dalton Sandstones (section 5.1.2).

The lower slopes of the valley sides were found to be mantled by types of loam, probably derived from the mixing of weathered mudstone and sandstone by slope processes in the past. This material lies above both mudstone and sandstone outcrops.

4.2.2 Alluvial deposits

The unit of floodplain alluvium, as proved from the BGS archive logs from West Moor Closes, and the soil surveys described in section 4.3, is somewhat more limited than that shown on Sheet 87, which shows alluvium over the majority of the site, for approximately 1 km north of Lowfield Road. While a large area of alluvium has undoubtedly been removed by opencast mining north of Lowfield Lane since the publication of the geological map in 1942, there is nonetheless some considerable discrepancy between this work and recent findings. The levelling survey described in section 4.1.2 unequivocally distinguishes between the low-lying floodplain and the valley slopes, and the separation between alluvial deposits and the materials forming the valley-sides is borne out by both soil surveys.

The BGS archive logs suggest that the alluvial deposits in the area are principally sands and gravels with pockets and lenses of clay and silt. Most of the gravel comprises weathered siltstone and sandstone, principally derived from the underlying bedrock of upstream slopes within the river catchment. The sands and fine particles are also derived from this source.

Mitchell et al (1947) emphasise that there were very few borehole records in the Dearne Alluvium prior to publication of the BGS Sheet Memoir, but stress that the “beds actually vary from place to place and as an indication the section at Adwick Bridge may be mentioned”. This particular core proved:

Sandy soil 6 feet
Sandy clay 2 feet 6 inches

Sand and gravel 5 feet
Gravel 6 feet 6 inches, not bottomed.

This concurs with the UK Coal (2003) description of the alluvium as principally composed of sand and gravels. At West Moor Closes, this deposit varies in thickness from 7.9 metres adjacent to the River Dearne to a thickness of 1 metre within 200 metres north of the river. When the whole project area is considered, the extent of this material within the floodplain appears to vary and may, in fact, be more limited than has been suggested. In addition, Lafarge Aggregates sunk four shallow assessment holes into the sand and gravel reserve in 2002, on behalf of UK Coal. They recorded the sand and gravel material as being heavily contaminated by clay and silt material, particularly in the upper layers.

4.2.3 Made Ground

Made ground is present in the form of surface mine backfill. The fill predominantly comprises a poorly sorted mixture of silty to cobble- and boulder-sized angular fragments of silty mudstone, siltstone, sandstone and seatearth. The total thicknesses of the backfill materials were recorded by UK Coal bores and ranges from 3.20 to 24.70 metres. No specific compaction was carried out during the placement of the fill, but it is considered that there will have been significant self-weight compaction.

The superficial backfill layers, which constitute the restored subsoil, are composed of a distinct dark grey silty clay loam.

Made ground was also encountered by UK Coal in two exploratory boreholes located within or adjacent to the northern part of the (UK Coal) site at West Moor Closes, but outside the area of surface mine backfill. Total thicknesses of 2.49 and 3.20 metres were recorded.

The Dearne flood embankments appear to be constructed principally of colliery spoil. Ground levels also appear to have been raised with colliery spoil by approximately 1 m along the banks of the soak dike running immediately inland of the River Dearne. In addition to the river embankment, surplus spoil has been used to embank both sides of West Moor Dike over a c.700 metre section from the river to its junction with Far Moor Dike. Additional fill has been used in the vicinity of the crossing where Lowfield Lane passes over the dike. Lowfield Lane and the eastern end of Marsh Lane comprise made ground of building rubble and colliery spoil, raised by up to 1.5 m above hinterland level.

4.3 Soils of the project area

This section refers to two soil surveys: the UK Coal (2003) survey covering West Moor Closes, which was also reviewed by Babbie et al (2004), and a complimentary survey of the whole project area undertaken by ELP. In order to assess the characters and distribution of soil types over the extended survey area, ELP conducted further fieldwork to compliment that conducted by UK Coal (2003).

The objectives of this fieldwork were:

- to match field characters with the 2003 survey
- to confirm the areal extent and field characters of the backfilled opencast area
- to identify the subsoil characters and extent of alluvial soils

46 cores were taken from throughout the project area. Core locations were selected to be representative of apparently homogeneous areas, as judged from the topography and ground surface features. Core locations were recorded using a GPS reading and are shown in Figure 6. All cores were taken using a Dutch Edelmann auger, using either the universal or riverside heads.

Arisings were examined in the field and recorded in a log showing the sequence of geological materials from the surface to a maximum depth of 2.25 m. Shorter cores were necessitated by subsurface compaction, or by the inability to extract arisings that were too wet. Extraction and assessment of the arising from each core comprised:

1. augering the core in c.20 cm depth sections;
2. distinguishing discrete sedimentary units by means of macrofabric characters, colour (using Munsell Soil Color Charts) and textural classification;
3. identifying unit boundaries by recording a 'below ground level' (bgl) measurement to the nearest centimetre;
4. recording the depth of water within the core when first encountered (ie the watertable depth) and also following the extraction of the last section – measured to the nearest centimetre bgl;
5. blocking the top of the core using the arisings.

4.3.1 UK Coal soil survey

UK Coal commissioned a Soil Resources and Land Quality report for their Environmental Statement (UK Coal, 2003) on the West Moor Closes site. The assessment of soils in this part of the project area was based on 69 hand auger holes, several soil pits and associated laboratory testing. The investigation met the requirements of MPG Note 7 (Reclamation of Mineral Workings) in coring to a depth of 1.2 m. The survey distinguished a suite of different soils types roughly in accordance with the subdivisions determined by the ELP survey for the whole project area: alluvium, restored soils within the surface mine, and soils that differentiated between the loam soils over the sandstone outcrops, and the heavy loam and clay soils formed in the weathered mudstone and slope materials. The findings were considered to be generally in agreement with the large scale mapping provided by the Soil Map of England and Wales.

4.3.2 Results of the ELP survey (2006)

4.3.2.1 General sequence of soil parent materials

The typical sequence of soil-forming materials varies with location within the four broad zones defined by the survey (sandstone, clay slopes, floodplain and restored soils), is summarised in Table 2.

Table 2. Summary of soil types

	Sandstone	Clay slopes	Restored soils	Floodplain
Topsoil	Sandy clay loam	Clay loam	Clay loam	Loams
Subsoil	Sandy loam/loamy sand	Clay	Coal Measures rubble	Clays and loams
Deep subsoil	Weathered sandstone	(weathered sandstone)*	Silty clay	Fine or coarse sand

* Sometimes proved at depth, indicating that sandstone underlies mudstone

The significance of the sequence and character of the materials shown in each sequence is discussed in the context of the permeability of each soil zone in section 5.3.3.

The log of individual soil cores is given as Appendix 2, where specific attributes of particular cores are noted. General characters of the soil parent materials are outlined in Table 3.

Table 3. General classification of soil parent materials

Class	Material	Description
Clay	Silty clay	Dark to light grey often mottled clay, either massive where <i>in situ</i> mudstone, or a sometimes strongly prismatic structure within slope materials and alluvium.
Loam	Clay loam	Usually part of topsoil, where friable or somewhat sticky; often contains variable proportions of silt or sand.
	Silty loam	Floodplain material near the surface; often lightly mottled, loose structure.
	Sandy loam	Light, friable material with a loose structure, found in the floodplain and sandstone areas.
Sand	Silty fine sand	Floodplain material found in most cores away from areas where coarse sand was proved.
	Loamy sand	Weakly structured material derived from weathered sandstone and restricted to the sandstone zone.
	Coarse sand	Floodplain material proved in limited areas at depth.
Coal Measures	Rubble	Sandstone, siltstone rubble with coal grains, located below the surface above dark grey silty clay.
	Mudstone	Recorded as silty soil.
	Sandstone	Weathered sandstone outcropping in the sandstone zone and occasionally at depth on the clay slopes.

4.3.2.2 Character of soils within the broad soil zones

The distribution of the soil types is shown on Figure 6, and they are described below.

The results of the current and previous soil surveys are interpreted within the framework provided by the Soil Survey in Appendix 3.

Sandstone soils. The loams over sandstone occur in four areas on the higher ground, within the extensive clay loam/clay soils. They have developed in moderately deep to shallow clay loam and sandy clay loam drift and their upper and lower subsoils contain sandstone fragments.

They have non-calcareous dark grey brown sandy clay loam, heavy to medium clay loam and silty clay loam topsoils to depths of between 25 and 50 cm, and they are generally slightly stony with approximately 6 to 8 % small sandstone fragments. The subsoil extends to depths of between 50 and 136 cm over impenetrable sandstone. The subsoils consist of sandy clay loams, sandy loams and loamy sands, and in some of the heavier profiles medium sandy and silty clays can occur at depth. The colour of these horizons is variable. Some are yellow brown to brown, and others are grey brown, light brownish grey and pale brown, and sometimes distinctly mottled. The structures in the heavier horizons are moderately developed coarse subangular blocky to medium subangular blocky and they are porous. The subsoils can be slightly to moderately stony (with sandstone contents of up to 10 %).

These soils correspond to the Rivington soil series. Typical particle size classes (per cent) are:

	Clay	Silt	Sand
Topsoil	15	31	54
Subsoil	10	29.5	60.5

These are generally well-drained soils, though they are prone to capping and ground compaction, promoting standing water.

Clay slope soils. On the higher ground, these soils have developed in shallow to moderately deep clay loam and sandy clay loam drift over clay and sandy clay. Some of the upper and lower subsoils contain sandstone fragments. These upper clay soils have perched watertables and are slowly permeable. On the toeslopes, some soils develop thick beds of silt loam beneath the topsoil, and may relate to soils in the floodplain.

They have non-calcareous dark grey brown heavy to medium clay loam and some sandy clay loam topsoils to depths of between 26 and 32 cm, and they are generally stone-free, or slightly stony with approximately 2 to 4 % sandstone fragments in some places.

The upper subsoil horizons extend to a wide range of depths (between 49 cm and 174 cm), and consist of a wide range of textures, including silty and sandy clay loams, heavy clay loams and some medium clays. The colour of these horizons is variable. Some are yellow brown to brown, but most

are grey brown, light brownish grey and pale brown, and distinctly mottled. The structures in the lighter textures are moderately developed medium subangular blocky and they are largely porous, if marginally so. In the heavier textures and with increasing depth, they become moderately developed coarse subangular blocky and they are non-porous. The upper subsoils can be slightly to moderately stony (with sandstone contents of 2 to 15 %).

The lower subsoils consist of prominently mottled grey and light grey and ochreous clays and sandy clays. The structures are moderately developed coarse to very coarse prismatic, and non-porous.

In some cores, the subtending weathered sandstone was proved at depth, though it appears that deeper mudstone-derived parent materials are associated with the dike corridors.

These soils correspond to the Bardsey soil series. The soils are slowly permeable to depth with deep watertables beyond auger depth

Restored soils. The artificial soils are present in the areas disturbed by open cast operations. They consists of a good depth of topsoil and upper subsoil, underlain by a silty clay overburden with a massive, moderately developed coarse platy structures as a substitute for the natural subsoil.

These soils have non-calcareous dark grey brown heavy clay loam topsoils. At variable depths between 30 cm and 67 cm, a distinctive layer of sand and mudstone rubble is encountered, often with coal chips and in a matrix of crushed siltstone and sandstone.

The moderately thick natural upper subsoils consist of heavy clay loam to medium clay textures to depths of between 50 and 80 cm. The colour of these horizons is variable. Some are yellow brown to brown, but most are grey brown, light brownish grey and pale brown, and distinctly mottled. The compacted and non-porous soil has a massive to moderately developed very coarse platy structure, which breaks down in places to coarse subangular blocky structures.

The lower subsoils consist of a distinctive dark grey silty clay overburden, which has been used as a soil-forming material. The lower subsoils consist of dark grey heavy silty clay, which is strongly compacted, dense and non-porous. It has a massive to moderately developed very coarse platy structure.

Both the natural upper subsoil and substitute lower subsoil are strongly compacted as a result of the lower standards of restoration required in the past.

These soils could be regarded as corresponding to the Bardsey soil series; they have a permeable sandstone rubble subsoil over clay to a depth of at least 225 cm.

Alluvial soils. On the lower ground, these soils have developed in moderately deep to deep sandy clay loam and sandy alluvium over coarse sands and silty or sandy clay, and some lenses of gravel.

They have non-calcareous dark grey brown heavy to medium clay loam, silty clay loam and sandy clay loam topsoils to depths of between 30 and 32 cm, and they are generally stone-free, or slightly stony with approximately 2 to 4 % sandstone fragments in some places.

The upper subsoil horizons extend to a wide range of depths (between 44 and 1.2 m), and consists of a wide range of textures, including sandy clay loams, heavy clay loams and silty clay loams, and some loamy coarse sands. The colour of these horizons is variable. Some are yellow brown to brown, but most are grey brown, light brownish grey and pale brown, and distinctly mottled. The sandy horizons have little structural development and are largely apedal. The heavier textures have moderately developed coarse prismatic structures, breaking to coarse subangular blocky and they are generally porous. The upper subsoils can be slightly to moderately stony (with gravel contents of 2 to 10 %).

The lower subsoils consist of coarse yellow and red sands, and prominently mottled grey-brown, grey and light grey and ochreous clays and sandy or silty clays. The structures in these heavier substrates are moderately developed coarse to very coarse prismatic, and non-porous. Gravels occur at depths of about 80 cm to over 220 cm in some of these profiles. There is some separation between the eastern cores, where coarse sand was found at depth, and the western cores, where silty (or sometimes loamy) fine to medium sand was more frequently recorded.

These soils do not correspond to a single soil series. Whilst the Conway series is common, areas near the river grade to the gravelly Kettlebottom series. Areas to the west, with silty fine sand subsoils, are perhaps closer to the Eversely series, while the slightly raised areas, with a lower watertable, correspond most nearly to the Trent series. This variability in soil type reflects the complex nature of the upper alluvium.

The natural soils have variable but generally good drainage. Sand and gravel subsoils south of Lowfield Lane are very free-draining, but fluctuating watertables are often present, which indicates that groundwater is affected by river level. Lenses of fine sand and clay layers are present, giving complex and variable permeabilities.

4.3.2.3 Cross-sections of the project area

In order to describe in detail many of the features revealed by this survey, three cross-sections (Figures 7a-c) have been constructed from the soil core logs, displayed at altitudes estimated from the topographic survey.

Cross-section A. This section runs from a sandstone outcrop in the north of the project area, at an altitude of c.20 m AOD across the clay slopes to the floodplain. It includes core 12, which demonstrates that the floodplain extends some distance up Crane Well Dike, then follows the low ground in

the vicinity of core 28, across the historical route of the Dike. On crossing Lowfield Lane, the section rises onto a second sandstone mound to core 11, and then descends back into the floodplain at the end at core 10.

The section between cores 20 and 25 suggests that the sandstone outcrop continues downslope, buried beneath the clay slope materials. These are quite uniform in this part of the site and, by core 44, display a deep clay subsoil. Between cores 29 and 12, the upper surface of the clay slopes is still evident, though at core 12 it is buried beneath c. 160 cm of alluvium. The section of floodplain across the low land to Lowfield Lane suggests that a similar sequence of alluvial materials is present over much of the ground (excepting, perhaps the old course of the Crane Well Dike) with the addition of a bed of fine sand. This material is widespread over the floodplain. The soil of the second sandstone outcrop is similar to that recorded on the first. The section of floodplain represented by core 10 lacks the bed of sandy loam found in cores 12 and 28.

Cross-section B. This section descends along the corridor occupied by West Moor Closes, and terminates in the floodplain. It therefore highlights the sandstone outcrop and the restored ground. As in section A, the sandstone soils (cores 19 and 31) demonstrate the potentially free-draining character of the substrates, and also indicate that the underlying Coal Measures geology in these sections of hillslope are made up of sandstones rather than clay-based materials.

Cores 46, 14, 13 and 37 are all taken from the area of restored soils, and each proved a similar sequence of constituents. The topsoil was a soft, often stony and slowly permeable clay loam that consistently included coal chips. At depth, it gave way to a moderately-draining sandy loam or mixed rubble of Coal Measures spoil. At each sample, the rubble had a defined lower boundary with a dark-grey, massive silty clay. This material was somewhat compacted, and sometimes proved too indurated to penetrate. When soft, the clay was penetrated to full auger depth, and no underlying material was proved.

Core 35 was typical of most floodplain cores in proving a layer of silty fine sand, which was lightly mottled and showed signs of periodic waterlogging.

Cross-section C. This floodplain section reveals the main variations within the disposition of alluvial materials. The cores along this section demonstrate the generally fair to good drainage within much of the floodplain. Nonetheless, four of the cores include a layer of silty clay at the top of, or within, coarse sand and gravels, which is revealed in section 4.2.2 as the dominant constituent of the floodplain south of Lowfield Lane. From the distribution of these cores, it would appear as if the soils in the centre of the floodplain have impeded drainage. Similarly, no coarse sand was proved in the cores west of West Moor Dike, and this zone may also have slow drainage. Indeed, cores 7 and 8 appear to lie within an area shown on 1960s O.S. maps as marsh (Figure 4).

Scheme design issues are:

- Current high watertables are perched and seasonal on the clay and restored soils
- Groundwater seepages are minimal and limited to small areas
- Upland and slope soils are slowly permeable
- Floodplain soils are largely permeable to very permeable and watertable height is dependent on river level

Appendix 2. ADWICK WASHLAND - LOG OF SOIL CORES**Soil - restored area**

	Clay loam	Heavy clay loam	Sandy loam	Rubble	Silty clay	Watertable	End
13	0		54	67	76	69	225
14	0		24	51	68		225
15	0			31	53		90
36	0	44		133	205		225
37	0			33	67		91
38	0			28	82		225
42	0			34	60		83
43	0			31	61		225
46	0			32	38		65

Most cores became too compacted to penetrate much beneath the surface of the massive silt clay.

Soil - floodplain

	loam	silt loam	sandy loam	silty clay	silty clay loam	silty fine sand	silty clay	coarse sand	silty clay	watertable	end
1	0	26	78					105		81	139
2	0	23	56					110		90	150
3	0	25	41	47	55			126			151
4	0	27	47					104		95	176
5	0	24	28			73	135	171		174	225
6	0	27	43		88			124	176	176	225
7	0	41		113		156				170	194
8	0	28				128				118	161
9	0	27				83				129	187
10	0	28		104		153				111	181
12	0	29	57	105	162						225
16	0		26	37	60	74					90
28	0	27	69	112		172				172	195
33	0		24			51		80		136	156
34	0	28	36			41					97
35	0	26				32					104
39	0		26			34		66		86	101
40	0		27			47				102	154
41	0		27			33				150	150

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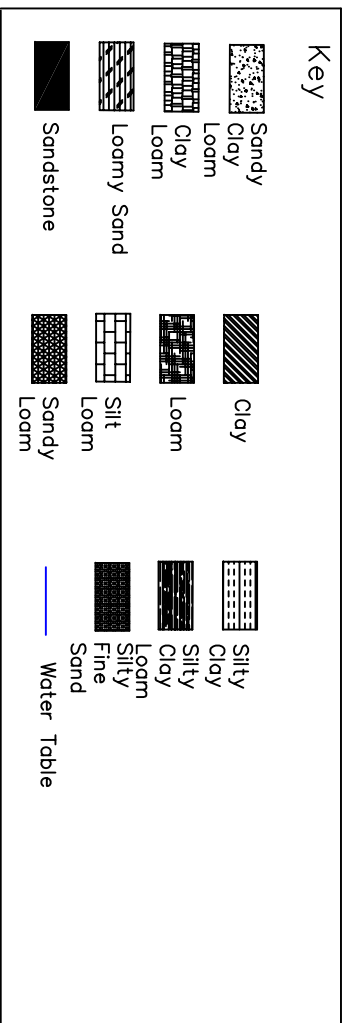
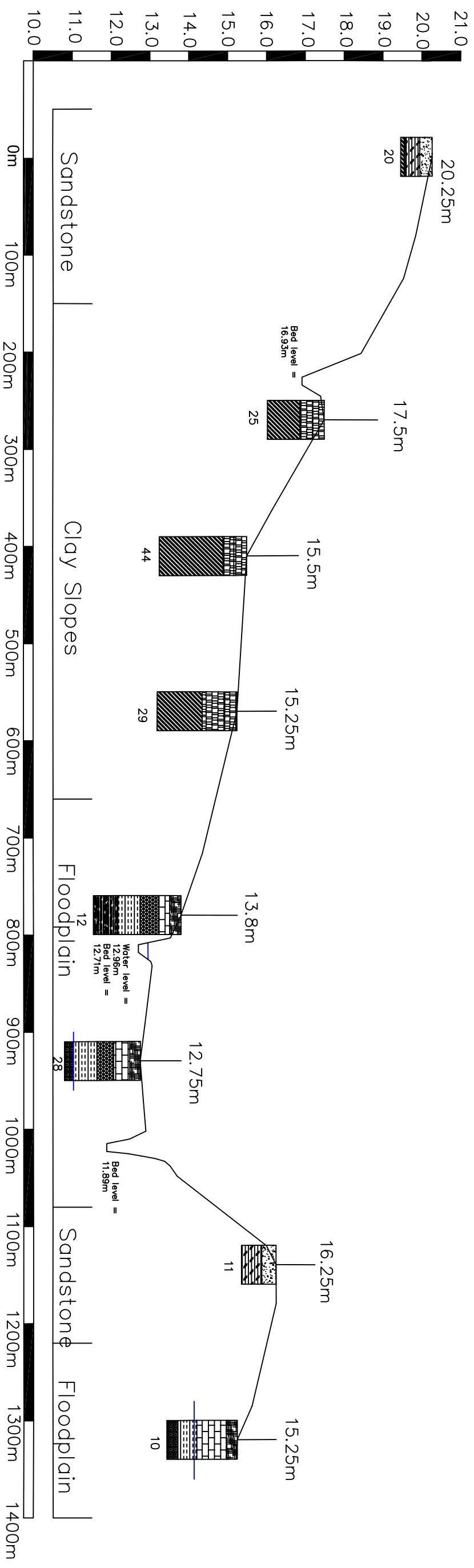
Soil - sandstone

Core	Sandy clay loam	Medium clay loam	Sandy loam	Medium clay loam	Loamy sand	Sandstone rubble	Silty clay	Watertable	End	Note
11	0				37				89	Too dry and compacted to pick up
17	0	40	57		92				100	Too dry and compacted to pick up
18	0				40				51	Too dry and compacted to pick up
19	0				41	72			75	Too dry and compacted to pick up
20	0				32	67	72		81	Too dry and compacted to pick up
23	0	29	58		69			64	132	Too wet to pick up
26	0		29	41		64			72	Too dry and compacted to pick up
27	0		30			73			136	Too dry and compacted to pick up
31	0		30		51	189		210	225	

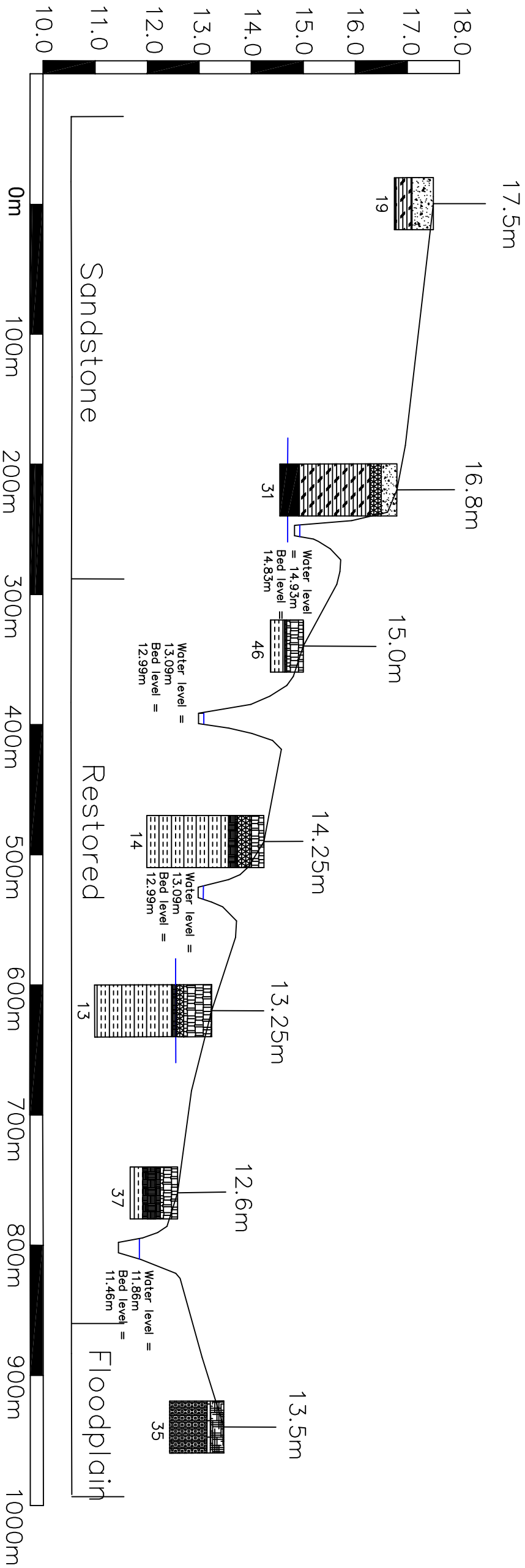
Soil - Clay slopes 15.02

	Clay loam	Clay loam	Clay	Sandstone	Watertable	End
21	0	29	85		96	144
22	0	29	125		139	225
24	0	32	162		162	225
25	0	30	63	146		149
29	0	31	89			205
30	0	30	49	176		225
32	0	25	174			225
44	0	33	61			225
45	0	32	57	194		205

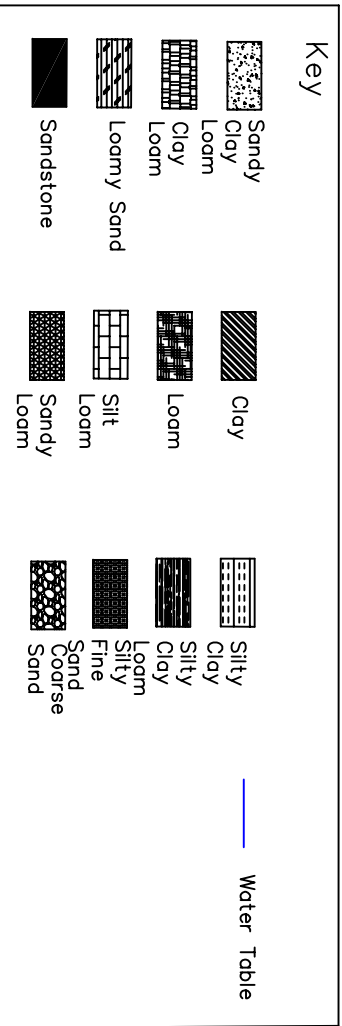
Cross-section
A



Cross-section
B



15.



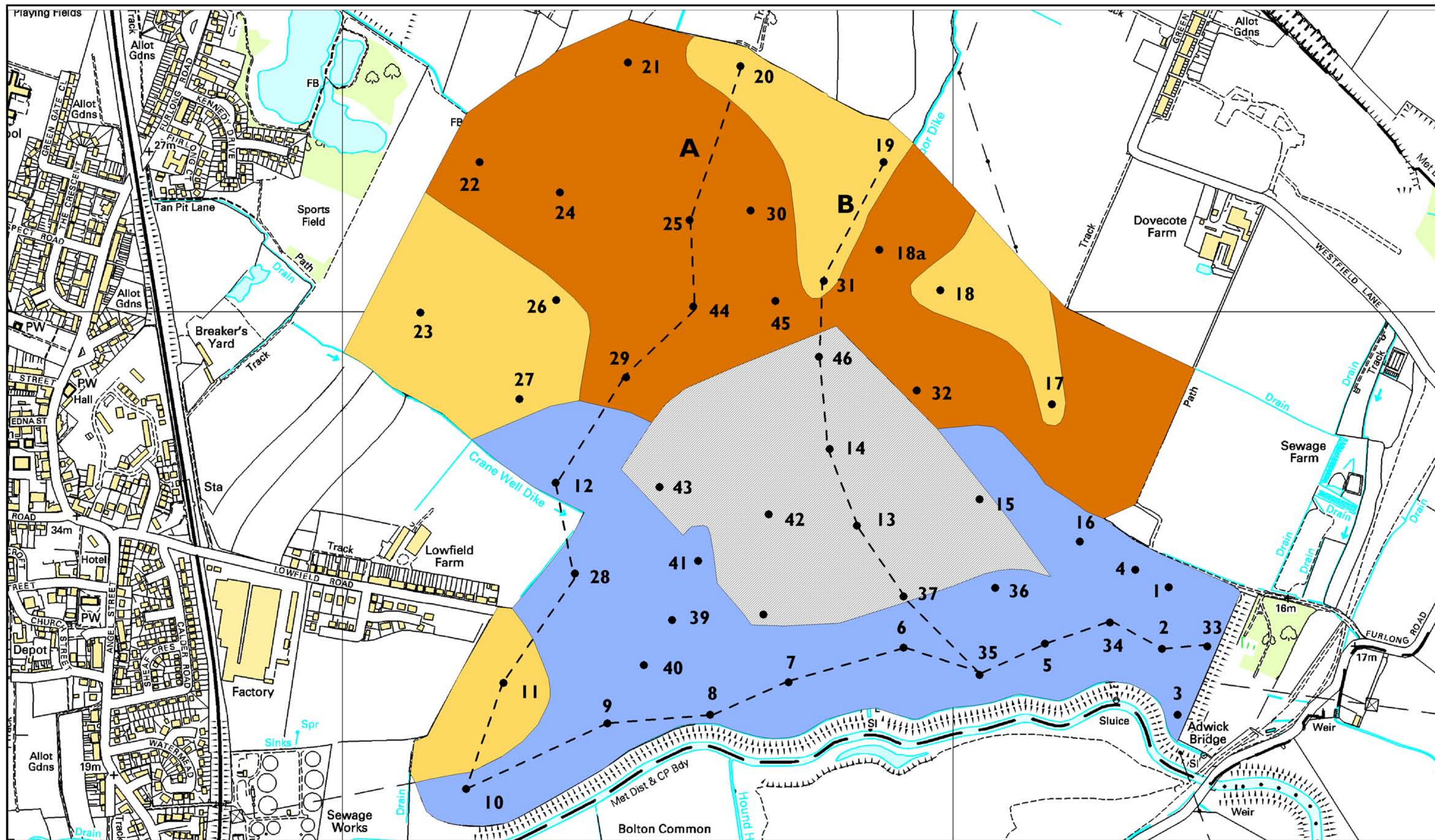


Figure 6. Soil Survey core locations and illustrative soil zones

Key:

 Clay	 Floodplain
 Sand	 Restored

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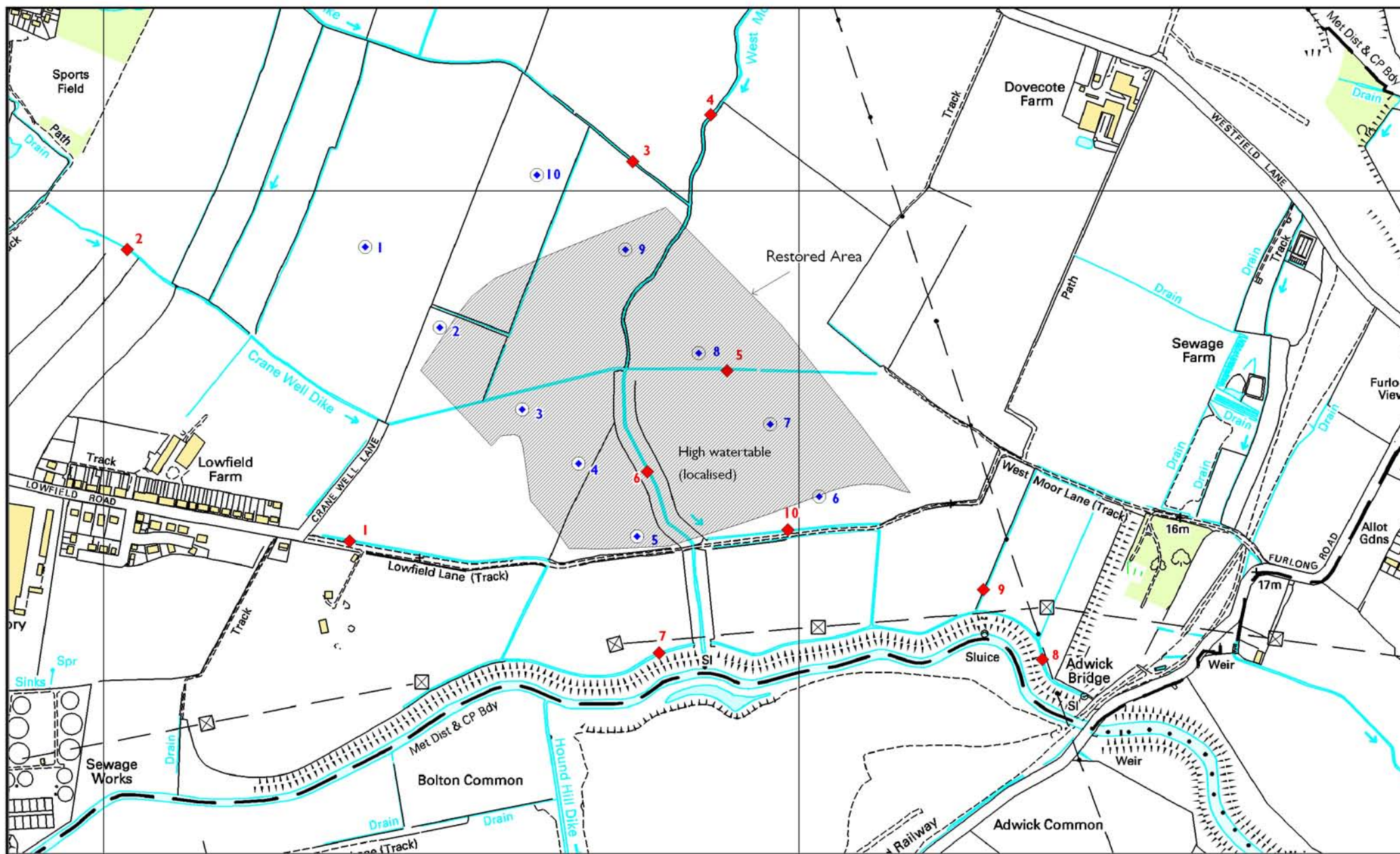


Figure 12. Soil and water test sampling points

Key: ♦ Water quality test sampling points ■ Restored area
 ● Soil contamination test sampling points

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