E54

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

Ecology and biodiversity

Habitats Regulations Assessment screening report for Pasturefields Salt Marsh Special Area of Conservation (EC-017-003)

July 2017

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Department for Transport

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HS2 Phase 2

HRA Screening Report for Pasturefields Salt Marsh SAC

September 2012

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1. Introduction

1.1.1. The proposed High Speed 2 rail link has considered a number of route options within the vicinity of Pasturefields Salt Marsh. Pasturefields Salt Marsh is designated as a Special Area of Conservation (SAC) under *European Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (92/43/EEC)* [the *Habitats Directive*] and the site is henceforth referenced throughout this report as the "Pasturefields Salt Marsh SAC".

1.1.2. The Habitats Directive is enacted in England & Wales through the *Conservation of Species and Habitats Regulations 2010 (as amended)*. This requires the competent authority to assess the effects of development on Natura 2000 sites and to determine if the development will result in a likely significant effect on any of them, either alone or in-combination with other projects and plans. Where a likely significant effect is concluded, or where no likely significant effect cannot be concluded, the competent authority must then undertake an Appropriate Assessment (AA), to determine whether the effects will result in an adverse effect on the integrity of any Natura 2000 site. If the assessment concludes that adverse effects may occur, further factors may need to be considered before any approval of a development can be given. The project must demonstrate that there are no other feasible alternatives, that there are Imperative Reasons of Overriding Public Interest (IROPI), and that appropriate compensation measures will be put in place to maintain the coherence of the Natura 2000 network.

1.1.3. The assessment is termed a Habitats Regulations Assessment (HRA) and there is a well-established process for undertaking it (see Section 2). Although it is the responsibility of the competent authority to undertake the HRA, it is expected that the proponent of any development will provide sufficient information to enable such an assessment to be undertaken. It is a very stringent process with often demanding requirements to be met (focusing on the conservation objectives for each Natura 2000 site) if it is to be demonstrated that a project can avoid adverse effects on the integrity of a Natura 2000 site.

1.1.4. HS2 Ltd in consultation with Natural England (as well as the Environment Agency) has recognised the need to consider the likely significant effects of the Birmingham to Manchester route options on Pasturefields Salt Marsh SAC at an early stage in the development of the scheme design.

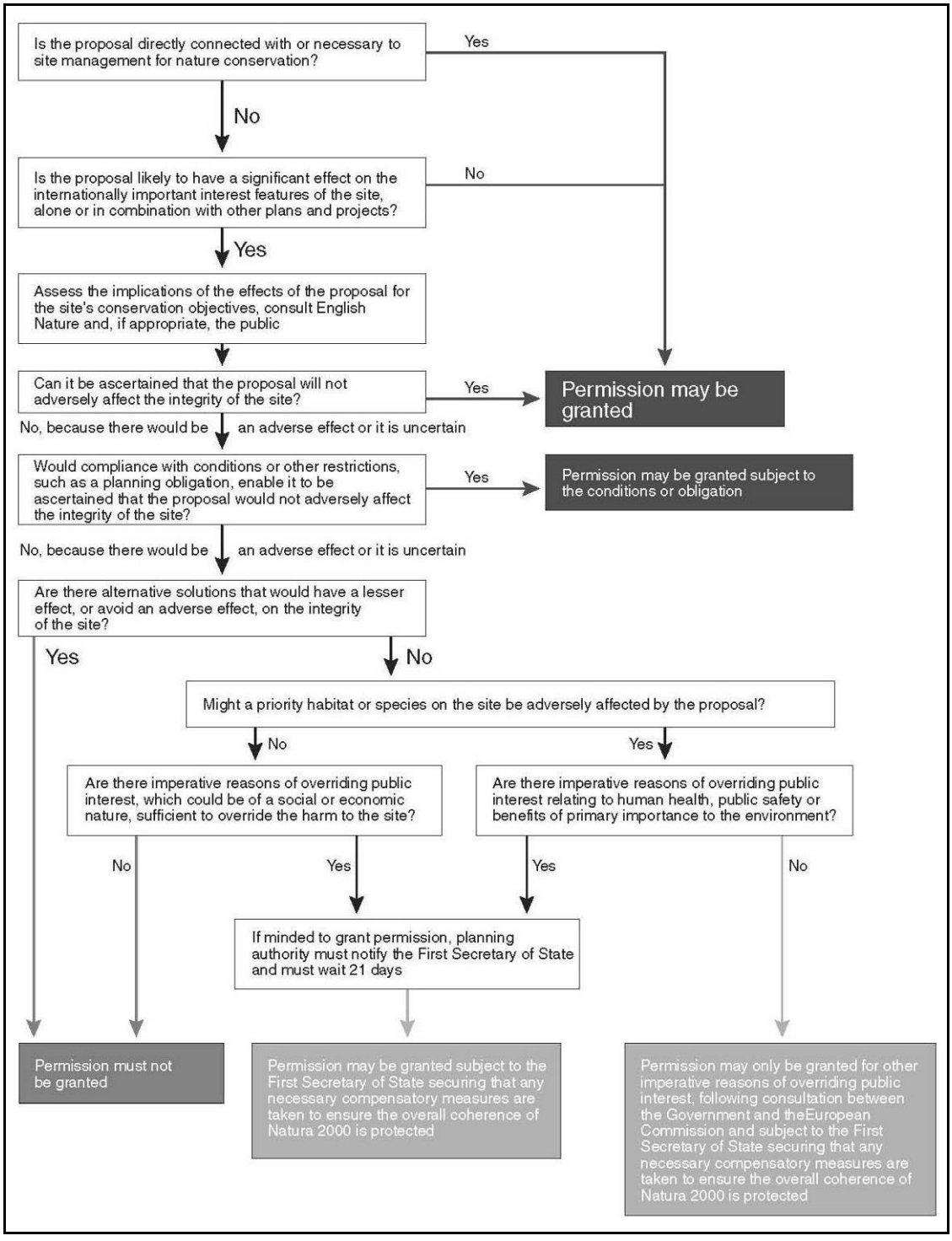
1.1.5. This report summarises the findings of the HRA screening. It has sought to identify issues relating to the route options close to the Pasturefields Salt Marsh SAC which have been considered thus far, and the likely potential impacts to the Pasturefields Salt Marsh SAC from each. It identifies avoidance measures for generic impacts at each stage of a typical large scale infrastructure development. Where applicable, a reasonable worst case scenario approach for the consideration of impacts has been adopted as appropriate to allow for uncertainty over development impact parameters.

2. Appraisal method

2.1. Summary of HRA process

2.1.1. The HRA process comprises a number of stages as shown in Figure 2-1 below which is taken from Circular 06/2005 produced by the Office of the Deputy Prime Minister (ODPM).

Figure 2-1 – Consideration of development proposals affecting internationally designated nature conservation sites



2.1.2. The HRA screening stage examines the likely effects of a project either alone, or in-combination with other projects and plans on a protected site, and considers whether significant effects are likely to occur. The following issues are considered:

- could the proposals affect the qualifying interest and are they sensitive / vulnerable to the effect;
- the probability of the effect happening;
- the likely consequences for the site's Conservation Objectives if the effect occurred; and
- the magnitude, duration and reversibility of the effect.

2.1.3. The screening stage has therefore sought to conclude one of the following three outcomes:

1. no likely significant effect;
2. a likely significant effect; or
3. it cannot be concluded that there will be no likely significant effect.

2.1.4. If the assessment concludes outcomes two or three, then the need for an Appropriate Assessment will be triggered.

'Likely significant effect' in this context is any effect that may reasonably be predicted as a consequence of the project that may significantly affect the conservation or management objectives of the features for which a site was designated[1].

2.1.5. A judgement as to the significance of an effect must take into account factors such as temporal considerations (e.g. length of time of effect) and physical considerations (e.g. extent of effect on the European site and the elements of the site including its conservation objectives). It is possible, therefore, for an effect to damage something on the European site, but because such damage is fleeting, limited in extent or damaging to something out with any conservation objectives the effect is insignificant on the European site. The judgement should also take into account the likely effects once avoidance measures have been applied.

2.2. Consultations

2.2.1. Consultations with Natural England (NE), as the Government's statutory advisors on nature conservation including HRA, are an important part of the process. HS2 Ltd has undertaken regular consultations with NE and continues to do so. Consultation has also been undertaken with the Environment Agency (EA) in relation to hydrological matters.

[1] Habitats Regulations Guidance Note 3. The Determination of Likely Significant Effect under The Conservation (Natural Habitats &c) Regulations 1994. English Nature, 1999.

3. Pasturefields Salt Marsh SAC

3.1. Location and general description

3.1.1. Pasturefields Salt Marsh SAC[1] is located approximately 7km to the east of Stafford centre, close to the Grand Trunk Canal in ;the West Midlands of England. Pasturefields Salt Marsh SAC is the only significant remaining example in the UK of a natural salt spring with inland saltmarsh vegetation.

3.1.2. Pasturefields Salt Marsh SAC covers a total area of 7.7ha and the boundary is the same as for the Pasturefields Salt Marsh Site of Special Scientific Interest (SSSI). The site was proposed as a Site of Community Interest in June 1995, and fully designated as an SAC in April 2005. The underlying SSSI was originally notified in June 1986. This site contains extremely rare and vulnerable habitat as it is one of only two known extant inland salt meadows remaining in the British Isles. The other is Upton Warren Pools which is designated as a SSSI. There is also a weak saline spring with saltmarsh plants at Napton (Warwickshire).

3.2. Qualifying interest features

3.2.1. The primary reason for the designation of Pasturefields Salt Marsh as an SAC is for the presence of inland salt meadows, a priority habitat which is listed on *Annex I* of the Habitats Directive.

3.2.2. **H1340 Inland Salt Meadows; Inland Saltmarshes** - The vegetation consists of *Festuca rubra* (red fescue) (see Figure 3-1), with *Puccinellia maritima* (common saltmarsh-grass), *Spergularia marina* (lesser sea spurrey), *Juncus gerardii* (saltmarsh rush) and *Triglochin maritimum* (sea arrowgrass) in the most saline situations[2].

3.2.3. The majority of the site comprises humid grassland and mesophile grassland[3] (making up 90.5% of the site). Pasture and steppes make up 6.5% of the site and inland water bodies are also present. This site supports a number of halophytic plants. The SSSI citation states that the most notable of these is *Plantago maritima* (sea plantain) (see Figure 3-2), known only from one other comparable inland site in Britain. The community is classified as *Festuca rubra* (red fescue) Saltmarsh, and shows three distinctive plant associations reflecting differences in salinity, waterlogging and poaching. The most saline situations are around small pans of standing saline water where there is a high cover of common *Puccinellia maritima* (saltmarsh-grass), with *Spergularia marina* (lesser sea spurrey), *Juncus gerardi* (saltmarsh rush) and *Triglochin maritima* (sea arrowgrass). On soils of intermediate salinity *Agrostis stolonifera* (creeping bent) replaces *Puccinellia* as the most abundant species with the same range, but with a lower cover of other halophytes. *Alopecurus geniculatus* (marsh foxtail) and *Glaux maritima* (sea milkwort) also occur.

[1] Site ref: UK0012789

[2] JNCC (1995) Natura 2000 Standard Data Form, Pasturefields SAC.

[3] Much of this is in the form of semi-improved pasture of low floristic interest, dominated by *Lolium perenne* (perennial rye grass). To the east of the dividing drain there is a gradual zonation from saltmarsh into a rushy, wet neutral grassland of *Deschampsia cespitosa* (tufted hair-grass), *Glyceria fluitans* (floating sweet-grass), and *Ranunculus repens* (creeping buttercup).

Figure 3-1 – *Festuca rubra* (red fescue) - key species of the community present at Pasturefields Salt Marsh SAC

(Source: D Taylor, not taken on the Pasturefields Salt Marsh SAC)

Figure 3-2 – *Plantago maritima* (sea plantain) - notable halophytic species present at Pasturefields Salt Marsh SAC, normally found in coastal communities

(Source: D Taylor, not taken on the Pasturefields Salt Marsh SAC)

3.3. Conservation objectives

3.3.1. Conservation objectives for SACs are set by Natural England to inform site management decisions. In particular, they seek to ensure that there should be no deterioration, or significant disturbance, of the qualifying features from their condition at the time the site was formally identified. The conservation objectives are also essential in determining whether the effects of a plan or project are likely to have a significant effect[1] on the qualifying interests of the site. NE has prepared revised conservation objectives for Pasturefields Salt Marsh SAC which were drafted in June 2012.

3.3.2. The Conservation Objectives for Pasturefields Salt Marsh are set out in Table 3-1 below

Table 3-1 – Pasturefields Salt Marsh Conservation Objectives

Qualifying Features (habitats and species)	Conservation Objectives
H1340 Inland salt meadows; Inland saltmarshes	With regard to the natural habitats and/or species for which the site has been designated ("the Qualifying Features"): **Avoid the deterioration of the qualifying natural habitats and the habitats of qualifying species, and the significant disturbance of those qualifying species, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features.** Subject to natural change, to maintain or restore: • The extent and distribution of qualifying natural habitats and habitats of qualifying species; • The structure and function (including typical species) of qualifying natural habitats and habitats of qualifying species; • The supporting processes on which qualifying natural habitats and habitats of qualifying species rely; • The populations of qualifying species; and • The distribution of qualifying species within the site.

(Source: Natural England, 2012)

3.4. Key site vulnerabilities and sensitivities

3.4.1. The key site sensitivities for the inland salt meadows feature were established by reviewing information provided within the JNCC *Conservation Status Assessment Article 17 reports (2007)*[2], and the revised conservation objectives of Pasturefields Salt Marsh SAC drafted in June 2012, and identifying the main sensitivities and vulnerabilities for each habitat, or species listed as a qualifying interest feature. The vulnerabilities and sensitivities are presented in Table 3-2.

[1] Article 6.2 of the Habitats Directive

[2] Joint Nature Conservation Committee. 2007. Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17

Table 3-2 – Pasturefields Salt Marsh SAC vulnerabilities and sensitivities

Interest Feature	Interest feature sensitivities and vulnerabilities
Inland Salt Meadows	**Nutrient Enrichment** Nutrient enrichment from flood/ atmospheric deposition has the potential to increase growth of competitive species and thereby reduce the diversity of the site. Investigations are underway through the Review of Consents process to see if this is a major issue contributing to unfavourable condition. This habitat was omitted from JNCC's overall assessment of air pollution impacts for FCS reporting, because it is not equivalent to the more widespread habitats which were considered. Much attention has focused on the possible impacts of enriched floodwater and diffuse inputs. A target of 30-40 kg/ha/year of nitrogen has been set by NE.[1]
	Drainage Artificial drainage channels have the potential to adversely affect hydrological system of the site. Poor drainage could lead to a dilution of the water and soil salinity levels thereby reducing the conditions that favour halophytic species.
	Grazing level Stocking levels need to be appropriate to the interest of the site. Overgrazing can lead to the direct loss of qualifying plant species of the SAC. Under-grazing can lead to a loss of plant diversity by competitive exclusion. The persistence of the salt meadow is dependent upon traditional agricultural management, livestock grazing and minimal use of agricultural chemicals.
	Other human induced changes in hydraulic conditions and/or brine source The site is regarded as vulnerable to any hydrological changes, particularly interference with the brine supply to the site. Any change in salinity could affect the sites ability to support the inland salt meadow community.

3.5. Current site condition

Information regarding the favourable conservation status of the Pasturefields Salt Marsh SAC is informed by the condition monitoring of the SSSI which underpins the SAC designation. The Pasturefields Salt Marsh SSSI site condition is taken from condition assessments carried out by NE. The latest condition assessment was carried out on 30th January 2009. During condition assessments the site is assessed against the criteria set out in the Common Standards Monitoring Guidance[2], which includes criteria such as the extent of the habitat. The site only has to fail one of the criteria to be considered unfavourable.

The condition assessment undertaken in January 2009 concluded that the entire site is in 'unfavourable recovering'[3] condition, although no additional details of the condition assessment are provided[4] . Despite stability in extent and area, the site was regarded as having more than 25% of its area in unfavourable condition in terms of specific structures and functions. Key concerns were inappropriate grazing (now regarded as under control) and nutrient enrichment from flooding and atmospheric deposition; the latter two likely to be exacerbated by climate change.

[1] Environment Agency. 2007. Final Draft Proforma for Stage 3 of Review of Consents – Pasturefields.

[2] JNCC (2004) Common Standards Monitoring Guidance for Lowland Wetland Habitats.

[3] SSSI units are not yet fully conserved but all the necessary management measures are in place. Provided that the recovery work is sustained, the SSSI will reach favourable condition in time.

(4) http://www.sssi.naturalengland.org.uk/special/sssi/reportAction.cfm?report=sdrt13&category=S&reference=1003939

3.5.1. Pasturefields Salt Marsh SAC is bordered to the south-west of the site by the River Trent and has an agricultural drain running through the middle of it. The site is dominated by damp semi-improved grassland. Salt meadow communities are found in a restricted section of the site at the south end fed by a brine water spring. In this area, south of the drain, salinity is highest and saltmarsh communities SM13 *Puccinellia maritime* salt marsh community/SM16a *Festuca rubra* salt marsh community (*Puccinellia maritime* sub-community)/SM23 *Spergularia marina-Puccinellia distans* salt marsh community are present. Directly to the south-east of this section is an area of saltmarsh with communities most similar to SM16 *Festuca rubra* saltmarsh community. To the north-east of the drain salinity is lower and saltmarsh communities are patchy. Knowledge of the source of the brine spring is limited, but it has been suggested that the source lies to the north-east (based primarily on two former brine sites, now destroyed, at Weston and Shirleywich), and that groundwaters flow over halite beds and rise up through sands and gravels overlying Mercia mudstone.[1]

3.5.2. The inland salt meadow is vulnerable/sensitive to a number of threats as discussed in Table 3-2. These threats are taken into account in the site specific targets for the Pasturefields Salt Marsh SSSI, set to help achieve and maintain the favourable condition of the SSSI and hence the favourable conservation status of the Pasturefields Salt Marsh SAC. The specific threats are summarised in Table 3-3 below which is based on the JNCC Article 17 report (2007) as well as NEs Views about Management (VAM) of the Pasturefields Salt Marsh SSSI designation which underpins the Pasturefields Salt Marsh SAC. To date site management to protect the interest features has concentrated in changing the grazing regime from aftermath grazing to light grazing through spring, summer and autumn, and improved drainage to reduce freshwater dilution.

1 Environmental Simulations International Ltd. 2004. An assessment of the hydrological conditions at the Pasturefields Saltmarsh SSSI.

Table 3-3 –Site threats to inland salt meadows

Attribute	Site-specific target (favourable condition status)	Threats
Vegetation Structure: Zonation of Vegetation	Maintain the range of variation of zonations typical of the site. The common standards monitoring is based on marine saltmarsh with classical zonation related to tidal inundation. The conservation objectives for the site recognize that these are not entirely applicable to inland saltmarsh, but note that there appears to "*be rough zonation within this broad grouping such that the most saline communities (small areas with similarities to SM13a) occur near to the well on the SW side of the drain, the least saline communities (SM16e) are found on the NE side of the drain and those of intermediate salinity (SM16/b/c) are found on the SW side of the ditch away from the well.".* Natural England targets required to support the vegetation structure are a soil salinity of 8000 ug/g and a brine salinity of 3700 ug/g.	The threats to the site were identified as air pollution, drainage and other human induced changes to the hydraulic regime.
Vegetation Structure: Sward Height	Maintain short sward (4-12 cm) in areas of species-rich vegetation.	Stocking levels need to be appropriate to the interest of the site. Over-grazing can lead to loss of rare plant species and affect bird breeding and feeding habitats and under-grazing can lead to a loss of plant diversity by competitive exclusion.
Vegetation Composition: Characteristic Species	Maintain or increase the diversity and frequency of those saltmarsh plant species and communities previously recorded. Pioneer Saltmarsh: *Salicornia* spp., *Suaeda maritime****, Puccinellia maritime****, Aster tripolium*. Low-mid Saltmarsh: *Puccinellia maritime, Triglochin maritime, Plantago maritima, Atriplex portulacoides, Aster tripoliu, Spergularia marina, Suaeda maritima, Salicornia* spp., turf fucoids. Mid-supper saltmarsh: ***Festuca rubra, Juncus gerardii, Armeria maritima, Agrostis stolonifera,*** *Limonium vulgare,* ***Glaux maritima****, Seriphidium maritimum, Plantago maritima, Aster tripolium, Juncus maritimus,* ***Triglochin maritima****, Blysmus rufus, Eleocharis uniglumis, Artemisia maritime,* ***Leontodon autumnalis****, Carex flacca, Carex extensa*, turf fucoides. Of the positive indicator species listed above only those in bold have been previously recorded at Pasturefields. In addition, at the time of notification the frequency of all the saltmarsh specialists in this list was never more than **rare** (i.e. present in fewer than 1 in 5 stops). The transition from saltmarsh plant communities to neutral grassland is abrupt.	Although no specific threats are mentioned in this category the general threats arising from agricultural improvement and changes in hydrology, the latter impacting on the extent of the saline influence, are relevant to this attribute. In addition inappropriate grazing and nutrient enrichment from flooding/ atmospheric deposition could apply.

Attribute	Site-specific target (favourable condition status)	Threats
Other Negative Indicators	Artificial drainage channels adversely affecting hydrology are absent or rare. No obvious signs of pollution. Turf cutting absent or rare. No increase in bare substrate as a result of anthropogenic activities such as vehicle use or trampling at vulnerable locations (tracks, access points). Poaching damage from stock or horses rare, with bare mud extent <25%	Artificial drainage channels Pollution Turf cutting Poaching damage Trampling
Indicators of local distinctiveness	Maintain distinctive elements at current extent/levels and/or in current locations (maintain existing populations of notable species, important structural attributes or notable transitions between habitats).	No threats are mentioned specifically but the current unfavourable condition assessment is based on concerns about the structural attributes vulnerability to; nutrient enrichment from flooding/ atmospheric deposition; hydrological changes and inappropriate grazing.
Vegetation Composition: negative indicator species	Record % cover of large Juncus spp, *Deschampsia cespitosa,* large *Carex spp.* (leaves more than 5mm wide) e.g. *Carex acutiformis,* large grasses (leaves more than 10mm wide, stout stems) i.e. *Glyceria maxima, Phalaris arundinacea, Phragmites australis, Cirsium arvense, Cirsium vulgare, Rumex crispus, Rumex obtusifolius, Urtica dioca* and *Senecio spp.* No species/taxa together or singly covering more than 10% of the sward.	The presence of large rushes and grasses and species considered to be negative indicators of species-rich neutral grassland and are indicative of nutrient enrichment, inappropriate grazing and changes in hydrology.

3.6. Hydrological characteristics

3.6.1. Due to lack of access to available data and inability to undertake additional ground investigation, the hydrological processes that support the salt meadows are imperfectly understood. A conceptual model bringing together an understanding of how brine flows reach the Pasturefields Salt Marsh SAC from the north-east, passing under the clay lined Trent Canal and then being forced upwards by the underlying Mercia Mudstone through overlying alluvial deposits, was prepared by Environmental Solutions International (2004). This model has been refined as part of this screening report, and is presented in Figure 3-3 (see also Appendix 1, Figure 3 and Figure 3.2 ESI site plan and Figure 3.3 borehole logs).

3.6.2. There are known to be a number of dissolution features[1] that lie to the north of Pasturefields Salt Marsh SAC (Appendix 1, Figure 1), indicating the likely route of the groundwater flow which feeds the saline spring and surfaces in Pasturefields Salt Marsh SAC. The saline nature of the spring is caused by groundwater dissolving salts from the rock as it passes through pockets of halite (rock salt) within Mercia Mudstone as it flows through the ground. Dissolution features to the west at Stafford are not related to the brine springs at Pasturefields Salt Marsh SAC. There exists a geological fault between Stafford and Pasturefields (Appendix 1, Figure 2) and strata to the west of this fault dip in a westerly direction, away from Pasturefields and groundwater flows are likely to do the same. As a result, there are not predicted to be any saline groundwater flows from the west or south of the site to the Pasturefields Salt Marsh SAC.

3.6.3. Details of the conceptual hydrological process model have been postulated as follows and further illustrated in Appendix 1, Figure 3; the saltmarsh lies in the floodplain of the River Trent (Appendix 1, Figure 5), between the River Trent to the west and the Trent and Mersey Canal to the east. It is situated within an area designated by the British Geological Survey (BGS) as superficial aquifer (Appendix 1, Figure 6). Surface geology of the surrounding area includes outcrops of Mercia Mudstone Group, River Terrace Gravels and alluvium (Appendix 1, Figure 2). Available BGS borehole data have been considered and are included in Appendix 1 for reference, however they are not sufficient in detail or extent to provide any firm conclusions. Conversely, there is nothing in the available BGS borehole data which contradicts the conclusions reached in this assessment.

3.6.4. The Pasturefields Salt Marsh SAC site and surroundings were visited by a hydrologist on the 8th May 2012 and photographs are included in Appendix 1 with locations indexed in Figure 4. The saltmarsh is bisected by a surface water ditch (see ESI site plan Figure 3.2) which is fed by an overflow weir from the Trent and Mersey Canal (see Section 3.4.9 below). East of the ditch, the Pasturefields Salt Marsh SAC is underlain by River Terrace Sands and Gravels over Mercia Mudstone within which there are recorded halite beds or pockets of halite bed structures (refer to on-site borehole data presented in *An assessment of the hydrogeological conditions at Pasturefields Saltmarsh SSSI*, October 2004, prepared by ESI for the Environment Agency, in Appendix 1 of this report). West of the central ditch the Pasturefields Salt Marsh SAC is underlain by (relatively impermeable) alluvium and the brine springs emerge at the interface of the alluvium and the River Terrace Gravels.

3.6.5. It is understood that the brine springs are fed entirely by rain water recharge of groundwater reserves. Fresh rain water filters into the ground to the north-east of the site (most likely through the River Terrace Gravels and peat dissolution features near Amerton) to charge up an underlying aquifer. Groundwater filters through both the river terrace gravels and

[1] Geological features caused by the dissolving of soluble outcrops of rock by groundwater resulting in caverns or sinks. The dissolution of the rock causes the dissolving water to become saline.

through the halite structures within the Mercia Mudstone, dissolving salts held within the halite structures along the way. If the halite beds were not present, groundwater filtering through the river terrace gravels would emerge as sweet (non-saline) water at Pasturefields Salt Marsh SAC.

3.6.6. Salinity in the aquifer (and the brine spring) will be sensitive to the rate of flow through the halite beds, the length of the flow path through the halite beds and the ratio of sweet water contributions from the river terrace gravels to the brine which emerges from the halite beds. After emerging as a spring, the brine flows through the marsh and mixes with surface water flows through the saltmarsh, which for most of the year, are very small.

3.6.7. Any surface water flow towards the saltmarsh from the east (including any groundwater which emerges east of the marsh to become surface water), will be intercepted by the Trent and Mersey Canal since the north-eastern bank is cut into the ground (see annotated photographs, Appendix 1). Any flow which enters the canal is either conveyed down the canal itself, or discharged via canal overflow features, which exist to regulate water levels along its length. Pertinent to the Pasturefields Salt Marsh SAC, there are two overflow weirs, one to the north (upstream of the Pasturefields Salt Marsh SAC) and one to the south (downstream of the Pasturefields Salt Marsh SAC). As such, when canal levels are lower than the overflow weir level, the Trent and Mersey canal forms an effective barrier to surface water flows from the east. When canal levels exceed that of the overflow weir to the north of the site, the weir spills into the central ditch within the Pasturefields Salt Marsh SAC. The frequency and rate of weir overflow is unknown, but most of the time it is likely to be a near-constant trickle. Sweet-water contributions from the central ditch will tend to dilute the salt-water contributions from the brine springs.

3.6.8. There are two watercourses which pass under the Trent and Mersey Canal and discharge into the River Trent, namely the Amerton Brook which crosses approximately 1km to the north and a small, un-named watercourse which rises on Farley Farm and crosses approximately 400m to the south. Neither of these watercourses have any direct impacts on the hydrology of the Pasturefields Salt Marsh SAC apart from their contributions to the flow in the River Trent.

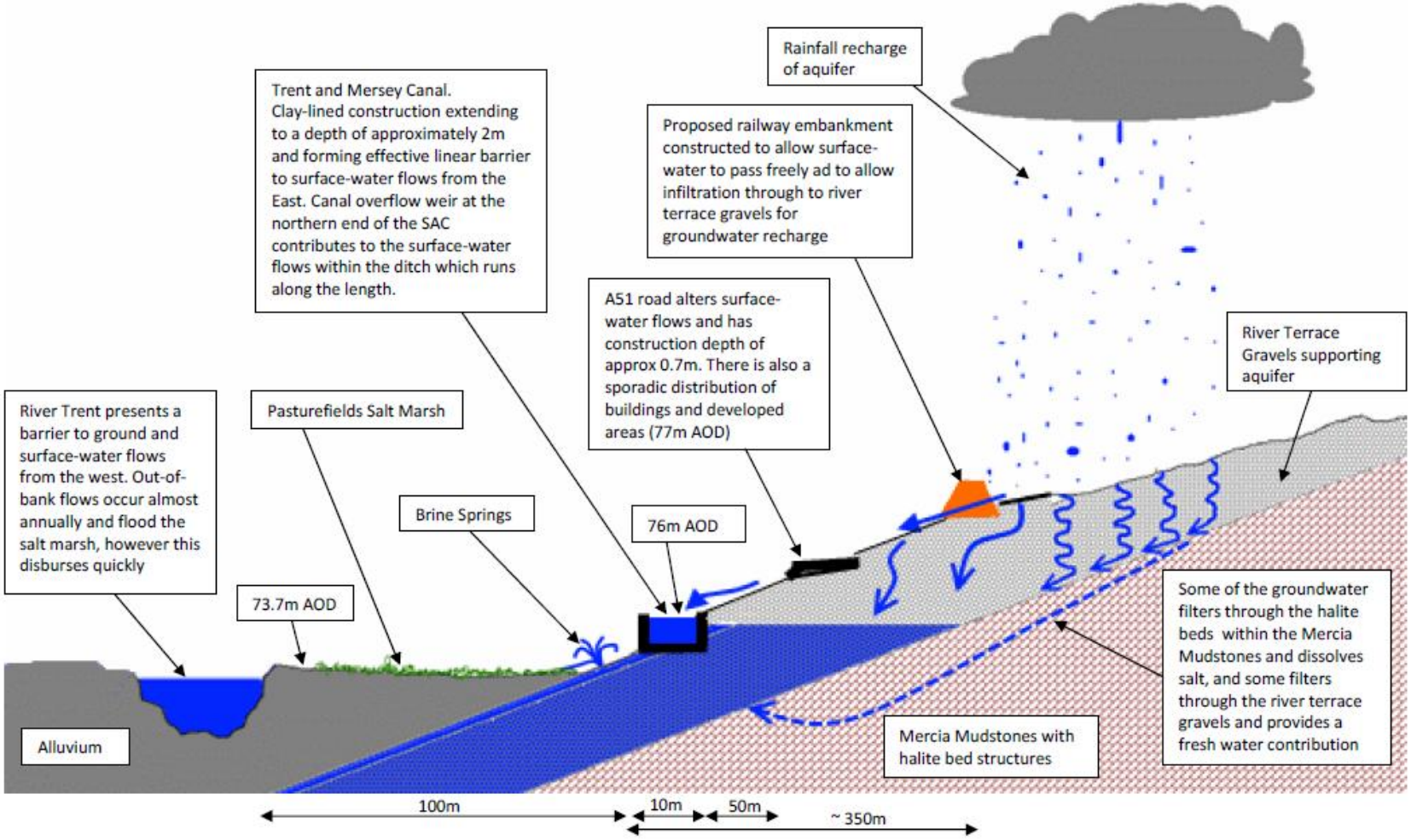
3.6.9. Any surface water flow towards the saltmarsh from the west will be intercepted by the River Trent which forms an effective barrier to surface water flows from the west for most of the year. Surface water flows from the west only contribute to flow on the Pasturefields Salt Marsh SAC are when the River Trent floods to the extent that it rises out of bank and floods the Pasturefields Salt Marsh SAC.

3.6.10. When they occur, flood flows from the River Trent are many orders of magnitude greater than the flows from the brine springs. Based on an assessment of the gauged flow at Great Hayward, 2km downstream, where the channel, catchment and floodplain are very similar, flooding of the Pasturefields Salt Marsh SAC occurs once or twice per year. The Gauge Rating Curve (Environment Agency) shows bank-full conditions occur at a flow rate of approximately 25m3/s, and the Gauged Daily Flow Exceedance curve (NERC) shows that flows in excess of 25m^3/s occur on average about 1½ days in every year (see Appendix 1, Figures 7 and 8). Flood waters are quickly drained following a flood event. For these reasons, contributions from the River Trent, and therefore contributions of surface water flows from the west, are unlikely to play a significant part in the day-to-day functioning of the saltmarsh. In fact, indications are that flooding of the saltmarsh is contributing to a decline in its condition.

3.6.11. Since flood flows and surface water flows from the east and west are restricted, it remains that the health of the saltmarsh is dependent on the following four components:

- the rate and salinity of flow from the brine spring (which in turn is dependent on the rainfall reaching the river terrace gravels to the north-east of the site and the rate and duration of flow through the halite beds);
- the rate of overflow from the Trent and Mersey Canal immediately north of the site feeding the central ditch;
- direct rainfall on the Pasturefields Salt Marsh SAC; and
- possible seepage from the canal (although this is very unlikely to be a significant contributor).

Figure 3-3 Conceptual Site Model of Pasturefields Salt Marsh SAC (showing northern route options)



4. Route options

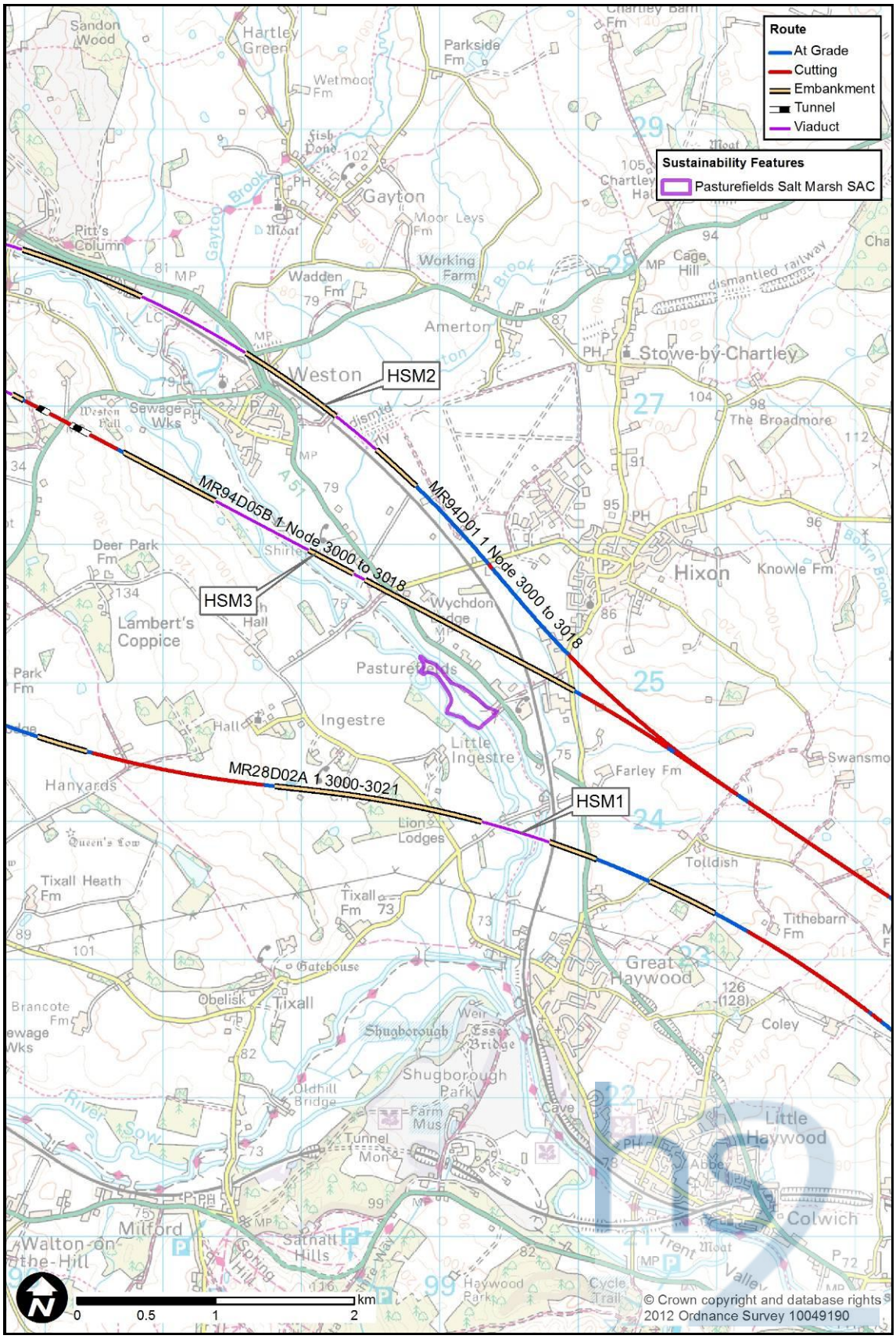
4.1.1. At the end of February 2012 there remained three principal potential options in the vicinity of Pasturefields Salt Marsh SAC, forming parts of route options **HSM01**, **HSM02** and **HSM03**. These options are illustrated in Figure 4-1.

4.1.2. The potential route options are listed below.

- MR28 D02A 1 Nodes 3000-3021. This route lies within Route Option **HSM01**. It runs from east to west to the south side of Pasturefields Salt Marsh SAC and at its closest point is 650 m to the south-west of the Pasturefields Salt Marsh SAC. This route passes through predominantly arable and improved grassland fields, in the vicinity of Pasturefields, crossing the Trent and Mersey Canal and River Trent approximately 750 m downstream of the Pasturefields Salt Marsh SAC. It also intersects a large woodland stand and a golf course.
- MR94 D01 1 Nodes 3000 to 3018 and MR94 D01A 1 Nodes 3000 to 3018. This route lies within Route Option **HSM02**. It runs from south-east to the north-west of Pasturefields and at its closest point is 660m to the north of the site. This route option passes through predominantly arable and improved grassland fields. The route intersects Hixon Industrial Estate.
- MR94 D05 B 1 Nodes 3000 to 3018. This route lies within Route Option **HSM03**. It runs from south-east to the north-west of Pasturefields and at its closest point is 300m to the north of the Pasturefields Salt Marsh SAC. For the most part it runs through agricultural land arable and improved grassland fields, it also intersects a small section of woodland after crossing the Trent and Mersey Canal and River Trent approximately 1.3km upstream of the Pasturefields Salt Marsh SAC.

4.1.3. The potential impacts of the route options during construction and operation are discussed in more detail in the following sections in the context of the interest features of Pasturefields Salt Marsh SAC.

Figure 4-1 Potential route options considered at the end of February 2012



5. Potential impacts

5.1. Introduction

5.1.1. The following impact assessment details the potential impacts that could arise as a result of construction and operation of the HS2 railway in relation to the qualifying interest features of the site.

5.1.2. The impacts described below are derived from the Pasturefields Salt Marsh HRA Screening Sheet (provided in Appendix 2) and expand on the principal hazards identified by that process.

5.1.3. Many of the potential impacts derive from possible hydrological links between the route options and the designated site. These are illustrated in Figure 5-1 and Figure 5-2 (the dashed line on Figure 5-1 indicates the surface water catchment of the River Trent at Pasturefields; the pink area on Figure 5-2 indicates the extent of the British Geological Society superficial aquifer).

Figure 5-1 – Surface water catchment of the River Trent and the BGS superficial aquifer at Pasturefields Salt Marsh SAC (overview)

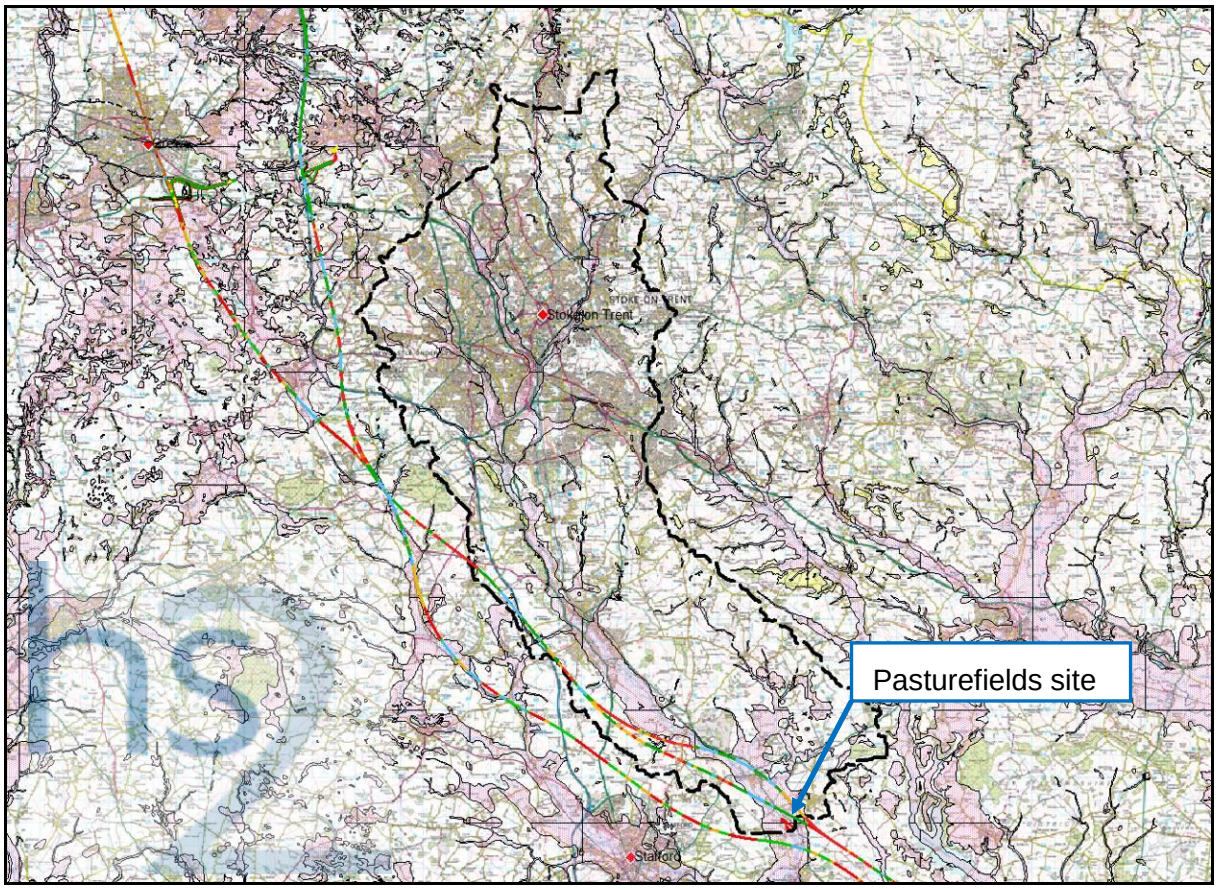
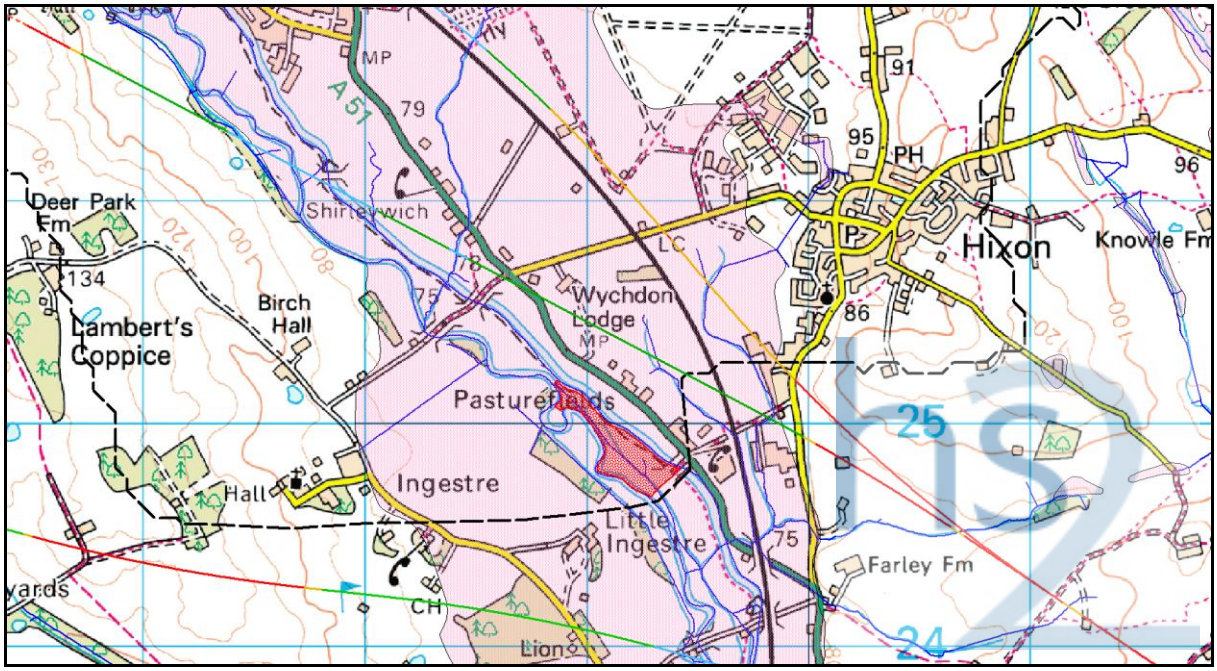


Figure 5-2 – Surface water catchment of the River Trent and superficial aquifer at Pasturefields Salt Marsh SAC (detailed)



5.2. Direct loss of habitat

5.2.1. There would be no direct loss of habitat from Pasturefields Salt Marsh SAC from the HS2 options.

5.3. Changes in surface water

5.3.1. The two main surface water contributions to the daily functioning of Pasturefields Salt Marsh SAC are direct rainfall and overflow from the Trent and Mersey Canal. Neither of these would be impacted in any way by any of the proposed routes.

5.3.2. Distinct from the surface water regime which supports the daily functioning of the Pasturefields Salt Marsh SAC, is occasional flooding of the SAC from the River Trent. This occurs once or twice a year, representing a flooding return period of less than a year. Provided there is no impedance of flood flows at the proposed crossing of the River Trent or any of its tributaries (ensured through the specification of clear-span crossings (ie viaducts over the floodplain) the proposed routes would have no impact on the frequency of flooding at Pasturefields Salt Marsh SAC.

5.4. Changes in groundwater

5.4.1. In the same way that some of the options lie within the surface water catchment, a similar idea can be extended to the groundwater, except that the groundwater catchment is defined by the underlying geology. The underlying geology is not clearly mapped in this area, and it is therefore difficult to evaluate the likely impacts during the construction phases. However there is a consistent trend in the various studies which have been carried out (e.g. ESI Ltd 2004, EA Review of Consents 2007, Temple-ERM 2012) and in the available geological information, indicating that groundwater flows which ultimately feed the salt meadow originate in an area to the north-east of Pasturefields between Stowe-on-Chartley and Weston. On this basis, only route options which incorporate below-ground works such as cut, tunnel or deep foundations in the region between Stowe-on-Chartley and Weston and Pasturefields Salt Marsh SAC (that is route options which pass to the

immediate north-east of Pasturefields) have the potential to affect the groundwater flow regime which feeds the salt meadow. This conclusion was discussed with the Environment Agency on 16th May 2012 and with Natural England on 20th May 2012 , with agreement reached that the groundwater flows feeding the Pasturefields site originate to the north-east of the Pasturefields Salt Marsh SAC, with no flow from the south or west.

5.4.2. Based on the geological information reviewed therefore, any route which passes to the south of the site should have no impact on the groundwater flow regime of the Pasturefields Salt Marsh SAC as they would not form a barrier to groundwater flows, and do not draw down groundwater levels by cutting into the aquifer and draining it to a surface water feature.

5.4.3. The health of the salt meadow is dependent on a delicate balance of surface water flows, groundwater flows and their interaction with the halite-bearing geological strata. Any increase or decrease in the salinity of the salt-water springs which feed the salt meadow could result in conditions which are unsuitable for the qualifying interest features. To illustrate the balance, increases in groundwater or surface water flow rates could result in reduced salinity of the salt-water springs. Reduction in groundwater or surface water flow rates could result in increased salinity of the salt-water springs. Diverting groundwater flows or excavation of halite-bearing geological strata within the groundwater catchment could result in reduced salinity of the salt-water springs.

5.4.4. Should changes in the regime, or quality of surface water or groundwater occur as a result of construction, there is the potential for indirect impacts on the composition and extent of the characteristic species of the salt meadow. Changes in the soil chemistry of the site could result in a reduction in the habitat suitability for characteristic species and could allow more competitive species that favour improved conditions and a more neutral chemistry to dominate.

5.5. Pollution

5.5.1. Since the River Trent flows from north to south and groundwater also flows from north to south (with reference to the argument presented in Section 5.4), there are no perceived risks of groundwater pollution or surface water pollution which could affect the Pasturefields Salt Marsh SAC during construction or operation for any route option which falls outside of the surface water catchment of the River Trent (which includes the Trent and Mersey Canal) at Pasturefields (which could pollute the Pasturefields Salt Marsh SAC during flooding of the river or from overflows from the canal) and passes to the south of the Pasturefields Salt Marsh SAC (and therefore outside of the groundwater catchment).

5.5.2. Only route options that exist either within the surface water catchment of the River Trent at Pasturefields Salt Marsh SAC (which includes the Trent and Mersey Canal); or within the groundwater catchment at Pasturefields could result in pollution of the Pasturefields Salt Marsh SAC for any pollutants which can be transported by the flow of groundwater or surface water/flood flows. The magnitude of the impact at Pasturefields Salt Marsh SAC would depend on the extent of the works and the distance from the SAC. Specific examples of how such impacts could arise are given in the paragraphs which follow.

5.5.3. Construction works may impact the surface water or groundwater catchments of the Pasturefields Salt Marsh SAC via pollutants entering the groundwater and surface water primarily from dust (cement powder) and hydrocarbons (fuels or oils) being released during movement across the construction site, or from general construction activities including spillages, the release of metal fines and construction material pollutants (from welding and use of wet concrete).

5.5.4. If flooding occurs during construction of bridges across the River Trent upstream of the site, pollutants may enter the watercourse and subsequently be washed downstream. They

would then have the potential to settle over the Pasturefields Salt Marsh SAC during the flood event exposing the inland salt meadow to potential contact with hydrocarbons (petrols, oils and lubricants), cements, and adhesives, welding residues and cleaning fluids. If sufficient quantities were able to concentrate on the Pasturefields Salt Marsh SAC for sufficient time, this could lead to dieback of halophytic species already stressed by the influx of flood water and the potential increases in nutrients and sediments that may arise.

5.5.5. Where routes intersect the contributing surface water or groundwater catchment of the Pasturefields Salt Marsh SAC, operation of the railway has the potential to pollute the surface water or groundwater. Pollution could arise from spills, leaks, sediments and discharges from the operational railway. However the likelihood of these impacts is predicted to be low as the passenger trains would be electrically powered and any discharges are likely to be limited to lubricants required by such trains. Diesel powered maintenance vehicle use would be very infrequent compared to passenger trains. Therefore the risk of hydrocarbon contamination would be mainly associated with mechanical failure, or an accident of the passenger trains.

5.5.6. Herbicides, if used during routine maintenance of the track in areas where they could enter surface water or groundwater catchments of the salt meadow may also have potential to reduce the vigour and growth of halophytic plants if sufficient quantities are released.

5.5.7. If the superficial aquifer becomes polluted during construction or operation, it may ultimately manifest in pollution of the groundwater which feeds the salt meadow. Any pollution of the groundwater or surface water could result in conditions which are unsuitable for the qualifying interest features.

6. Potential effects of route options on qualifying features

6.1. Introduction

6.1.1. The likely effects of the route options during construction and operation are discussed in more detail in the following sections in the context of the interest feature of the Pasturefields Salt Marsh SAC, namely Inland Salt Meadows. Impacts, as detailed in Section 5, would result primarily from changes to surface water and groundwater flows to the site, changes to the brine source and pollution impacts as a result of these changes.

6.1.2. From the information available and discussed in Section 5.4 it is considered, and agreed in principle through meetings with the EA hydrogeology officers, that the salt water feeding the Pasturefields site comes from an area to the north-east of the site (EA Review of Consents 2007). However the exact extent of the contributing groundwater catchment and saline geostrata are poorly understood and would, if necessary, require detailed intrusive investigation to determine these more precisely.

6.2. HSM01

6.2.1. This route option (MR28 D02A 1 Nodes 3000-3021) would not intersect with the surface water catchment of the Pasturefields Salt Marsh SAC. Given the strong evidence of groundwater flows and halite-bearing geology originating in an area to the north-east of Pasturefields between Stowe-on-Chartley and Weston and flowing in a south-westerly direction (a conclusion agreed by EA hydrogeologists at a meeting on 16th May 2012 and with Natural England on 20th May 2012), it was also concluded that it would not intersect the groundwater catchment. The studies undertaken, based primarily on two former sites now destroyed at Weston and Shirleywich, support this. The study found that the groundwater flows over halite beds and rises up through sands and gravels overlying Mercia mudstone,[1] as referred to in Section 3.5.

6.2.2. On this basis, the proposed route would not affect the upstream course of the surface water and groundwater to the Pasturefields Salt Marsh SAC, nor would it act as a barrier to groundwater flows, or draw down groundwater levels by cutting into the aquifer and draining it to a surface water feature downstream of the SAC. As a result this route option is not predicted to affect the hydrology of the Pasturefields Salt Marsh SAC. In addition, the proposed river crossing is downstream of the Pasturefields Salt Marsh SAC (see Figure 5-1), pollution impacts are therefore not predicted to occur; and impacts from ground and surface water contamination are also not predicted. This route is therefore not predicted to have any effect on the site's hydrology.

6.2.3. Distances are too great for herbicide drift from railway maintenance to have any effect, particularly as any such application is likely to be by knapsack sprayer and hence the spray would be applied close to the ground.

6.2.4. The crossing of the River Trent approximately 1km downstream of the Pasturefields Salt Marsh SAC would be designed in order to ensure that there is no upstream aflux which could have an impact on the frequency of flooding.

6.2.5. There would therefore be no likely significant effect on the Pasturefields Salt Marsh SAC from HSM01 (or indeed any options on this general alignment to the south of the SAC).

1 Environmental Simulations International Ltd. 2004. An assessment of the hydrological conditions at the Pasturefields Saltmarsh SSSI

6.3. HSM02

6.3.1. This route option ((MR94 D01 1 Nodes 3000 to 3018 and MR94 D01A 1 Nodes 3000 to 3018) would pass through the surface water catchment of the River Trent at Pasturefields Salt Marsh in the form of an embankment immediately north-east of the site, before crossing the River Trent on a high viaduct. Potential impacts of this route on the Pasturefields Salt Marsh SAC would be due to changes in the groundwater regime or pollution, as discussed in Sections 5.4 and 5.5. The route would be mostly on embankment or at-grade and would closely follow the existing railway line in its vertical and horizontal alignments. Although the length of embankment would be shorter than HSM03, the ground conditions may mean that a multispan viaduct would be required to support the embankment, as it passes close to known dissolution features at Amerton. The route option would require a viaduct over the Amerton Brook to the north of Pasturefields which would require deep foundations that may affect the superficial aquifer feeding the saltmarsh. For this reason it is possible that the proposed route may alter the groundwater flow regimes which contribute to the saltmarsh. However, were this option to be progressed, hydrological studies, as set out in Section 8, would be required to confirm these predictions and allow confirmation of detailed impact avoidance measures.

6.3.2. In order to avoid the possible impacts on the groundwater regime, various foundation options have been put forward by HS2 Ltd. for embankments crossing the river terrace deposits in the Trent river valley (see Appendix 3). The approaches outlined may result in alterations to the groundwater flow regime which could potentially affect the flow of saline water to Pasturefields Salt Marsh SAC. As a result, prior to the implementation of impact avoidance measures it cannot be concluded that there will be no likely significant effects.

6.3.3. This route option would include construction of a large structure over the River Trent, approximately 4km upstream. Construction would include foundations that would extend into the superficial aquifer. These are unlikely to have a significant impact on the Pasturefields Salt Marsh SAC at this north-westerly and distant location although as detailed above, on-site hydrological studies would be required to inform the appropriate impact avoidance measures.

6.3.4. There would be a section of cut and tunnel through the hill adjacent to Hixon. However, this is not within a superficial aquifer which is linked to the salt meadow. There is less infiltration on the steep hillside and more surface water runoff, so providing the underlying geology is impermeable (as much of the Mercia Mudstone appears to be), no impact on the salt meadow is predicted from these works.

6.3.5. The low risk of spillages etc arising from operational impacts are minimised by the low probability of any such discharges finding their way into the aquifer supplying the salt meadow. However, control mechanisms to avoid effects occurring are set out in Section 8.0.

6.4. HSM03

6.4.1. This route option ((MR94 D05 B 1 Nodes 3000 to 3018)) would pass through the surface water catchment of the River Trent at Pasturefields in the form of an embankment immediately north-east of the site before crossing the River Trent on a high viaduct. Potential impacts of this route on the Pasturefields Salt Marsh SAC are due to changes in the groundwater regime, or pollution as discussed in Sections 5.4 and 5.5.

6.4.2. In order to avoid the possible impacts on the groundwater regime, various foundation options are put forward by HS2 Ltd for embankments crossing the river terrace deposits in the Trent river valley (see Appendix 3). Where dissolution features, or areas of brine flow are identified running under the proposed embankment, concrete pile foundations would be sunk into the bedrock to support the embankment. Where a relatively small confined brine

flow is identified (<20 m wide), it may be possible to bridge the embankment over the flow without affecting the lateral flow of water. However, where the brine flow is extensive, or the flow path of the brine spring is not known (which is currently the case), a multispan viaduct (albeit at the level of the embankment) would be required, which would necessitate sinking piles through the zone of brine flow into the bedrock below the spring. This approach could result in alterations to the groundwater flow regime, either by impeding or causing changes to the lateral course of groundwater flows, or by introducing vertical pathways to the flow which the brine may preferentially move along. Either alteration would potentially affect the flow of saline water to the Pasturefields Salt Marsh.

6.4.3. The viaduct crossing of the River Trent would also require deep foundations within the superficial aquifer, which is contiguous with the river terrace gravels that contain the aquifer which supplies the salt meadow. Alterations in the groundwater flow regime, either from the River Trent crossing or embankment viaduct, would need to be investigated further were this option to be progressed in order to establish if these would affect flows into the salt meadow.

6.4.4. All of the above impacts have the potential to reduce the salinity of the site and therefore affect the extent, zonation and composition of the salt meadow contrary to the conservation objectives for the Pasturefields Salt Marsh SAC. Control mechanisms to avoid effects are set out in Section 8.0, however prior to the implementation of impact avoidance measures it cannot be concluded that there will be no likely significant effect.

6.4.5. There is the potential for water pollution to enter the site during construction phases as water from all the minor watercourses within the River Trent catchment upstream of Pasturefields salt meadow may eventually reach the site. An increase in nutrients, or pollutants entering the site, may increase the competitive advantage of non-halophytic species, and alter the extent and composition of the qualifying feature contrary to the conservation objectives for the Pasturefields Salt Marsh SAC. However, control mechanisms to avoid effects are set out in Section 8.0.

6.4.6. As this route option intersects the likely surface and groundwater catchments, it is more vulnerable to the potential operational impacts such as spillages, accidents and herbicide use. Other control mechanisms to avoid these effects are set out in Section 8.0.

7. Potential in-combination effects

7.1.1. Other plans and projects within the local area may have a significant in-combination effect when considered together with the identified impacts of the HS2 route options. Table 7-1 summarises the current information which will inform the assessment of in-combination effects.

Table 7-1 In-combination Effects

Plan/ Project	Proposal	Source of possible likely significant effect
Staffordshire and Stoke-On-Trent Structure Plan 1996 - 2011,	The structure plan allocates a borough wide housing provision of 5600 houses and 150ha total employment land. There are no significant proposed/permitted housing or employment allocations in close vicinity of the site.	No Presumption against development and the need for appropriate mitigation to protect the designated site if it did proceed.
	Para 5.2 states that development in open countryside should be strictly controlled. As well as protecting the countryside from unnecessary visual incursion, sporadic development away from settlements should be reduced in the interests of sustainability. There may be circumstances where such development is appropriate, but these should be regarded as exceptional and should be consistent with the overall aims of rural regeneration.	No Presumption against development and the need for appropriate mitigation to protect the designated site if it did proceed.
	Policy NC7A states that proposals for development likely to have significant effects on an existing or proposed sites of international importance for nature conservation will be subject to the most rigorous examination. Proposals not directly connected with or necessary to the management of such a site, and which are likely (either individually or in combination with other plans or projects) to have an adverse effect on the integrity of the site, will not be permitted unless the planning authority is satisfied that there is no alternative solution, and there are imperative reasons of overriding public interest for the development or land use change. Where the site concerned hosts a priority natural habitat type and/ or a priority species, development or land use change will not be permitted unless the planning authority is satisfied that it is necessary for reasons of human health or public safety or for beneficial consequences of primary importance for nature conservation. It is expected that this policy would be applicable for Pasturefields Salt Marsh SAC. Para 3.7 adds to the policy above by stating that for development proposals a key issue will be delivering appropriate mitigation and avoidance measures to protect the integrity of these sites	No Presumption against development and the need for appropriate mitigation to protect the designated site if it did proceed.

Plan/ Project	Proposal	Source of possible likely significant effect
Staffordshire Waste Local Plan	Pasturefields Garage Biscuit Waste Transfer Station (WTS) is located less than 200m to the east of the site. It was permitted in 2010 and is now operational.	No. Contained within industrial estate and operating with waste permit. As WTS is less than 200m from the SAC atmospheric deposition may be an issue but any increase in emissions will require regulatory scrutiny from the Environment Agency.
Stafford Borough Local Plan 2001	The entire Pasturefields Salt Marsh SAC is designated as a SSSI. It is also adjacent to the Trent and Mersey Canal which is a conservation area. Three Recognised Industrial Estates (RIE) fall within 1km of the Pasturefields site. The Pasturefields Industrial Estate and Hixon Industrial Estate are both located less than 200m to the south-east of the site. Hixon Airfield Industrial Estate is less than 1km to the north-east of the site. All these sites will be considered favourably for any employment related (class B) development in the future. However it is recognised that all these areas are located within rural areas. It should be noted that as of 31st March 2010 Hixon airfield has 8.02ha and Hixon Industrial Estate has 0.38ha of land with planning permission for employment use. This area is yet to be developed.	No. Probable Expansion of industrial estates could lead to greater emissions to air and water. However any such changes will require HRSA and Water Framework Directive screening.
The Plan for Stafford Borough Draft Publication Consultation September & October 2011	Development Management Policy 5 of this emerging policy document talks about securing the integrity of European Sites such as Pasturefields Salt Marsh SAC. It states that the European Sites will be given the highest level of protection, with new development only permitted where: There will be no adverse effect on the integrity of any European site, or If adverse effects are identified it can be demonstrated that the proposed mitigation measures shows that there will be no adverse effect on the integrity of any European site.	No Presumption against development without sufficient mitigation.

7.1.2. Pasturefields Salt Marsh SAC is located in a rural area. Current and emerging policy documents recognise the protected status of the Pasturefields Salt Marsh SAC and the rigorous assessments which will be required for any potential developments on/near the site. There are no significant proposed or permitted housing or employment allocations in the vicinity of the site. Discussions with the local planning officers confirm that the local authority has no plans to allocate any further employment or housing land in the area in the near future.

7.1.3. However the employment uses within the three Recognized Industrial Estates located within 1km of the site (namely Pasturefields Industrial Estate, Hixon Industrial Estate and Hixon Airfield Industrial Estate) could be intensified over the next few years. However it can be reasonably assumed that any such intensification will be permitted only on condition that it would not have a likely significant effect, either of alone or in-combination on the

quality of the Pasturefields Salt Marsh SAC. A Waste Transfer Station (WTS) is located within the Pasturefields Industrial Estate, less than 200m from the site and is likely to continue operations in the near future. However the SSSI condition assessment does not mention any current issues with the WTS in relation to the Pasturefields site, and any intensification of activities would be subject to new applications during which in-combination effects with HS2 would need to be considered.

7.1.4. Potential climate change impacts and future management, particularly in relation to restoring the site to favourable condition, are also relevant to discussions concerning in-combination effects.

7.1.5. Management of the site to date had involved moving towards appropriate levels of grazing through a conservation grazing agreement between the site managers (Staffordshire Wildlife Trust) and Natural England. In addition the central drain and a culvert have been improved to reduce freshwater influences on the saline area. The EA are conducting a review of the impact of flooding events upon the Pasturefields Salt Marsh SAC with particular reference to water quality in the River Trent.

8. Impact Avoidance Measures

8.1. Introduction

8.1.1. The early incorporation of design led impact avoidance measures (through an iterative design process) has been a priority for those parts of the route options potentially affecting Natura 2000 sites. Effectively at this early stage of assessment and route refinement, thishas been based on avoidance through changing the vertical and horizontal alignment, and the incorporation of specific control and design measures. Impact avoidance options will be further assessed and refined as the scheme progresses to more detailed environmental assessment in parallel with the detailed design process, to ensure that the potential impacts on the sites are avoided or mitigated to insignificant levels. These would involve the careful design of crossing structures and the implementation of industry best practice guidance. The following sections summarise the potential impact avoidance measures which could be implemented by HS2 Ltd.

8.1.2. HS2 Ltd will dictate strict environmental performance standards and specific control measures that contractors will be required to adhere to as a condition of appointment. The use of a *Code of Construction Practice* or similar will be the principal tool through which standards are defined and implemented and this will be developed in close consultation with relevant agencies, including the Environment Agency and Natural England. The preliminary construction control measures to be implemented are set out below.

8.1.3. The assessment presented in Section 6 concluded that no likely significant effects to the Pasturefields Salt Marsh SAC will result from route options which pass to the south of the SAC (eg: HSM01), therefore the impact avoidance measures set out below in relation to the SAC only relate to route options that could pass to the north of the SAC (e.g. HSM02 and HSM03).

8.2. Avoidance of hydrological impacts

8.2.1. Impacts would be associated with changes in hydrology, and contaminants entering the Pasturefields Salt Marsh SAC through exchange of surface and groundwater from routes HSM03 and HSM02. The following impact avoidance measures aim to remedy potential impacts from the scheme, by either maintaining the current status of the Pasturefields Salt Marsh SAC, or seeking to assist with plans for its rehabilitation.

8.2.2. The exact extent of the contributing groundwater catchment and saline geostrata are unknown and would require detailed studies, which would involve intrusive investigation of the catchment to determine them. Geo-hydrological modelling and monitoring would need to be undertaken to further investigate the possibility and extent of any impacts resulting from the proposed works. If these studies are undertaken, the resulting data will be made available to both the site managers and the regulatory authorities for future management of the Pasturefields Salt Marsh SAC.

8.2.3. Should the detailed hydrological investigations demonstrate that there is a potential for impact on the Pasturefields Salt Marsh SAC, further consideration will be given to the design and also the development of impact avoidance measures, to ensure that that saline groundwater flow can be crossed without interrupting the natural flow. For example some potential options are included as follows:

- **Structural solution**: if the saline flow path is confined within a width of <20m it could be bridged by a single span structure (see Appendix 3).
- **Vertical alignment solution**: in order to confine any consolidation or compaction of the underlying ground to a thin layer immediately below the earthworks formation, it

may be possible to change the vertical alignment to 'at grade' where it passes the groundwater flows (note that HSM02 is already designed to be 'at grade' within the vicinity of the Pasturefields Salt Marsh SAC). However this approach may still require supporting piles if the underlying terrace deposits contain soft, compressible layers or if dissolution features are present in the bedrock; this could be possible along the path of the brine spring. This would result in a third, intermediate solution, outlined below.

- **Intermediate solution**: due to the soft nature of the underlying deposits, a pile raft structure could be used to support the low level embankment (see Appendix 3). This approach could only be implemented where the piles would not affect the groundwater flow.

8.2.4. If a risk of groundwater contamination is perceived during the construction process it would be possible to restrict groundwater flow temporarily through the use of techniques such as liquid nitrogen ground freezing. This involves pumping liquid nitrogen into the groundwater in the vicinity of the works, and temporarily freezing the groundwater to prevent pollutants from migrating into the aquifer. Any accidental surface spills can be dealt with using standard procedures such as spill kits. When the works are complete the groundwater is allowed to thaw and resume normal flow.

8.2.5. More generally, assistance with water management of the site may be available, possibly through the provision of engineering advice based on knowledge gained about the ground hydrology of the Pasturefields Salt Marsh SAC during detailed studies.

8.3. Avoidance of pollution impacts

8.3.1. The potential impacts associated with the operation of the HS2 routes are centred on the risk of impacting on the hydrology of the site. Potential impacts include both impacts on the aquifer and the potential for pollution and contaminants entering the Pasturefields Salt Marsh SAC site in the form of herbicides from the railway corridor and the Pasturefields site being exposed to hydrocarbons via surface and groundwater flows.

8.3.2. Best practice techniques such as those specified in the Pollution Prevention Guidance Notes published by the Environment Agency for construction sites and works near water are appropriate in order to reduce the risks of accidental pollution. Detailed method statements for construction will also be agreed with the Environment Agency and implemented through contractually mandated adherence to a *Code of Construction Practice* or similar.

8.3.3. The use of electric trains significantly reduces the likelihood of hydrocarbons permeating into the Pasturefields Salt Marsh SAC, and only those sections of route options to the east and north-east of the site, or river crossing HSM03 at Shirley and HSM02 at Amerton Brook are at risk from accidental spills entering the catchment of the Pasturefields Salt Marsh SAC.

8.3.4. Given the sensitivity of salt marshes to even low levels of herbicide residues[1] a precautionary ban on the use of herbicides, pesticides and fertilisers along the railway corridor within the surface water catchment area would be observed to protect the Pasturefields Salt Marsh SAC salt meadow.

[1] C.F Mason, C.F, Underwood, G.J.C, Baker, N.R, Davey, P.A, Davidson, I, Hanlon, A, Long, S.P, Oxborough, K, Paterson, D.M & Watson, A. 2003. The role of herbicides in the erosion of saltmarshes in eastern England. *Environmental Pollution* **122**: 1: pp 41-49

9. Conclusions and recommendations

9.1. Conclusions

9.1.1. Route option HSM01 would have no likely significant effect on the site as it is downstream of Pasturefields Salt Marsh SAC, outside of the surface water catchment of the River Trent at Pasturefields (and therefore the Pasturefields Salt Marsh SAC), and south of the SAC (downstream of the groundwater catchment of the SAC). Appropriate Assessment would therefore not be required for this route option as described, nor to other route options were they to follow a similar southern alignment past Pasturefields Salt Marsh SAC at a similar or greater distance from the SAC.

9.1.2. It is not possible to conclude no likely significant effect on the basis of the information currently available for route options HSM02 and HSM03. The engineering work proposed for the HSM02 route option may require piled foundations for embankment or even at grade sections, should the underlying deposits prove not to be strong enough to support the proposed loading. As this route option passes through the groundwater catchment area of the Pasturefields Salt Marsh SAC, the route may therefore interfere with groundwater flows of the SAC. The engineering work required for route option HSM03, both at the river crossing and at cuttings and embankments (including potential sinking of foundation piles into the superficial aquifer or zone of brine flow), has the potential to affect groundwater flows. Due to the uncertainties which remain in relation to the underlying geology and route of the brine flow which feeds the Pasturefields Salt Marsh SAC, on-site intrusive investigations would be required to fully understand the groundwater and brine flows for either route. Hence, Appropriate Assessment would be required for HSM02 and HSM03, and this would require the further development of impact avoidance by design.

9.1.3. In-combination effects are not predicted. Any changes within the WTS and the three existing industrial estates would be subject to regulatory scrutiny under both the Habitat Regulations and Water Framework Directive and it is unlikely these would allow any in-combination effectson the Pasturefields Salt Marsh SAC to arise.

9.2. On-going appraisal and consultation

9.2.1. HS2 Ltd will maintain regular communication with NE and the EA in relation to the Pasturefields Salt Marsh SAC, the scheme option and designs to ensure that potential impacts are avoided or mitigated.

9.2.2. Should the decision be taken that either HSM03 or HSM02 be the potential preferred routes, then an Appropriate Assessment and further information to support such an assessment are likely to be required.

APPENDIX 1
Minutes of Meeting between HS2 and Stakeholders

[Minutes of meeting deleted from appendix]

APPENDIX 2
Hydrology Figures and Annotated Photographs

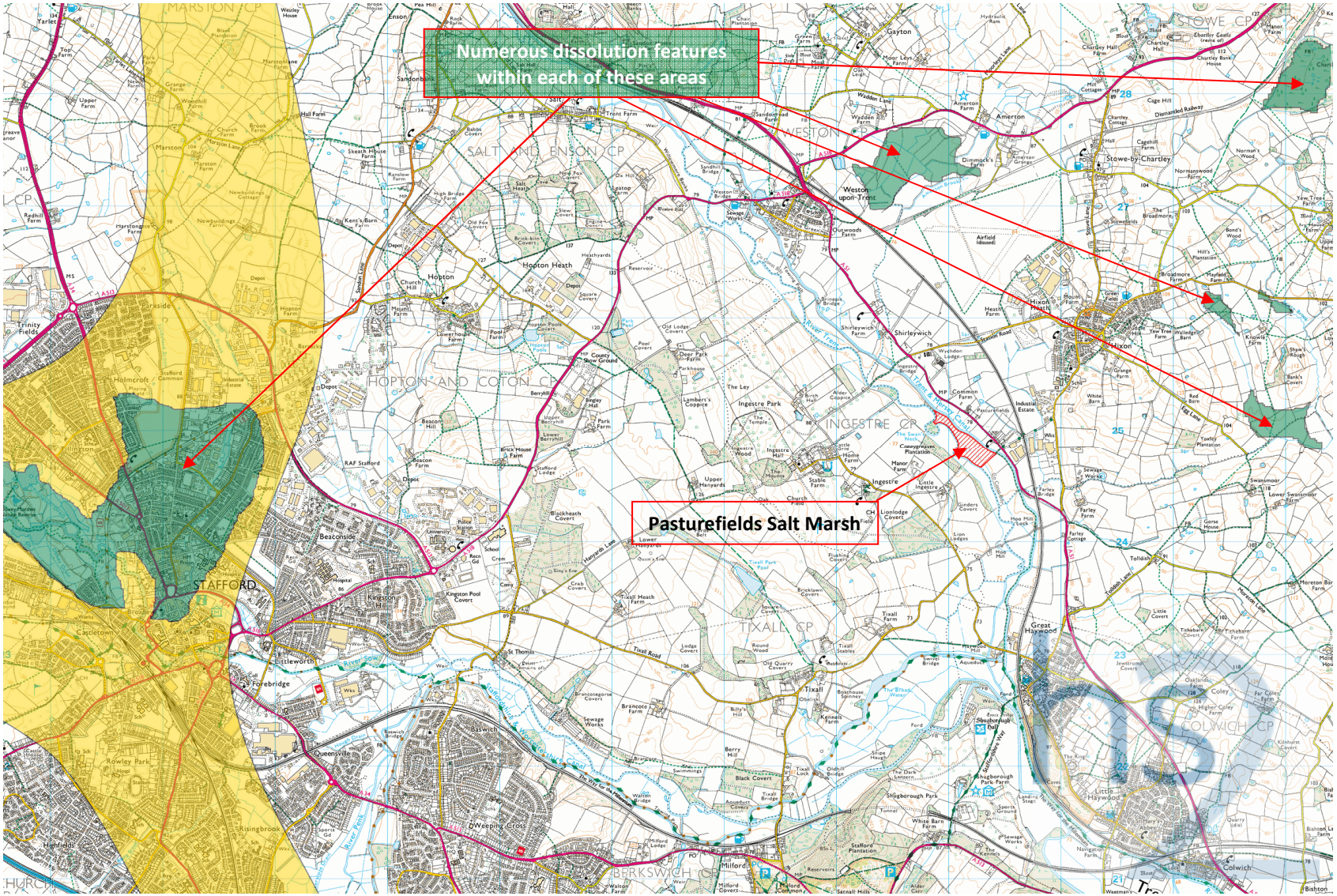


Figure 1 – Dissolution features surrounding Pasturefields often associated with brine extraction

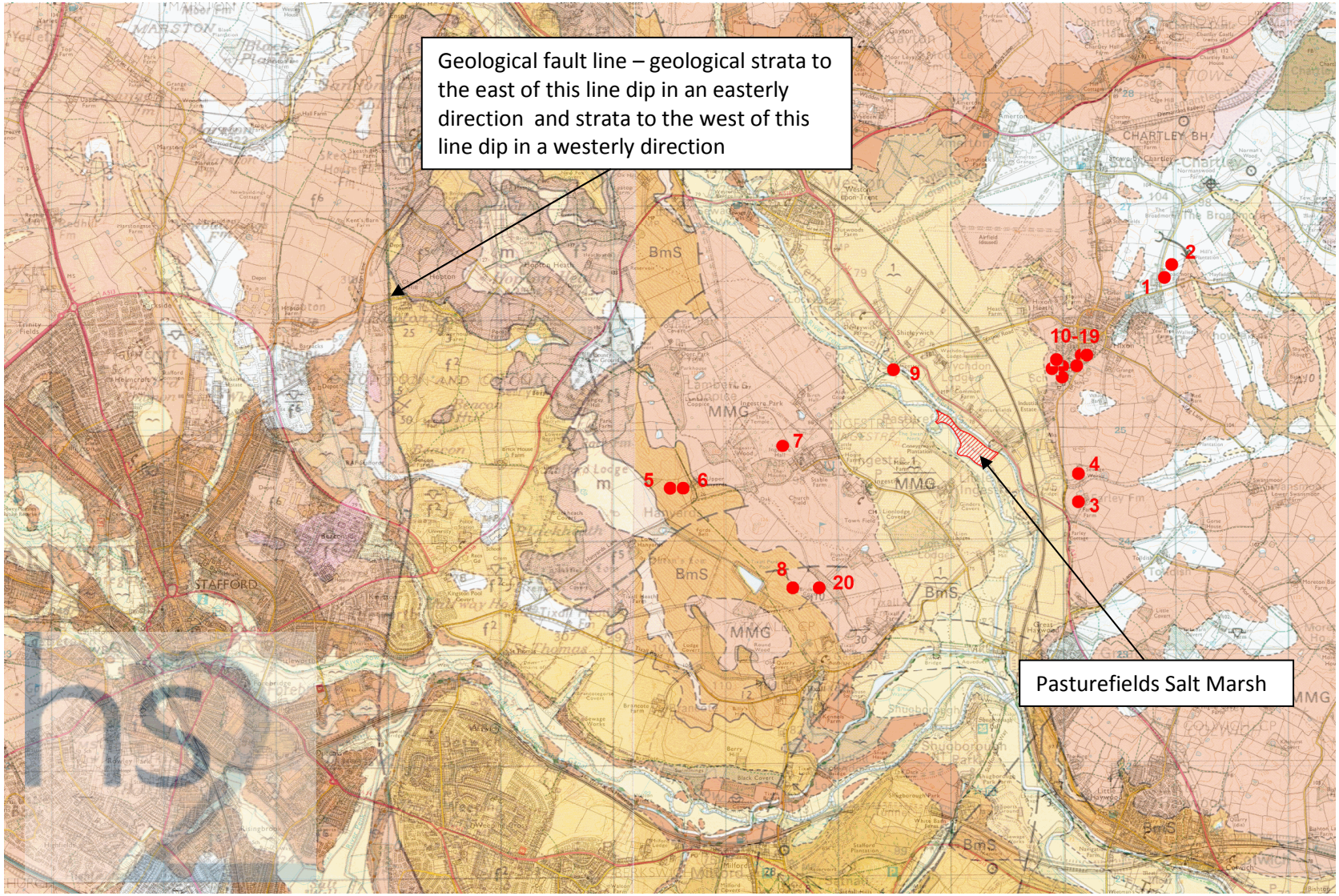


Figure 2 – Surface Geology as presented in BGS maps overlaid by BGS borehole locations in the area (borehole logs included in appendix)

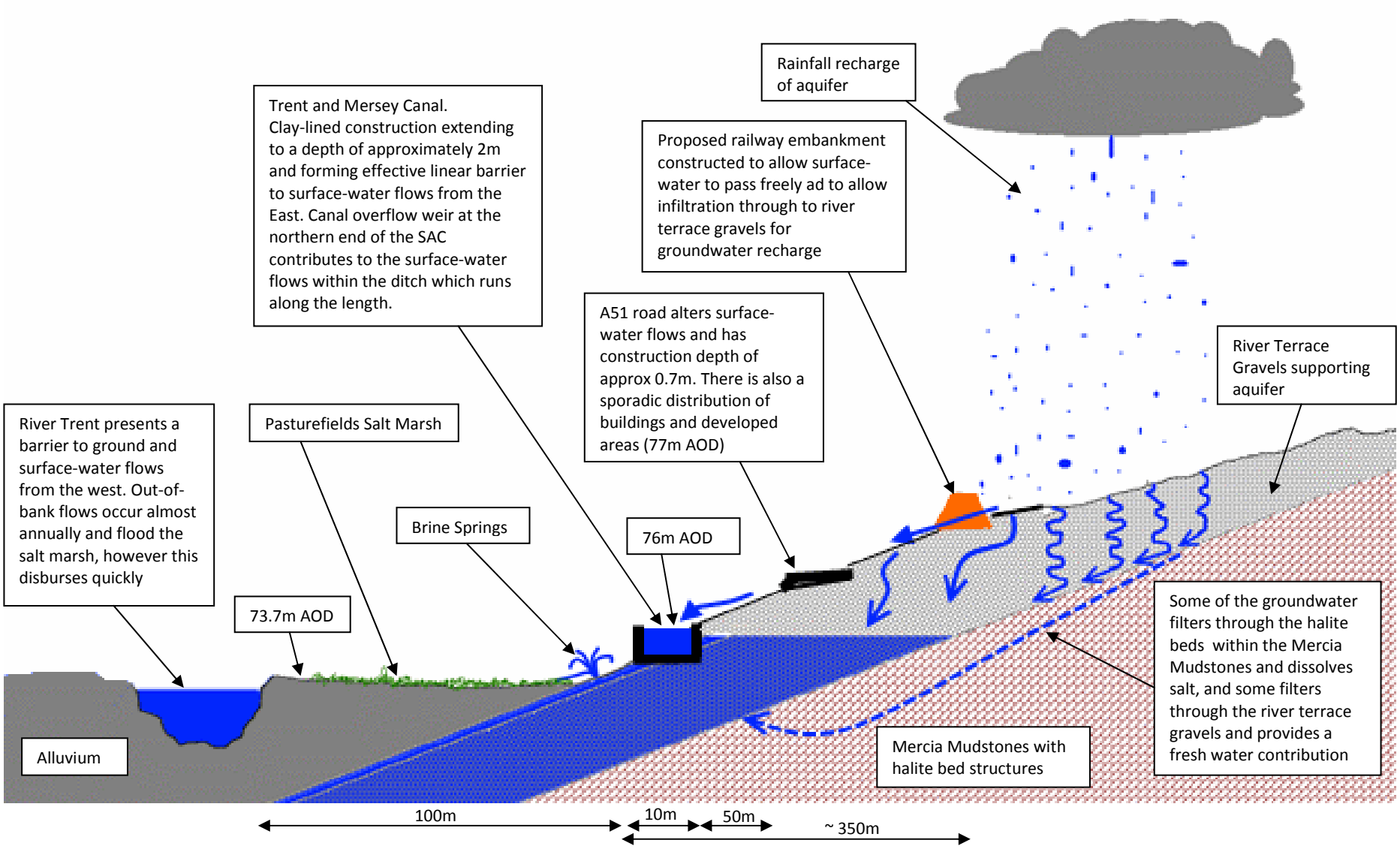


Figure 3 – Conceptual Site Model of Pasturefields Salt Marsh

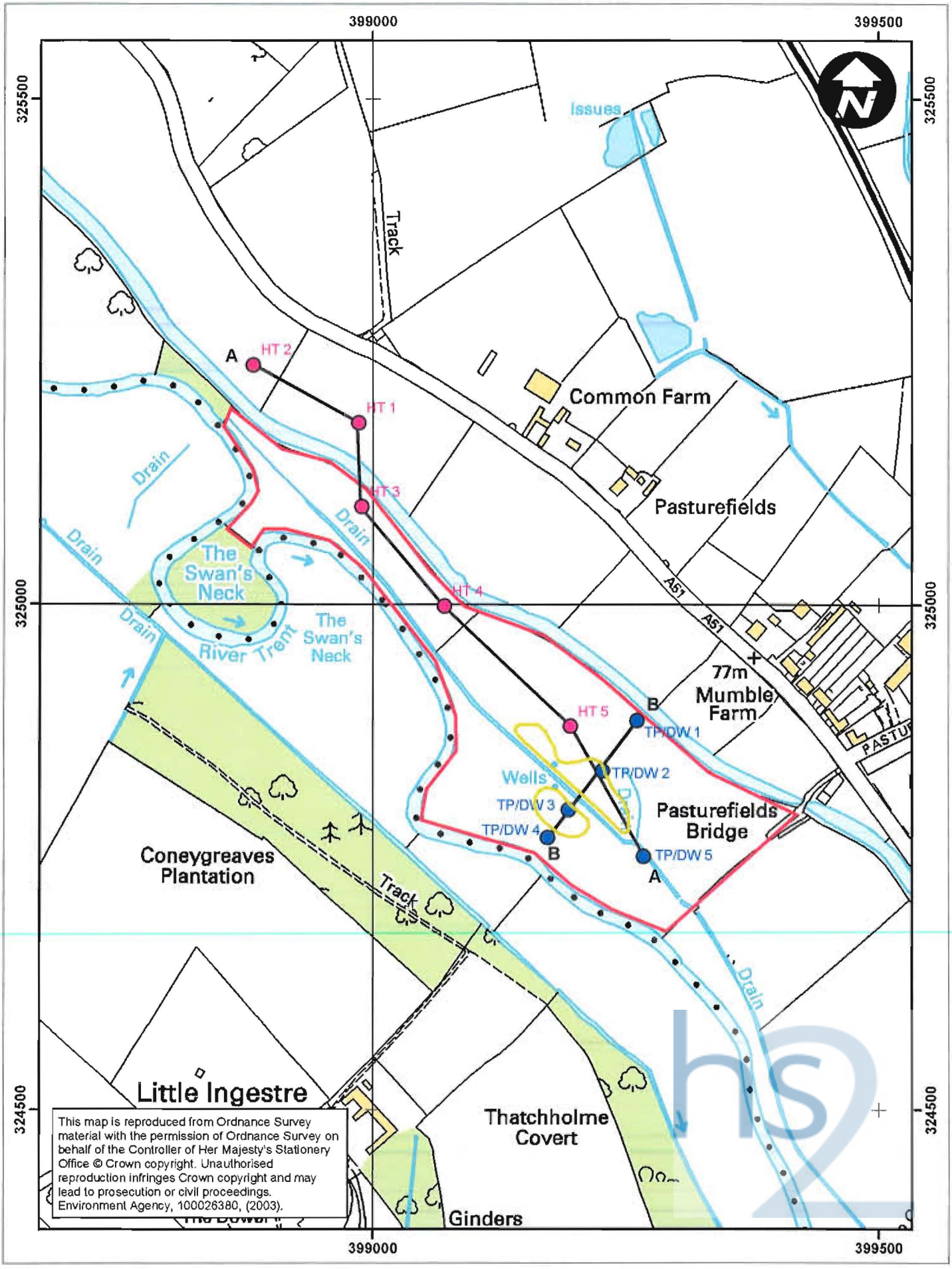
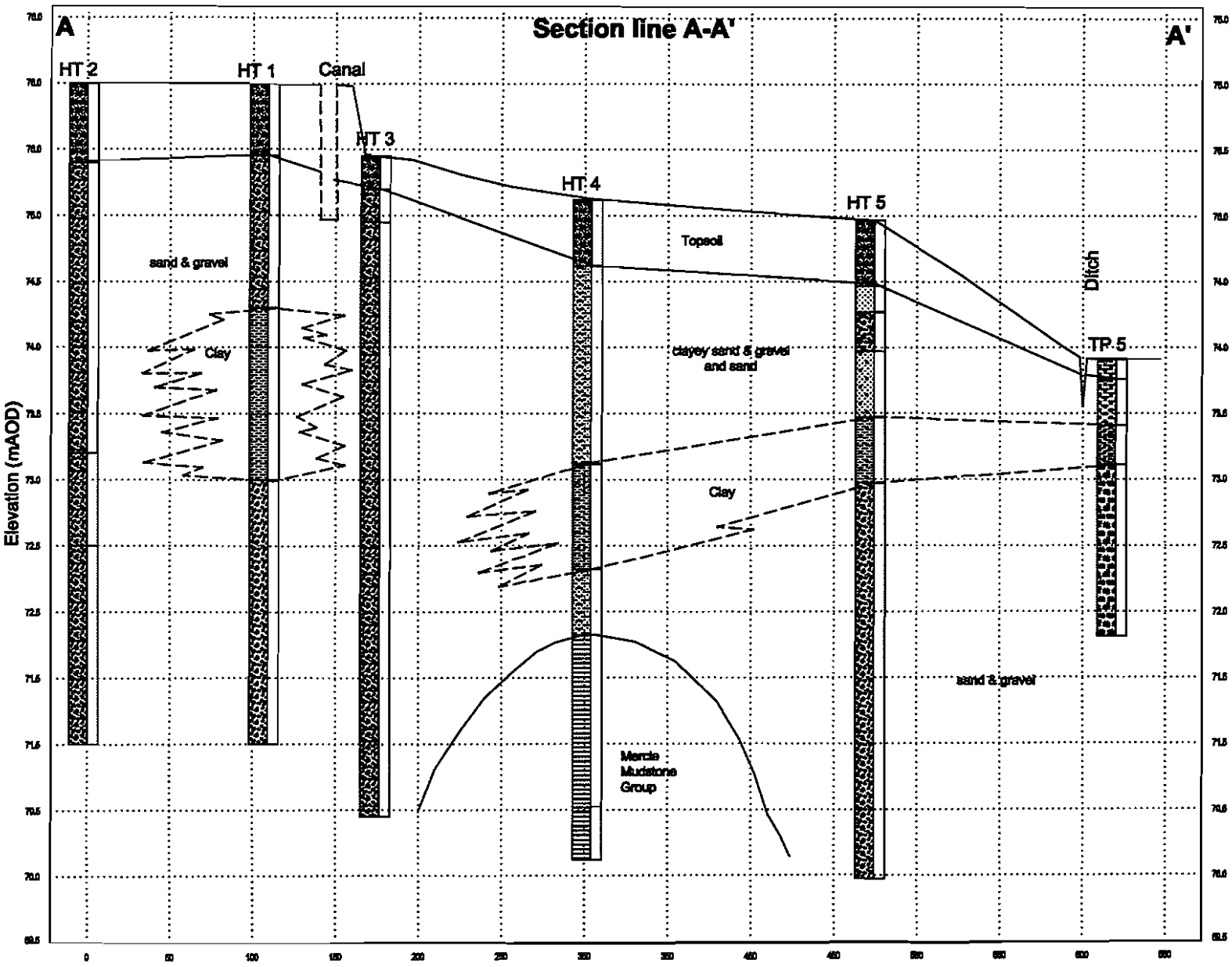


Figure 3.2
Site Investigation Boreholes

Site Location
Salt Marsh (approx)
Trial Pits
Boreholes (Hydrotecnica)
Section lines

Date: Jan 2004	Drawn: OXS
Scale: 1:5,000	Checked: GEC
Original: A4	Revision: 2
File Reference: O:/6271X/Reports/Figures/Figure 3.2.mxd	

Environmental Simulations International Ltd



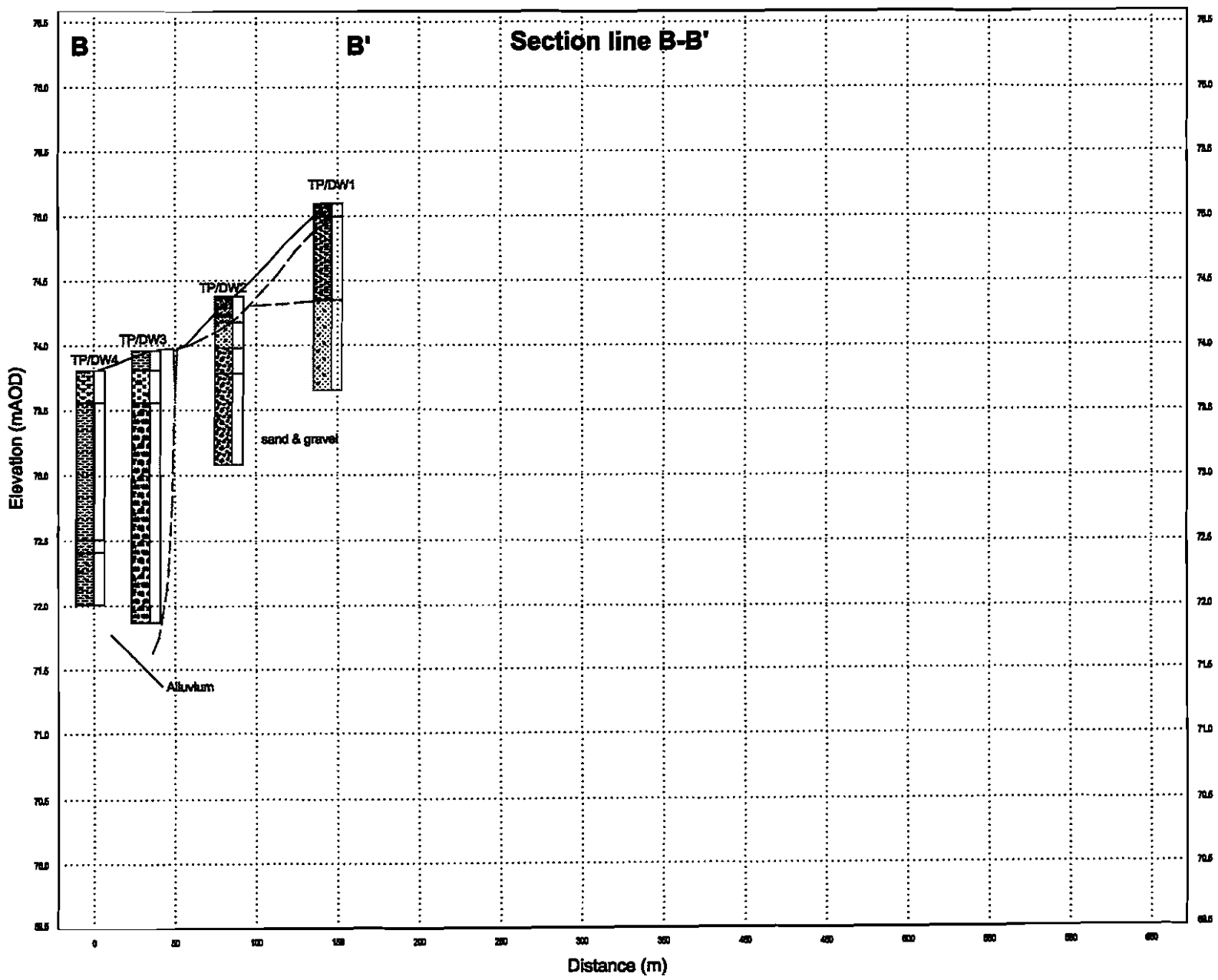


Figure 3.3
Geological cross sections
A-A' and B-B'

Topsoil
Sand and Gravel
Clay
Gravel
Clayey Sand
Gravelly Clay
Mudstone
Sand
Clayey Gravel
Gravelly Sand

Date: March 2003	Drawn: CDB
Scale: see drawing	Checked: GEC
Original: A3	Revision: 2
File Reference: O:/8271x/Reports/Figures/R1\Figure 3.3.dwg	

Environmental Simulations International Ltd

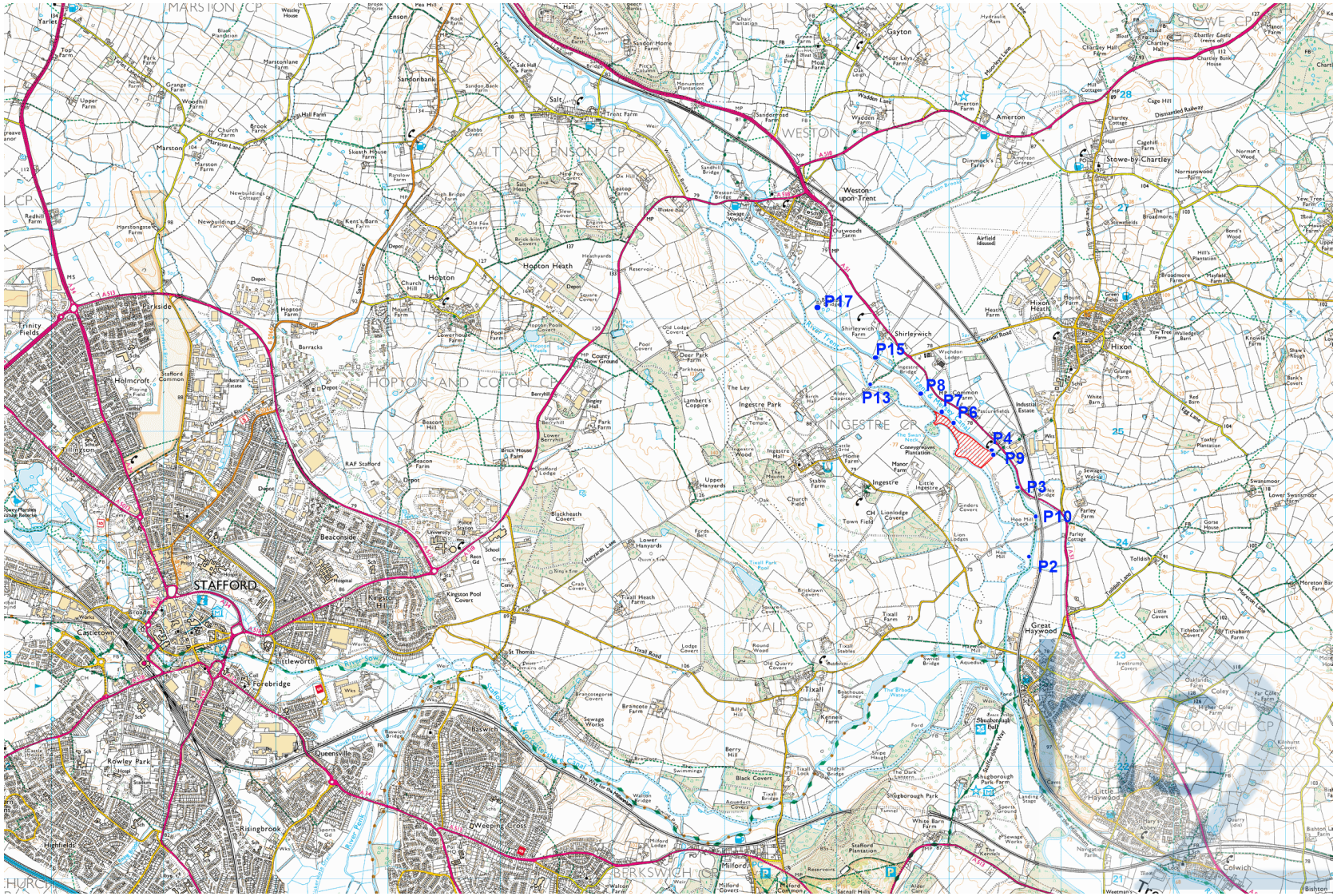


Figure 4 – Locations of selected photographs from site visit

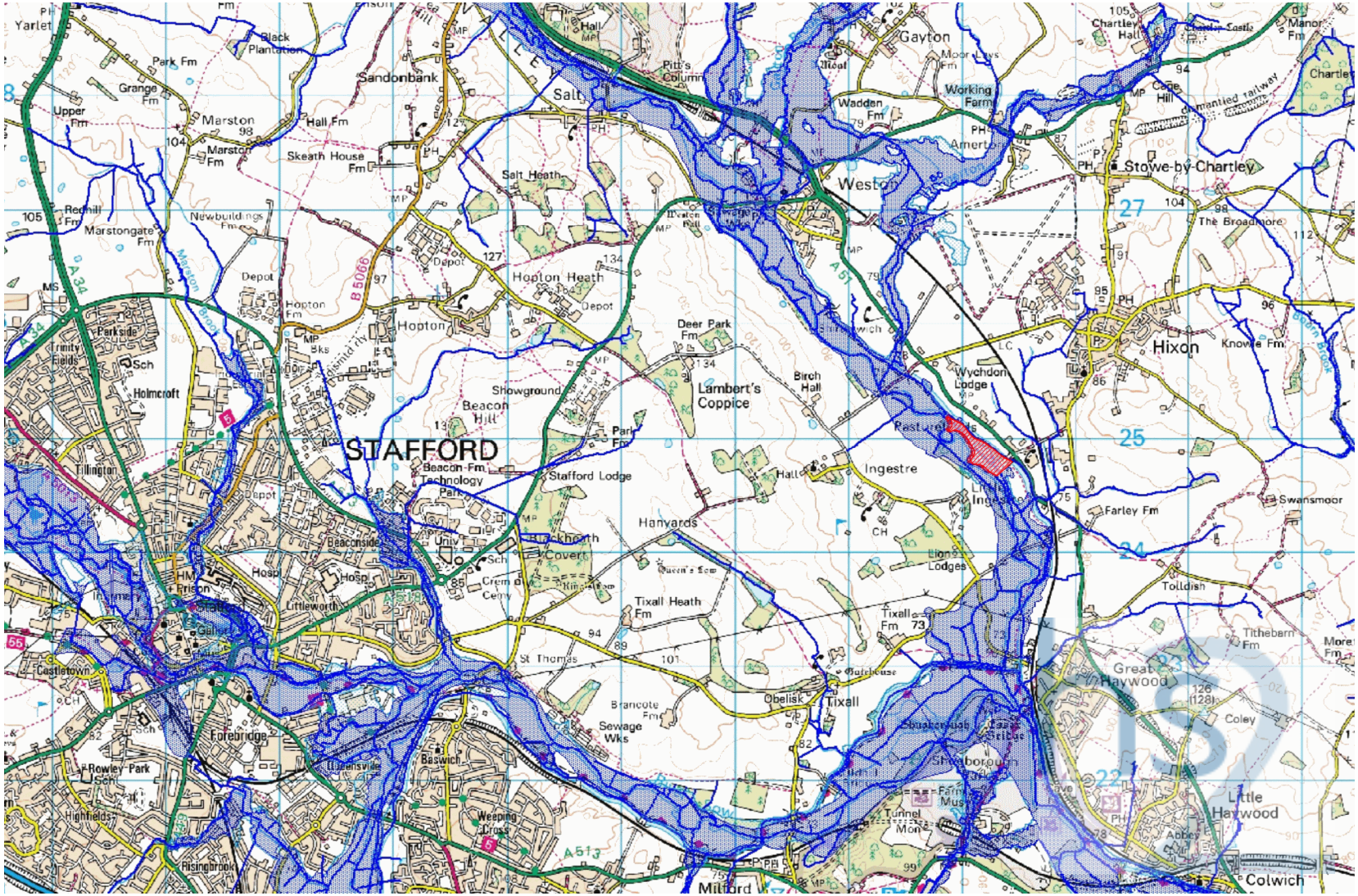


Figure 5 – Environment Agency published 100-year floodplain of the River Trent at Pasturefields

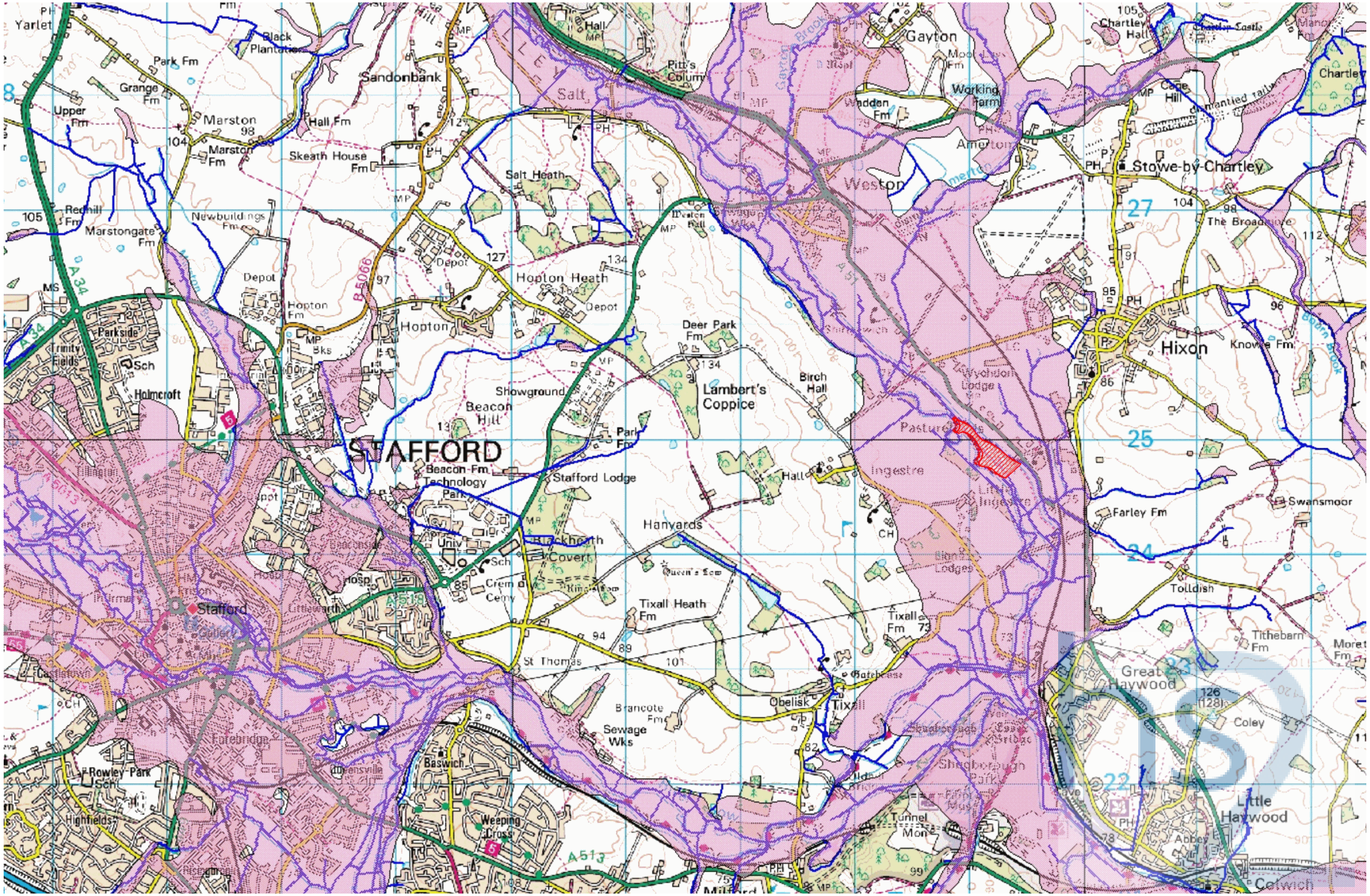


Figure 6 – Extent of superficial aquifer at Pasturefields as defined by the British Geological Survey

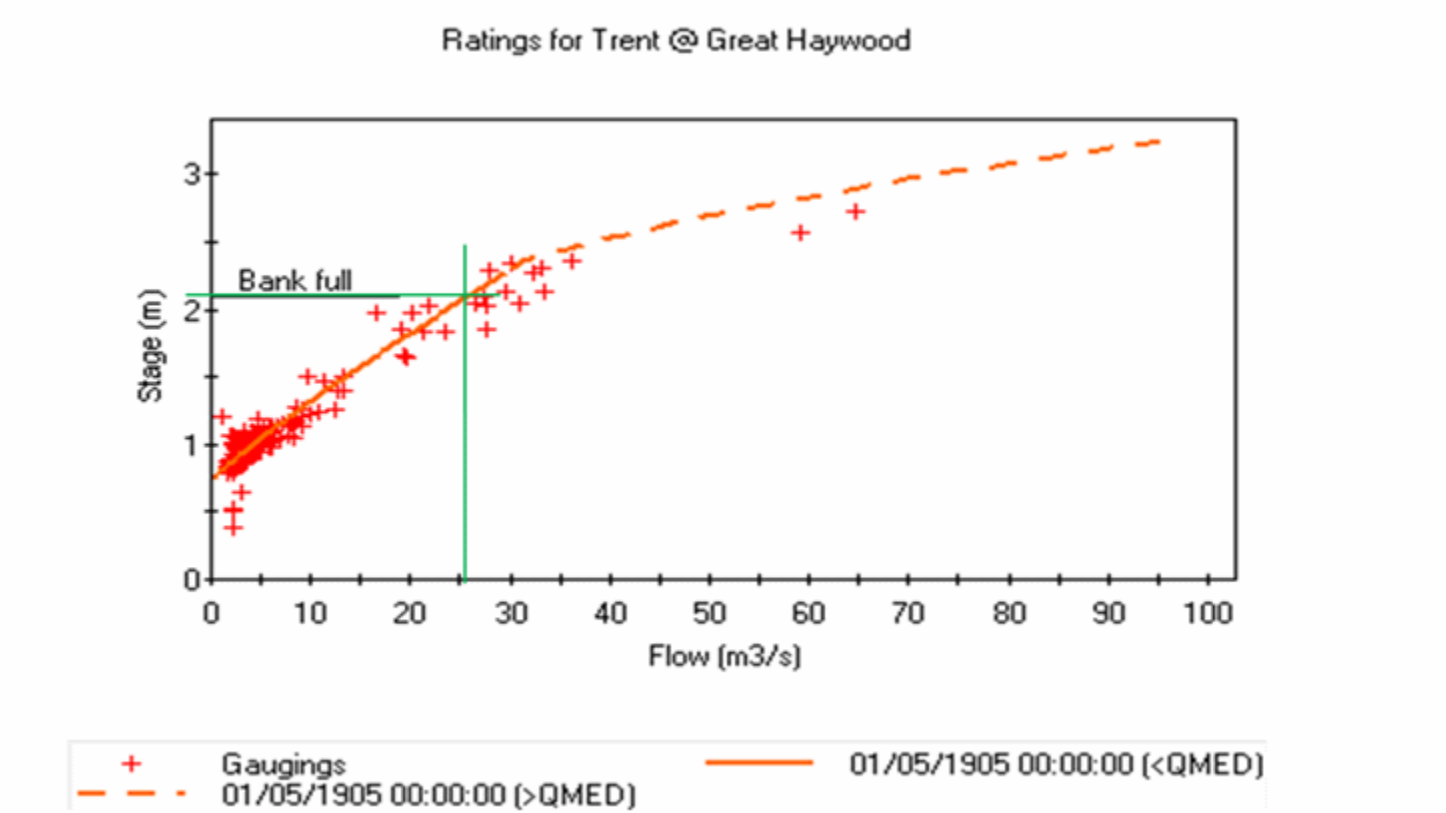


Figure7 – Environment Agency gauging station rating curve for the River Trent at Great Hayward, based on flow record commencing May 1905 (as published on the Environment Agency website

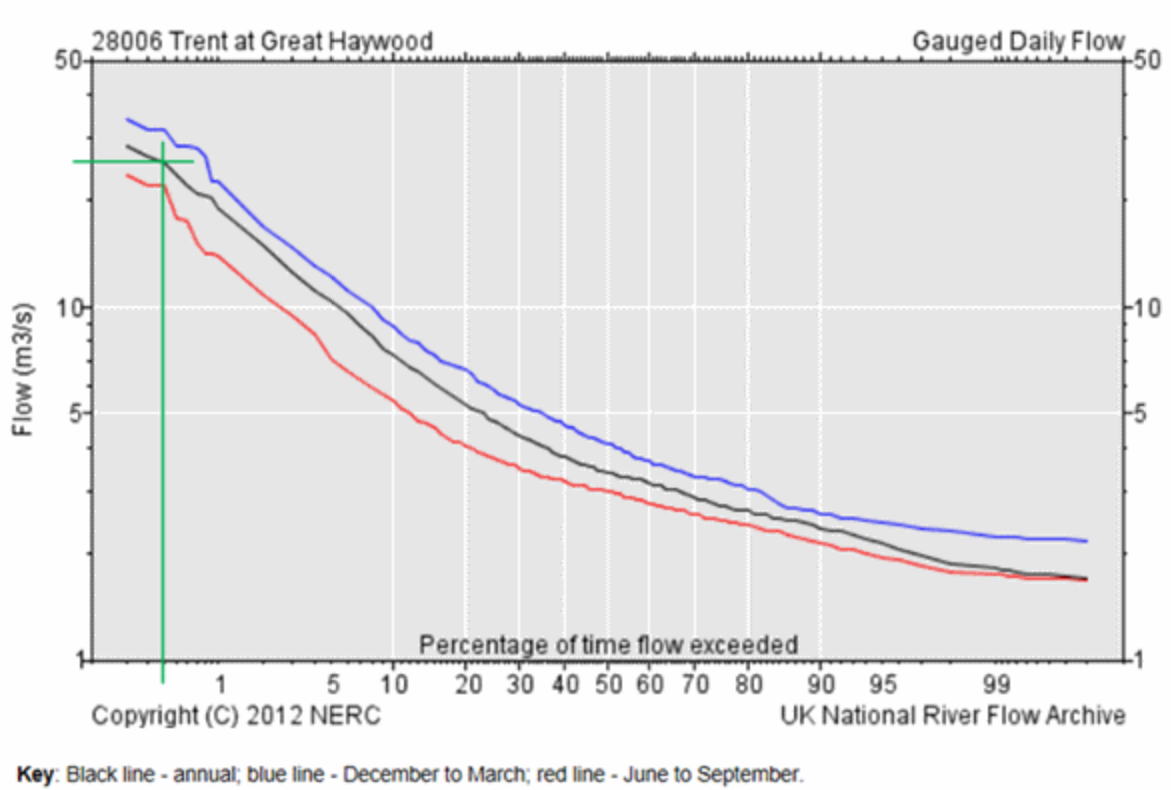


Figure 8 – Daily flow exceedence probability based on 7-year record from 1957 to 1964 (as published on the CEH website)

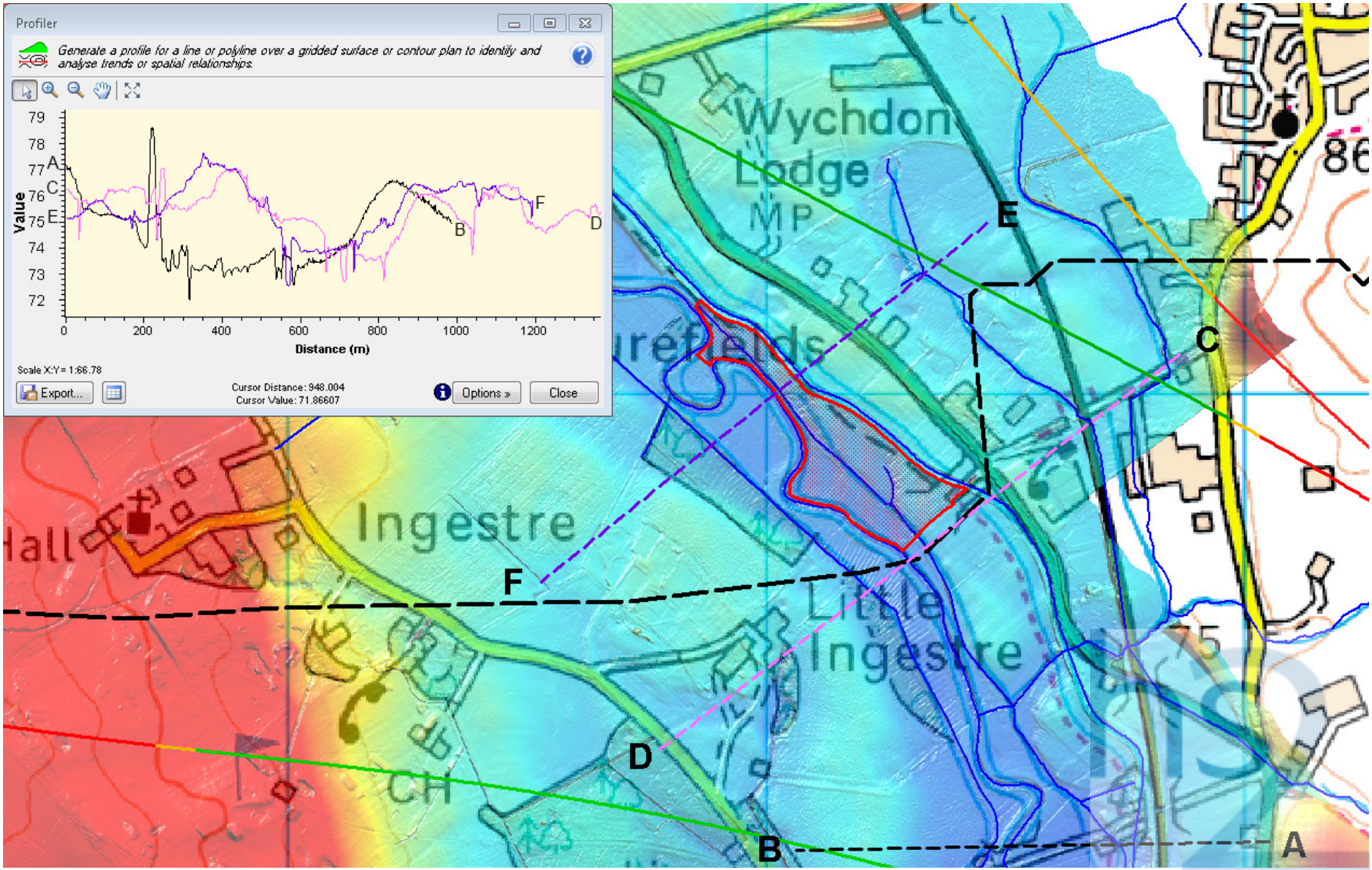
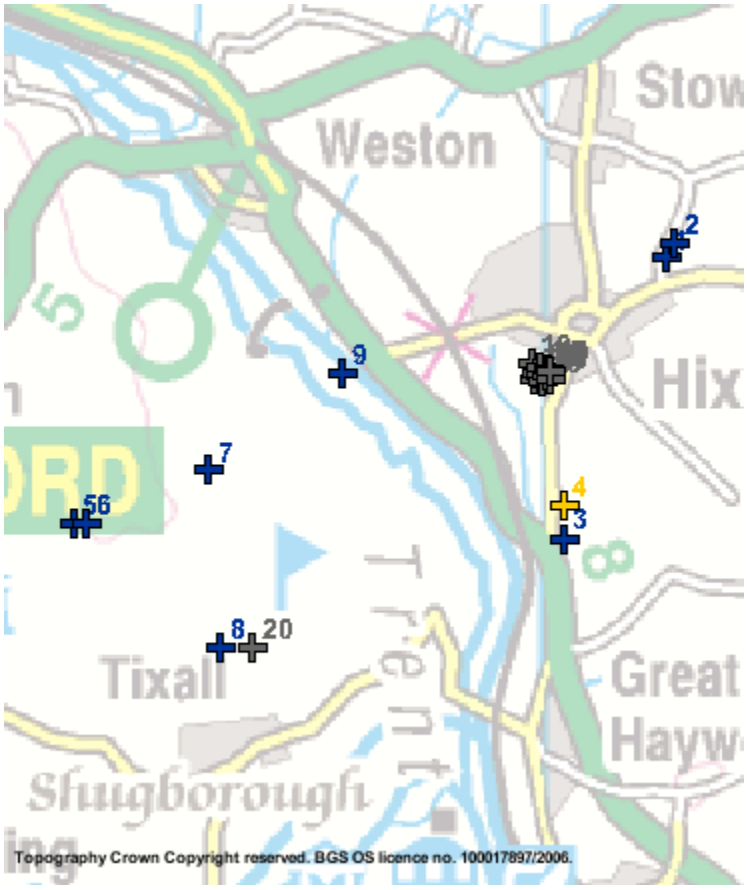


Figure 9 – LiDAR Thematic Map and extracted cross sections



9 Boreholes available to buy	
SK02NW46	1 STOWE CHARTLEY GYPSOM 45 Water Well 191178 67.36m at 400890,326430 (± 10m) BNG
SK02NW47	2 STOWE CHARTLEY GYPSOM 46 Water Well 191179 64.00m at 400960,326540 (± 10m) BNG
SK02SW3	3 INGESTRE FARLEY FARM COLWICH Water Well 191251 33.83m at 400150,324390 (± 10m) BNG
SK02SW41	4 HIXON STW IMPROVEMENTS 10 Borehole 15640623 6.85m at 400150,324640 (± 10m) BNG
SJ92SE31	5 UPPER HANYARDS FARM Water Well 182782 76.00m at 396600,324500 (± 100m) BNG
SJ92SE3	6 INGESTRE UPPER HANYARDS Water Well 182754 46.93m at 396700,324500 (± 10m) BNG
SJ92SE9	7 PARK HOUSE Water Well 182760 909.21m at 397580,324892 (± metre) BNG

SJ92SE10	**8** ✣ BRICKLAWN ✣Water Well 182761 981.45m at 397664,323606 (± metre) BNG
SJ92NE3	**9** ✣ TRENT LANE ✣Water Well 182587 281.02m at 398551,325588 (± metre) BNG
11 Confidential boreholes (may be available upon request)	
SJ92NE32	**10** ✣ SITE AT HIXON STAFFORD TP 2 15627476 Confidential record at 399930,325661 (± metre) BNG
SJ92NE30	**11** ✣ SITE AT HIXON STAFFORD TP 4 15627474 Confidential record at 399935,325548 (± metre) BNG
SJ92NE31	**12** ✣ SITE AT HIXON STAFFORD TP 3 15627475 Confidential record at 399948,325598 (± metre) BNG
SJ92NE28	**13** ✣ SITE AT HIXON STAFFORD TP 7 15627472 Confidential record at 399983,325572 (± metre) BNG
SJ92NE33	**14** ✣ SITE AT HIXON STAFFORD TP 1 15627477 Confidential record at 399985,325634 (± metre) BNG
SJ92NE29	**15** ✣ SITE AT HIXON STAFFORD TP 5 15627473 Confidential record at 399995,325533 (± metre) BNG
SK02NW84	**16** ✣ SITE AT HIXON STAFFORD TP 6 15627471 Confidential record at 400028,325575 (± metre) BNG
SK02NW83	**17** ✣ SITE AT HIXON STAFFORD TP 8 15627470 Confidential record at 400039,325623 (± metre) BNG
SK02NW82	**18** ✣ SITE AT HIXON STAFFORD TP 9 15627469 Confidential record at 400049,325555 (± metre) BNG
SK02NW81	**19** ✣ SITE AT HIXON STAFFORD TP 10 15627468 Confidential record at 400062,325604 (± metre) BNG
SJ92SE36	**20** ✣ LION LODGE 182787 Confidential record at 397900,323600 (± 100m) BNG

SJ 9661 2456

SJ92SE31
SJ 92/54A

140/76

At UPPER HANYARDS

Town or Village UPPER HANYARDS.

County STAFFORDSHIRE Six-inch quarter sheet 38 NW/W SW

For ~~Mr.~~ EARL OF SHREWSBURY

Exact site of well

Attach a tracing from a map, or a sketch-map, if possible.

Level of ground surface above sea-level (O.D.) ft. If well-top is not at ground level, state how far ... {above; / below;} ft.

SHAFT ft.; diameter ft. Details of headings

BORE 153'-6" B.; diameter of bore: at top 6" ins.; at bottom 4 3/4 ins. Lengths, diameters, perforations, etc., of lining tubes Existing 6" lined to 19ft:

Water struck at depths below well top, of (feet)

Rest-level of water 65 ft. ~~above~~ below well-top. Suction at 140 ft. Yield on 10 hours' ~~days'~~ pumping, 900 gal. per hour with depression to ft. below well-top, Capacity of pump g.p.h. Recovery to rest level in 1 ~~mins.~~ hours. Date of measurements 30/10/80 Date of well 30/10/80.

Quality of water (*attach copy of analysis if available*)

Well made by WYATT BROS (WHITCHURCH) LTD. SALOP

Information from do.

Additional notes in space overleaf.

(For Survey use only) GEOLOGICAL CLASSIFICATION	NATURE OF STRATA	THICKNESS Feet	THICKNESS Ins.	DEPTH Feet	DEPTH Ins.
	If measurements start below ground surface, e.g., from bottom of an existing shaft, state how far				
		18	-	18	-
	SANDSTONE	8	-	26	0
	MARLY SANDSTONE	60	-	86	0
	SANDSTONE	44	-	130	0
All in Keuper Sandstone according to 1" Memoir (P. 143)	WHITE SANDSTONE (WATER BEARING)	7	-	137	0
	HARD MARL	6	-	143	0
	MARLY SANDSTONE	10	6	153	6
	Staffs 38 NW/W.				
	Data Bank · Jun 1980				
	In Existing 6" Lined Borehole to 19ft.				
	Abandoned by 1st. Contractor				
	Sited by owner 15/9/80. P.M.S.				

Continued overleaf

GEOLOGICAL SURVEY AND MUSEUM,	Date received	Correspondence File No.	1" N.S. Map No.	1" O.S. Map No.	Site marked (use symbol) on 1" Map	on 6" Map

Form P.70
(Series 610)

SJ92SE9

BORINGS DEPT.
NOTIFICATION
SN 73/209
Initials RJ 3/9/73
Date 4/9/73

6-inch Map	B/H Regd. No
SJ92SE/9 (County, Sheet and Qtr.)	
SJ 92 SE (Nat. Grid, Sheet and Qtr.)	503

SECTION OF PARKHOUSE BOREHOLE

PURPOSE PROVING TRIAS AND COAL MEASURES

EXACT SITE NATIONAL GRID REFERENCE

E 397580

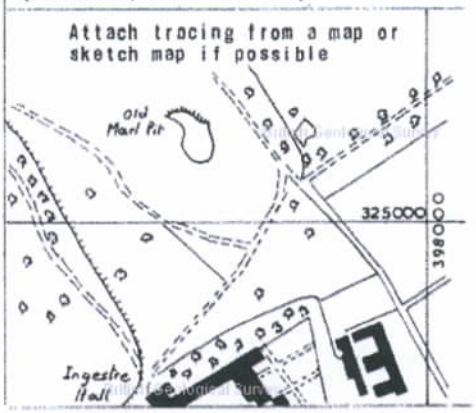
N 324892

LEVEL AT WHICH shaft / bore / drift COMMENCED RELATIVE TO O.D. 10307·85 ft.

DATE OF SINKING OR BORING 1973-74

SINKER OR BORER D. P. I. LTD.

Attach tracing from a map or sketch map if possible



GEOLOGICAL CLASSIFICATION	NATURE OF STRATA	THICKNESS FEET	THICKNESS IN.	DEPTH FEET	DEPTH IN.
	Rock Bit Samples.				
	Made up ground	5	0	5	0
Mudstone	Red. brown, silty to slightly silty, some pebbles, manly.	5	0	10	0
Mudstone	Red brown, chocolate, silty to slightly silty, manly, Some red brown and light brown finely bedded sandstone. Some pebbles, probably cave.	5	0	15	0
Mudstone	Red brown, silty, manly. Traces of lilac sandstone	5	0	20	0
Mudstone	Red brown to dark brown, finely banded, occassionally manly. slightly silty to silty. Traces of purple sandstone	15	0	35	0
Mudstone	Red brown to chocolate, silty to slightly silty, finely laminated. Traces of light grey and green manly mudstone.	15	0	50	0
Sandstone	Red brown, to light brown, with red brown mudstone occ light grey to green.	5	0	55	0
Mudstone	Red brown, occassionally purple, or grey, slightly silty, laminated, Traces of light brown sandstone.	15	0	70	0
Mudstone	Red brown, chocolate, occassionally grey green, Finely laminated, silty with traces of sandstone	15	0	85	0

Form P.71
(Series 610)

6-inch Map | B/H

SECTION OF PARK HOUSE BOREHOLE | SS 92. SE/9 [redacted]

OF STRATA		THICKNESS FEET	THICKNESS IN.	DEPTH FEET	DEPTH IN.
Brought forward:-				85	0
Mudstone	Light grey to green, also red brown and chocolate. Large pebble fragments. Traces of brown sandstone	5	0	90	0
Mudstone	Red brown, and chocolate, silty, manly. Traces red brown sandstone	20	0	110	0
Mudstone	Red brown, chocolate occassionally pale green, slightly silty, manly.	5	0	115	0
Mudstone	Red brown, chocolate, finely laminated, silty. Occassionally grey green sandstone.	5	0	120	0
Sandstone	Light brown, also red and purple. Muddy, with red brown to chocolate silty marl.	5	0	125	0
Mudstone	Red brown, also light grey and green, manly slightly silty with large pebble fragments.	5	0	130	0
Mudstone	Red brown. silty, occarsionally light grey green. Traces of red brown sandstone Traces of variegated marl bellow 140 ft	15	0	145	0
Sandstone	Light grey, also red brown, to purple. Also mudstone, light grey to red brown manly, increasing to base.	20	0	165	0
Mudstone	Red brown to grey, green, silty, manly, Large sandstone fraction, buff to grey	5	0	170	0
Sandstone	Red brown, occarsionally buff. Also mudstone silty, red brown to grey, occassionally lilac.	80	0	250	0
Mudstone	Red brown, chocolate, silty with brown and green sandstone	20	0	270	0
Sandstone	Light brown, fine to course grained, with mudstone manly red brown to green.	15	0	285	0

Form P.71
(Series 610)

6-inch Map	B/H
SJ. 92. SE/9	[redacted]

SECTION OF PARKHOUSE BOREHOLE

OF STRATA		THICKNESS FEET	THICKNESS IN.	DEPTH FEET	DEPTH IN.
Brought forward :-				285	0
Sandstone	Red brown, chocolate, micaceous, course grained, rarely light brown or green sandstone. Traces of mudstone red brown silty.	15	0	300	0
Sandstone	Red brown, chocolate, muddy. Large mudstone fraction, red brown to green, variegated.	15	0	315	0
Sandstone	Red brown, chocolate, occassionally purple. Fine to course grained. Traces of red brown mudstone, manly.	40	0	355	0
Sandstone	Red brown, chocolate occassionally purple or light grey. Large fraction of red brown mudstone manly.	5	0	360	0
Sandstone	Red brown to light brown, occassionally purple. Traces of red brown manly mudstone, increasing to base.	25	0	385	0
Mudstone	Chocolate brown, silty occassionally variegated Traces of brown sandstone	35	0	420	0
Sandstone	Chocolate to red brown and light brown. Fine to medium grained, Traces of chocolate mudstone manly. Very manly 230 to 235ft	35	0	455	0
Sand	Brick red, fine, medium to course grained, sub-angular to sub-round. Slightly muddy.	5	0	460	0
Sand	Brick red, fine to medium grained, muddy Also mudstone red to white manly.	35	0	495	0
Sand	Brick red, medium to course grained, sub-angular to sub round slightly muddy.	30	0	525	0

Form P.70
(Series 610)

SJ92SE10

SJ92SE/10

CONFIDENTIAL

6-inch Map (County, Sheet and Qtr.)	B/H Regd. No
SJ 92 SE/10 (Nat. Grid, Sheet and Qtr.)	~~504~~

SECTION OF BRICKLAWN BOREHOLE

PURPOSE PROVING COAL MEASURES.

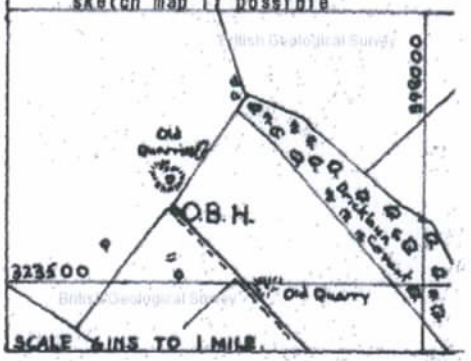
EXACT SITE NATIONAL GRID REFERENCE.
E 397664
N 323606

LEVEL AT WHICH shaft / bore / drift COMMENCED RELATIVE TO O.D. 10,344ft A.M.D.

DATE OF SINKING OR BORING 1974.

SINKER OR BORER D.P.I. LTD.

Attach tracing from a map or sketch map if possible



GEOLOGICAL CLASSIFICATION	NATURE OF STRATA	THICKNESS FEET	THICKNESS IN.	DEPTH FEET	DEPTH IN.
	Mudstone: Red-brown, buff, light brown silty to slightly silty. Marly, occasionally grey-green marl. Also fine grained, light-brown, loose, sandstone.			10	0
	Silty Mudstone: A red-brown, occasionally light brown and green silty or slightly silty Mudstone.	5	0	15	0
	Mudstone: Red-brown, buff, light brown occasionally green silty to slightly silty. A few sandstone bands, red-brown to light brown, rarely green; it is fine grained and loose. Increasingly sandy below 20 feet with traces of variegated marl.	10	0	25	0
	Silty Mudstone: Red-brown, light brown, occasionally green, fine grained silty to slightly silty and marly.	5	0	30	0
	Silty Sandstone: Red-brown to light brown, rarely green, and purple silty to slightly silty sandstone. It is loosely consolidated.	30	0	60	0
	Silty Sandstone: Red-green and red-brown rarely variegated silty to smooth fine grained sandstone.	5	0	65	0
	Mudstone: Red-brown to brown, rarely green marly and slightly silty. There is a slight purple staining and traces of a red-brown, fine grained, loose sandstone.	5	0	70	0

FORM P 71 T
SERIES 660

6-INCH MAP	B/H
SJ 92 SE / 10	~~504~~

Section of Bricklayon Borehole

*Delete as appropriate

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA	THICKNESS m or ft*	THICKNESS cm or in*	DEPTH m or ft*	DEPTH cm or in*
Silty Mudstone with Sandstone Bands.	Red-brown to light brown, also green and grey-green silty Mudstone. It is less marly than above. The sandstone bands are red-brown to light brown, fine grained and loosely consolidated. From 75 feet to 80 feet fragments of an off white limestone are found.	10	0	80	0
Interlaminated Mudstone and Sandstone:	The mudstone is predominantly red-brown, occassionally light brown, green and grey. It is silty to slightly silty, and marly in parts. The sandstone is of two types; off white, fine to medium grained and fairly well consolidated; and red-brown, fine grained and loosely consolidated.	10	0	90	0
Interlaminated Sandstone and Mudstone:	The sandstone is red-brown to light brown, and green to off white, fine to medium grained and loosely consolidated. The mudstone is red-brown occassionally grey-green, and is silty.	5	0	95	0
Sandstone:	Red brown, occassionally light brown, fine grained and well consolidated. It contains some red-brown silty mudstone. The mudstone fraction decreases below 100 feet.	15	0	110	0
Sandstone:	Pale red and grey green, mottled in parts. Occassional large sand grains. A silty grey-green mudstone occurs in parts.	5	0	115	0
Muddy Sandstone:	Red-brown, fine grained, fairly well consolidated and muddy. A red-brown silty mudstone is present. There are traces of limestone in the top 5 feet. Increasingly muddy below 130 feet.	25	0	140	0
Sandy Mudstone and Muddy Sandstone:	The mudstone is red-brown and silty to slightly marly with sand grains. The muddy sandstone is red-brown and fine grained.	5	0	145	0

FORM P 71 T
SERIES 680

6-INCH MAP	B/H
SJ 92 SE/10	~~504~~

Section of Bricklawn Borehole.

*Delete as appropriate

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA		THICKNESS m or ft*	THICKNESS cm or in*	DEPTH m or ft*	DEPTH cm or in*
	Mudstone and Sandstone:	Both are red-brown and grey-green, mottled in parts. The mudstone is silty, and the sandstone is muddy.	5	0	150	0
	Sandstone:	Red-brown to tan to buff, occassionally green and mottled. It is fine to medium grained and fairly well consolidated. A red-brown silty mudstone occurs in parts. Below 155 feet it is predominantly buff in colour, and there is only a trace of mudstone.	15	0	165	0
	Sandstone:	Red-brown, tan, and buff, more rarely yellow and grey. It is poorly sorted and loosely consolidated. Some red-brown to grey silty mudstone occurs. Poor samples from 170 to 180 feet.	20	0	185	0
	Sandstone:	Red-brown, fine grained and muddy with occassional large quartz grains.	25	0	210	0
	Sandstone:	Tan to buff in colour, fine to medium grained, loosely consolidated and poorly sorted.	5	0	215	0
	Muddy Sandstone:	Red-brown, fine grained and fairly well consolidated with some loose quartz grains.	5	0	220	0
	Sandstone:	Pale red and buff, more rarely green and mottled. It is loosely consolidated, and fine to coarse grained with a sugary texture. There are traces of green marl.	5	0	225	0
	Sandstone:	Red-brown, occassionally tan, it is fine grained. Some red-brown slightly silty mudstone occurs.	5	0	230	0
	Mudstone:	Silty to slightly silty, red-brown, and occassionally grey-green. Some fine grained muddy sandstone also occurs.	10	0	240	0
	Sandstone:	Red brown, fine grained and muddy, fairly well consolidated. Mudstone also occurs that is usually red-brown, it is rarely pale green and marly. There are occassional large quartz grains.	20	0	260	0

Central h.S.
Severn Trent NRA

Burton upon Trent 140

~~SJ92/54B~~
(TO BE TYPE WRITTEN)

SJ92SE3

SJ92SE 31

NRA (SEVERN-TRENT REGION)
BOREHOLE RECORD

~~SJ92NWR 152~~

SITE LOCATION DETAILS

Borehole drilled for	J S MADDERS & SONS.
At	UPPER HANYARDS FARM
Town	TIXALL
County	STAFFORD ST18 0YA.
National Grid Reference ...	SJ 966 245
Borehole drilled by	POWERFIT DRILLING SERVICES
Date of drilling	15-10-93.

CONSTRUCTION DETAILS

Borehole datum description ..... GROUND LEVEL.
(ground level/flange/dip tube/other)

Borehole drilled diameter .....
10" mm from 0 to 13 m/depth
6" mm from 13 to 76 m/depth
mm from ____ to ____ m/depth

Casing material P.V.C. diameter
(Solid, Slotted, Screen)
6" mm from 0 to 12 m/depth
mm from ____ to ____ m/depth
mm from ____ to ____ m/depth

TEST PUMPING DETAILS

Water struck at depths of ..... NOT NOTICED. Metres below datum (mbd)

Rest water level in borehole on completion ..... 10.00. mbd

Pump suction depth ..... 58 mbd

Pumping water level ..... 36 mbd after 8 hours days pumping

Pump rate ..... 264 ~~l/s~~ : ~~m³/d~~ : gph

Recovery to rest level in ..... NOT RECORDED. mins : hrs : days
(from end of pumping)

Date of measurements ..... 21st OCT. 1993.

~~SJ92SE/5~~

(TO BE TYPE WRITTEN)

SJ92SE/31

STRATIGRAPHICAL LOG

Description of strata (ie. colour, grain size & lithology)	Thickness m	Depth m
BROWN SANDY CLAY.	0.7	0
RED/BROWN SANDSTONE.	39.3	0.7
WHITE SANDSTONE.	5	40
RED/BROWN SANDSTONE.	31	45.
TOTAL DEPTH = 76M.		

RECORD OF SHAFT OR BOREHOLE

SJ/92NE/3

Name and Number of Shaft or Borehole: SJ92NE3

Trent Lane

For whom made N.C.B. Lea Hall Colliery

Town or Village Shirleywich near Weston County Staffs

Exact site (reference to a fixed point on 1-in map):

1.8km, S22°E of Weston (Disused) Railway Station

Purpose for which made To prove sequence in Trias

National Grid Reference
E 398551
N 325588

1-in New Series Map No.	Enter 'C' if Confidential
140	C

Ground Level at shaft bore relative to O.D. 250ft If not ground level give O.D. of beginning of shaft bore

Made by NCB Area Rig and Crew Date of sinking Feb73 - May73

Information from Cores Examined by B C Coppack

SPECIMEN NUMBERS AND ADDITIONAL NOTES

GEOLOGICAL CLASSIFICATION	DESCRIPTION OF STRATA	THICKNESS FT	THICKNESS IN	DEPTH FT	DEPTH IN
	Cores begin at	50	9	50 (15·47m)	9
Keuper Marl.	Mudstone dark red-brown, weahtered and slightly crumbly. Gypsum vien up to 2" thick and containing angular fragments of mudstones, commonly ¼" thick in an intricate and roughly horizontal pattern. Dark greenish, sandy mudstones between 57/6 and from 61/1-61/5 and from 63/9-64/3 thick 1½" gypsium vien, near vertical and cutting roughly horizontal vienlets in lower part.	13	6	64 (14·58m)	3
887' 11" KM KEUPER SST. TO BOTTOM OF B.H. AT 922'	Mudstones, as above, less weathered and probably slightly browner in colour. Gypsum in viens as above, is fibrous—fibres are vertical even if vien is at angle to core horizontal.				

D 7547 Wt. 243081 4,000 9/67 KCN Gp. 807 (5556) (B88)

Name and Number of Shaft or Borehole: Trent Lane

National Grid Reference

Geological Classification	Description of Strata	Thickness Ft	Thickness In	Depth Ft	Depth In
	Brought Forward			64 (19·58m)	3
	Green in colour with some loss due to solution by drilling fluids from 77/6-79/6	15	3	79 (24·23m)	6
	Mudstone red brown, blocky to very eregular fracture. Rock is eventually pellotoid, with large fragments of mudstone often larger than core diameter (almost 5") Fibrous gypsum viens up to 1" wide. Appears to pass down into	4	0	83 (25·45m)	6
	Mudstone, green, sandy, unbedded, fairly hard, slightly flakey. Patches of gypsum throughout. Gypsum cement? Abrupt base	1	0	84 (25·76m)	6
	Mudstone red brown, unbedded as described in ~~borehole 1~~ beds above The gypsum viens contain angular fragments of mudstones, and are themselves affected by what appears to be an extreme collapse structure due to solutain of presumably the saline beds in the ~~strata~~ strata. The core is coated intermittently with fire salt crystals. These have crystalised out from the drilling fluid (groundwater). Mottles and blotches from 96/1 to 96/8 abrupt colour base at	31	5	121 (37·03m)	6
	Mudstone, pale green, sandy unbedded, taste of salt in core. Small viens of gypsum The brecciation due to collapse with the old mudstone, seems to increase immediately above these green beds The resultant red brown rock type is much more "friable" and finely broken	0	11	122 (37·31m)	5
	Mudstone red brown, gypsum viens, freely brecciated breaking into small angular pieces.	0	11	123 (37·59m)	4

D 7548 Wt. 243082 10,000 9/67 KCN Gp. 807 (5557) (B87)

Name and Number of Shaft or Borehole: Trent Lane

National Grid Reference

3

Geological Classification	Description of Strata	Thickness Ft	Thickness In	Depth Ft	Depth In
	Brought Forward			123 (37·59m)	4
	Mudstone, pale green, sandy as above	0	6	(37·74m) 123	10
	Mudstone, red brown as above	0	7	124 (37·92m)	5
	Mudstone pale green, sandy, as above	0	10	(38·08m) 125	3
	Mudstone red brown as above	1	7	126 (38·66m)	10
	Mudstone, pale green, sandy very hard, slightly brittle, gypsum viening in part. Essentially unbedded	0	10	127 (38·91m)	8
	Mudstone red brown, much broken by solution. Gypsum viens, fibrous and up 1½" thick esentially horizontal. Occasional thin greenish, slightly sandy bands at 134ft and 139/6	12	4	140 (42·67m)	0
	Mudstone pale green, sandy, unbedded quite hard, slightly friable when broken fairly thick gypsum viens open criss-crossing and pomplex, containing angular fragments of green mudstones Gypsum as always, is friable. Several layers of more argillaceous red brown mottled bands appear to pass down into about	7	0	147 (44·81m)	0
	Breccia bed. diseminated fragments of red brown mudstones, pale green pellets and mottled pellets. Secondary fibrous gypsum viening	7	2	154 (46·99m)	2
	Mudstone red brown, thick irregular intricate fibrous gypsum veins. Fibres are vertical even when vein is at an angle to core horizontal. Unbedded and pelletoid. Even to about	13	4	177 (54·10m)	6

D 7548 Wt. 243682 10.000 9/67 KCN Gp. 807 (5557) (887)

Name and Number of Shaft or Borehole: Trent Lane

National Grid Reference

Geological Classification	Description of Strata	Thickness Ft	Thickness In	Depth Ft	Depth In
	Brought Forward			177 (54·10m)	6
	Mudstone, pale greyish green, slightly massive, fairly hard, slightly brittle	1	2	178 (54·46m)	8
	Mudstone red brown, sandy in pupper part, as above unbedded, Green marls present from 182/5 to 182/8 and from 185/8 to 186/3. Pale greenish grey mottles and large blotches common below this level	17	10	196 (59·89m)	6
	Mudstone, pale greyish green, appears to be bedded with fibrous gypsum. Quite sandy fairly hard slightly brittle	4	6	201 (61·26m)	0
	Mudstone-marl, completely unbedded red brown in colour, irregular sharp smooth faced fractures below about 204 ft, blocky fractured disemintated blocky noted at certain levels. Mottles of green. Small uncommon veinlets of gypsum noted. Seen to about	18	6	228 (69·65m)	6
	Mudstone, brecciated, large viens of fibrous gypsum. Abrupt base	4	4	232 (70·97m)	10
	N.B. Mudstone, red brown, import finely laminated Pale red brown mudstone with small pale green colour mottles, apparently unbedded. With ¼" laminated dark chocolate brown beds. The latter are open cut of vertical, several at a time , over zones several inches wide. This would appear to be a penecontemporaneous feature as quite often laminations above and unaffected. The loss of lamination may well be due to solution loss in beds below, probably less soon after isolation from the				

7548 Wt. 243082. 10,000 9/67 KCN Gp. 807 (5557) (B87)

Name and Number of Shaft or Borehole: Trent Lane

National Grid Reference

5

Geological Classification	Description of Strata	Thickness Ft	Thickness In	Depth Ft	Depth In
	Brought Forward			232 (70·97m)	10
	depositing medium and certainly before complete lithification of beds affected by desolution of beds below. These beds are seen to	2	2	236 (71·93m)	0
	Mudstone, dark chocolate red brown, much broken and brecciated with vienlets of slightly pinkish gypsum	1	6	237 (72·39m)	6
	Mudstone dark red brown, unbedded, but not broken many large green blotches and mottles. Small gypsum viens	3	4	240 (73·41m)	10
	Mudstone dark red brown, thoroughly broken, and brecciated on large scale, in part laminations persist. Abundant gypsum viening in upper part with occasional "eyes" of gypsum. Sandy towards base where it is slightly orange in colour	15	8	256 (78·18m)	6
	Mudstone dark red brown, smoothly cored but in detail finely brecciated with them viens and occasional "eyes" of gypsum. Appears to be a graded unit, in as much as, the lesser part shows more large scale brecciations, a rougher slightly more sandier mudstone. Abrupt base of these beds at	9.	2	265 (80·98m)	8
	Mudstones, the repeated	11	10	277 (84·58m)	6
	Mudstone cycle repeated	8	0	285 (87·02m)	6
	Mudstone cycle repeated	10	6	296 (90·32m)	0

D 7548 Wt. 243082 10,000 9/67 KCN Gp. 807 (5557) (887)

HTU/69

SK 02 NW/37. N.G.R 01520 2730
No 36 BORE O.D. 341.21

Drift, red marl 121'
gypseous marl 131'
red marl 202'
[Depth of white gypsum 3']

SK 02 NW/38 N.G.R. 0147. 2724
No 37 BORE O.D. 337.16.

Drift, red marl 134'
gypseous marl 139'
red marl 192'

SK 02 NW/39 N.G.R. 0143 2725.
No. 38 BORE O.D. 337.71

Drift, red marl 114'
gypseous marl 144'
red marl 203'
[Depth of white gypsum 5']

SK 02 NW/40 N.G.R 0131 2716
No. 39 BORE O.D. 324.28

Drift, red marl 140'
gypseous marl 180'
red marl 212'.
[Depth of white gypsum 10']

SK 02 NW/41 N.G.R 0109 2699.
No 40 BORE O.D. 338.11

Drift, red marl 122'
gypseous marl 137'
red marl 212'

SK 02 NW/42. N.G.R 0116 2702.
No. 41 BORE O.D. 333 Bored 212'.

SK 02 NW/43. N.G.R 0102 2681.
No. 42 BORE. O.D. 334.31 Bored 183'

SK 02 NW/44. N.G.R 0113 2700.
No 43 BORE. O.D. 337.39.

Drift, red marl 114'
gypseous marl 140'
red marl 190'
[Depth of white gypsum 2'6"]

SK 02 NW/45. N.G.R. 0117 2700
No. 44 BORE O.D. 333.41

Drift, red marl 103'
gypseous marl 118'
red marl 210'
[Depth of white gypsum 2']

SK 02 NW/46. N.G.R 0089 2643.
No. 45 BORE O.D. 340.54. Bored 221'

SK 02 NW/47. N.G.R 0096 2645
No. 46 BORE O.D. 336.74. Bored 210'

HTU/69

SK 02 NW/37. N.G.R 01520 2730
No 36 BORE O.D. 341.21
Drift, red marl @ 121'
Gypseous marl @ 131'
red marl @ 202'
[Depth of white gypseous 3']
SK 02 NW/38 N.G.R. 0147. 2724
No 37 BORE O.D. 337-16.
Drift, red marl @ 134'
gypseous marl @ 139'
red marl @ 192'
SK 02 NW/39 N.G.R. 0143 2725.
No. 38 BORE O.D. 337.71
Drift, red marl @ 114'
gypseous marl @ 144'
red marl @ 203'
[Depth of white gypsum 5']
SK 02 NW/40 N.G.R 0131 2716
No. 39 BORE O.D. 324.28
Drift, red marl @ 140'
gypseous marl @ 180'
red marl @ 212'.
[Depth of white gypsum 10']
SK 02 NW/41 N.G.R 0109 2699.
No 40 BORE O.D. 338.11
Drift, red marl @ 122'
gypseous marl @ 137'
red marl @ 212'
SK 02 NW/42 N.G.R 0116 2702.
No. 41 BORE O.D. 333 Bored @ 212'.
SK 02 NW/43. N.G.R 0102 2681
No. 42 BORE. O.D. 334.31 Bored @ 183'
SK 02 NW/44. N.G.R 0113 2700
No 43 BORE. O.D. 337.39.
Drift, red marl @ 114'
gypseous marl @ 140'
red marl @ 190'
[Depth of white gypsum 2'6"]
SK 02 NW/45. N.G.R. 0117 2700
No. 44 BORE O.D. 333.41
Drift, red marl @ 103'
gypseous marl @ 118'
red marl @ 210'
[Depth of white gypsum 2']
SK 02 NW/46. N.G.R 0089 2643
No. 45 BORE O.D. 340.54. Bored @ 221'
SK 02 NW/47. N.G.R 0096 2645
No. 46 BORE O.D. 336.74. Bored @ 210'

INSTITUTE OF GEOLOGICAL SCIENCES

RECORD OF SHAFT OR BOREHOLE

SK 02 SW/3.

Name and Number of Shaft or Borehole: Farley Farm. - Ingestre

For whom made

Town or Village Colwich County Staffs

Exact site (reference to a fixed point on 1-in map):

Purpose for which made Water

National Grid Reference: 0015 2439.

1-in New Series Map No.	Enter 'C' if Confidential
140'	

Ground Level at shaft bore relative to O.D. 260' approx if not ground level give O.D. of beginning of shaft bore

Made by Date of sinking

Information from Burton-upon-Trent Memoir pg 143 No 19 Examined by

SPECIMEN NUMBERS AND ADDITIONAL NOTES

GEOLOGICAL CLASSIFICATION	DESCRIPTION OF STRATA	THICKNESS FT	THICKNESS IN	DEPTH FT	DEPTH IN
	Keuper Marl (MMC).			111'	
	Depth			111'	
	Standing water level below surface 22'.				
	Yield: gallons/hour 280				

D 7547 Wt. 24308 4,000 9/67 KCN Gp. 807 (5556) (B88)

0015.2439

Sk 02 SW 3

140/77

At Harley Farm

Town or Village Ingestre

County Staffordshire Six-inch quarter sheet 38 ~~NW~~ or SW ~~SE~~

For ~~Mr.~~ Earl of Shrewsbury

Exact site of well

Attach a tracing from a map, or a sketch-map, if possible.

Level of ground surface above sea-level (O.D.) _____ ft. If well-top is not at ground level, state how far ... {above; / below; _____ ft.

SHAFT _____ ft.; diameter _____ ft. Details of headings _____

BORE 110'-6" ft.; diameter of bore: at top 5 ins.; at bottom 5 ins. Lengths, diameters, perforations, etc., of lining tubes 5" Liner tube (drilled) from 29 ft. to 110'6"

Water struck at depths below well top, of (feet) _____

Rest-level of water 22 ft. ~~above~~ below well-top. Suction at _____ ft. Yield on 10 hours' / ~~days~~ pumping, 290 gal. per hr with depression to 106 ft. below well-top, Capacity of pump _____ g.p.h. Recovery to rest level in 24 ~~mins.~~ hours Date of measurements 10/10/40 Date of well 2/10/40

Quality of water (*attach copy of analysis if available*) _____

Well made by WYATT BROS (WHITCHURCH) LTD. SALOP

Information from do.

Additional notes in space overleaf.

(For Survey use only) GEOLOGICAL CLASSIFICATION	NATURE OF STRATA	THICKNESS Feet	THICKNESS Ins.	DEPTH Feet	DEPTH Ins.
	If measurements start below ground surface, e.g., from bottom of an existing shaft, state how far	38	6	38	6
KM according to Memoir P143	Red Marl (Hard)	72	-	110	6

Continued over leaf

GEOLOGICAL SURVEY AND MUSEUM,	Date received	Correspondence File No.	1" O.S. Map No.	6" O.S. Map No.	Site marked (surveyed) on 1" Map

BOREHOLE LOG

SITE: Hixon STW Improvements			BOREHOLE Nº: 10
CLIENT: SEVERN TRENT WATER LTD.	CO-ORDS: E- N-	LOGGED BY: SC / SCALE: 1:50	
DRILLING METHOD: Light Cable Percussion, Vertical	BORING DIAMETER: 150mm to 6.85m.	DATE: 03/06/96	
	CASING DIAMETER: 150mm to 3.20m.	GROUND LEVEL: 85.65 m. A.O.D.	SHEET: 1 of 1

SAMPLE DEPTH(m)	SAMPLE TYPE	N	WATER DEPTH (m)	THICKNESS (m)	DESCRIPTION OF STRATUM	DEPTH (m)	REDUCED LEVEL (m A.O.D)	LEGEND
0.05 - 0.40	B1			0.05	FILL - topsoil*	0.05	85.60	
0.40 - 1.20	B2			0.35	FILL - firm to stiff red brown silty gravelly clay, topsoil, clinker, large rock fragments and fine roots	0.40	85.25	
				0.80	Firm and firm to stiff partially desiccated red brown silty sandy gravelly CLAY (possible fill)			
1.20 - 1.65	U3	(28)				1.20	84.45	
				0.80				
1.70	D4				....becoming gravelly from 1.70m			
1.70 - 2.00	B5				Firm to stiff red brown locally grey green silty CLAY with lenses/bands of moist red brown sand (ALL)	2.00	83.65	
2.00 - 2.45	S6	21						
2.00 - 2.45	D7							
2.00 - 3.00	B8							
				1.00	Firm red brown locally grey green silty CLAY with occasional mudstone lithorelicts (MMG)			
3.00 - 3.45	U9	(49)				3.00	82.65	
					Stiff red brown silty CLAY with mudstone lithorelicts (MMG)			
3.50	D10							
3.50 - 4.00	B11							
4.00 - 4.38	S12	50/225			....becoming very stiff with occasional thin beds of fragmented mudstone very weak from 4.00m			
4.00 - 4.40	D13							
4.00 - 5.00	B14							
5.00 - 5.36	S15	50/210	4.97 (4)	3.85				
5.00 - 5.35	D16							
5.00 - 6.00	B17							
6.00 - 6.50	D18		6.00 (1)					
			6.27 (3)					
6.50 - 6.81	S19	50/160						
6.50 - 6.85	D20		6.50 (2)					
6.85	W21					6.85	78.80	
					END OF BOREHOLE			

GROUNDWATER AND CASING DETAILS
1. Slight groundwater seepage encountered at 6.00m.
2. Groundwater seepage encountered at 6.50m, rising to 6.27m after 20 mins(3)
4. Water level at 4.97m after withdrawing casing.

REMARKS
1. * - Based on drillers description
2. Hand dug to 1.20m for services.
3. Chiselling 6.50-6.85m : 0.5 hrs.
4. Falling head permeability test carried out at 6.80m : 1.5 hrs.

NICHOLLS COLTON AND PARTNERS — LR 47033

Pasturefields Salt Marsh Site Visit 8th May 2012.

Location P2 – looking West along line of route HSM01 crossing of River Trent. The river is a reasonably constant width, approximately 14m, for the entire reach between Shirleywich and Great Hayward with a fairly constant gradient with short-grass floodplain. Flood events at Pasturefields are therefore likely to respond in a very similar way to the same events at Great Harwood gauging station.

Location P2 – looking East along line of route HSM01 crossing of elevated railway line which will also form a barrier to surface-water flows

Location P3 – Looking West, brook crossing under canal and railway.

Location P4 – Looking West from the south-east corner of Pasturefields Salt Marsh illustrating flat grassland nature of the site

Location P4 – Looking East opposite Pasturefields Salt Marsh. Illustrates the fact that the canal is not elevated from the East and any surface-water contributions will be intercepted by the canal and conveyed to controlled canal overflow points. As such, the canal forms an effective barrier to surface-water flows from the East, with the exception of a few overflow points which drain into ditches.

Location P6 – Looking over Pasturefields Salt Marsh. Swampy nature (high groundwater levels) obvious by the presence of Sedge grasses and standing surface water

Location P6 – Looking East showing boggy area with high water table outcrop to the east of the canal. Salinity of this feature is unknown, but could possibly be salty . The fact that it is outcropping to the east of the canal is another indicator that the groundwater flow is coming from the east.

Location P7 – Looking East at the northern most point of the salt marsh, illustrating the fact that the canal is still intercepting any surface-water flow from the East, as it does for the entire length of the salt marsh.

Location P7 – Looking over the salt marsh and the central disch can be clearly seen. This is fes from a canal overflow weir a short distance to the North.

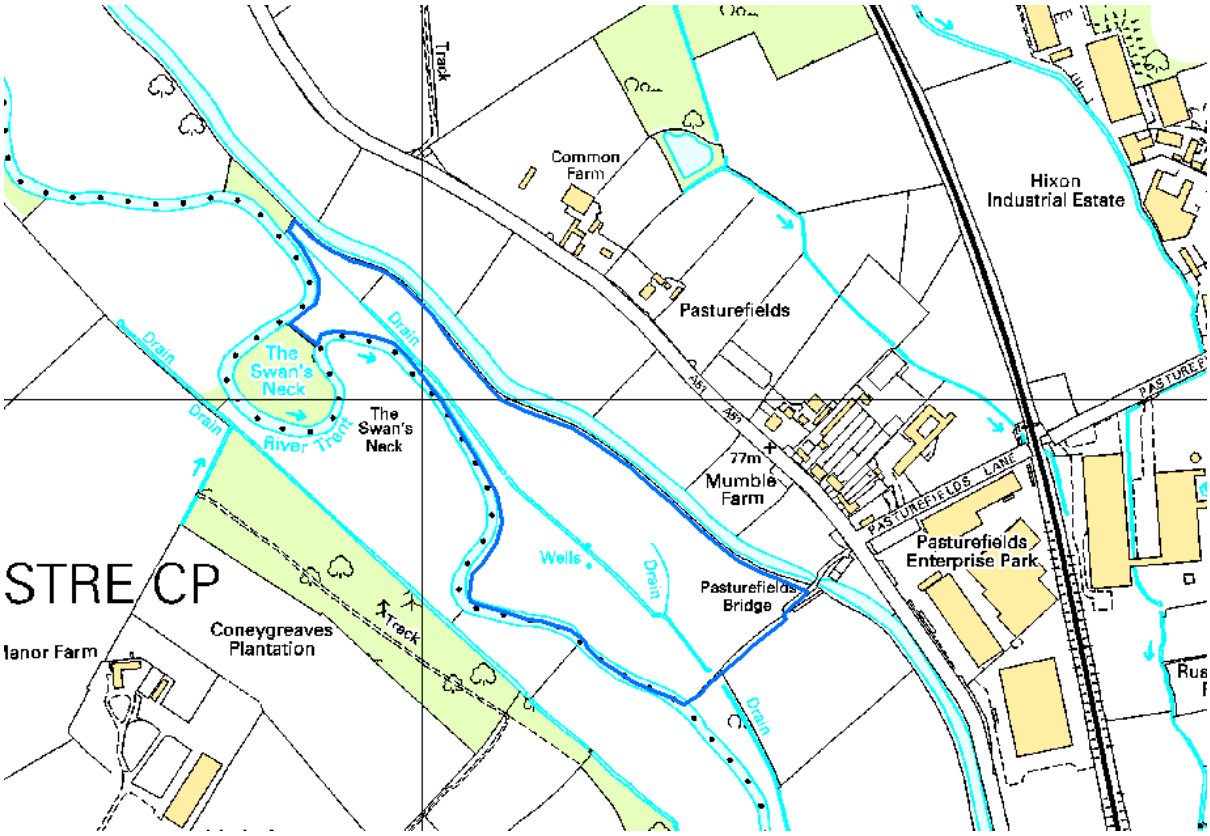
Location P13 – Looking downstream along the River Trent which has very similar geometry and flow characteristics to the crossing at Great Hayward.

Location P15 – Looking West showing the Amerton brook as it flows towards the River Trent. Information boards in the area suggest that this watercourse is slightly salty which further adds to the argument that the source of the salt water in Pasturefields is from the North

Location P17 – Example of Pipe and Weir overflow to control levels in the canal, flowing toward the River Trent.

APPENDIX 3
Pasturefields Salt Marsh SAC HRA Screening Sheet

Site name: PASTUREFIELDS SALT MARSH	SAC ✓	SPA	Ramsar



Location and general description

Pasturefields Salt Marsh SAC (7.7 ha) is situated to the east of Stafford in Staffordshire and is the only known remaining significant area of natural inland salt meadow in the UK (1).

Qualifying Interest

Primary reason for site selection: inland salt meadows, a habitat listed on *Annex I* of the Habitats Directive. The SAC comprises of a natural salt spring with inland saltmarsh vegetation.

(1) Apart from this SAC, there is only one other confirmed site which is very small in extent (64 m2) and situated in Cheshire.

Conservation objectives

Conservation Objectives are written at the underlying Site of Special Scientific Interest (SSSI) level. The Conservation Objectives for Pasturefields Salt Marsh SSSI (1) are, subject to natural change, to maintain the neutral grassland (SM16 – *Festuca rubra* salt marsh and SM23 – *Spergularia marina – puccinellia distan*s salt marsh) in favourable condition (or restored to favourable if features are assessed as unfavourable).

Habitat objectives aim to maintain the extent of the salt marsh habitats on site.

Site-specific standards defining favourable condition in the **salt marsh** habitat include maintaining:

- vegetation structure (appropriate zonation of vegetation and sward height);
- vegetation composition (maintain characteristic salt marsh species);
- no/low negative indicators (eg artificial drainage channels, signs of pollution, negative indicator species, turf cutting, recreational damage and poaching by livestock); and
- indicators of local distinctiveness (maintaining local populations of rare/scarce plant species).

Current site condition and site vulnerabilities and sensitivities

Condition status determined through monitoring of the SSSI by Natural England. The condition of the site was last assessed in January 2009 (2) and was deemed to be in 100% unfavourable condition with the prospect of recovery over time, as appropriate management measures are implemented.

Vulnerabilities and sensitivities

- **Inappropriate management:** the persistence of the salt marsh is dependent upon traditional agricultural management, livestock grazing and minimal use of agricultural chemicals.
- **Groundwater:** the hydrogeology of the site is not fully understood but is likely to require a certain level of water in the underground aquifer.
- **Brine levels:** the salt marsh is also vulnerable to any change in the brine source.

(1) Holland, T. (2008) Conservation Objectives and Definitions of Favourable Condition for Designated Features of Interest: Pasturefields Salt Marsh SSSI. Consultation Draft 28th November 2008. Natural England.

(2) Accessed from the SSSI section of the Natural England website on 25.05.11 - http://www.sssi.naturalengland.org.uk/Special/sssi/search.cfm

GENERIC POTENTIAL IMPACTS		
Potential impact	**Source of impact**	**Potential extent**
1. Direct habitat loss	• New railway corridor. • Associated infrastructure including new bridges, depots, culverts, and access. • Temporary construction areas and haul roads.	Localised within site boundary
2. Direct/indirect impact on species	• Loss of habitat for species. • Risk of killing and injury (e.g. from movement of vehicles during construction and operation, construction).	Localised within site boundary
3. Fragmentation or severance of habitat and/or animal species	• New rail corridor and associated access routes. • Temporary construction work areas preventing movement of species.	Extent depends on habitat type and typical ranges of fauna species affected.
4. Permanent or temporary effects on habitats and species through:		
• 4a: changes in surface water	• Surface run-off during construction and operation. • Pollution during construction and operation (e.g. from spills / leaks, sediments). • Discharges from excavated voids.	Localised effects likely but could extend large distances downstream if pollution / inappropriate discharge is released into a watercourse.
• 4b: changes in ground water	• Changes due to flows and profiles from excavations including tunnelling. • Pollution during construction and operation (e.g. from spills / leaks).	Localised effects likely but could affect a much wider area if pollution connects with groundwater.
• 4c: air pollution	• Dust from construction activities especially in dry weather and involving soil stripping, excavations, blasting or piling.	Localised effects (often ≤ 200 m subject to controls). Concerns more likely if sensitive habitats in surrounds.
• 4d: shading	• Bridges, culverts, embankments, buildings.	Localised on site and immediate surrounds. Extent will depend on size and location of structures.
5. Disturbance to fauna	• Construction activities generating noise, human presence and lighting especially at night, or where blasting or piling. • Operating trains and depots. • Maintenance activities.	Largely localised to in and around site with effects possible up to 100m if blasting / piling. Wider effects possible if certain bird species present.

Potential impacts	MR94D05B 1	MR28D02A 1	MR94D01 1 / MR94D01A 1							
Approximate distance to SAC (at nearest point)	300 m	650 m	660 m							
Direct habitat loss										
Direct/indirect effects on species*	✓	✓	✓							
Fragmentation or severance of habitat and/or animal species										
Changes in surface water	✓	✓	✓							
Changes in ground water	✓		✓							
Air pollution										
Shading										
Disturbance to fauna										

* No direct effects are predicted but indirect effects on species and associated habitats are possible if changes in surface or ground water impact on the qualifying interests of the site.

✓✓ denotes a likely significant effect

✓ denotes that it cannot be concluded that there will be no likely significant effect

Conclusions

To determine if the proposals are likely to have any significant effects on the designated sites the following issues are considered:

- could the proposals affect the qualifying interest and are they sensitive / vulnerable to the effect;
- the probability of the effect happening;
- the likely consequences for the site's Conservation Objectives if the effect occurred; and
- the magnitude, duration and reversibility of the effect.

'Likely significant effect' in this context is any effect that may reasonably be predicted as a consequence of the project that may significantly affect the conservation or management objectives of the features for which a site was designated. A judgement as to significance must take into account factors relevant to the question of significance as described above. These will include temporal considerations (i.e. length of time of effect) and physical considerations (i.e. extent of effect on the European site and the elements of the site including its conservation objectives). It is possible, therefore, for an effect to damage something on the European site, but because such damage is fleeting, limited in extent or damaging to something outwith any conservation objectives the effect is insignificant on the European site.

The screening stage should conclude one of the following three outcomes:

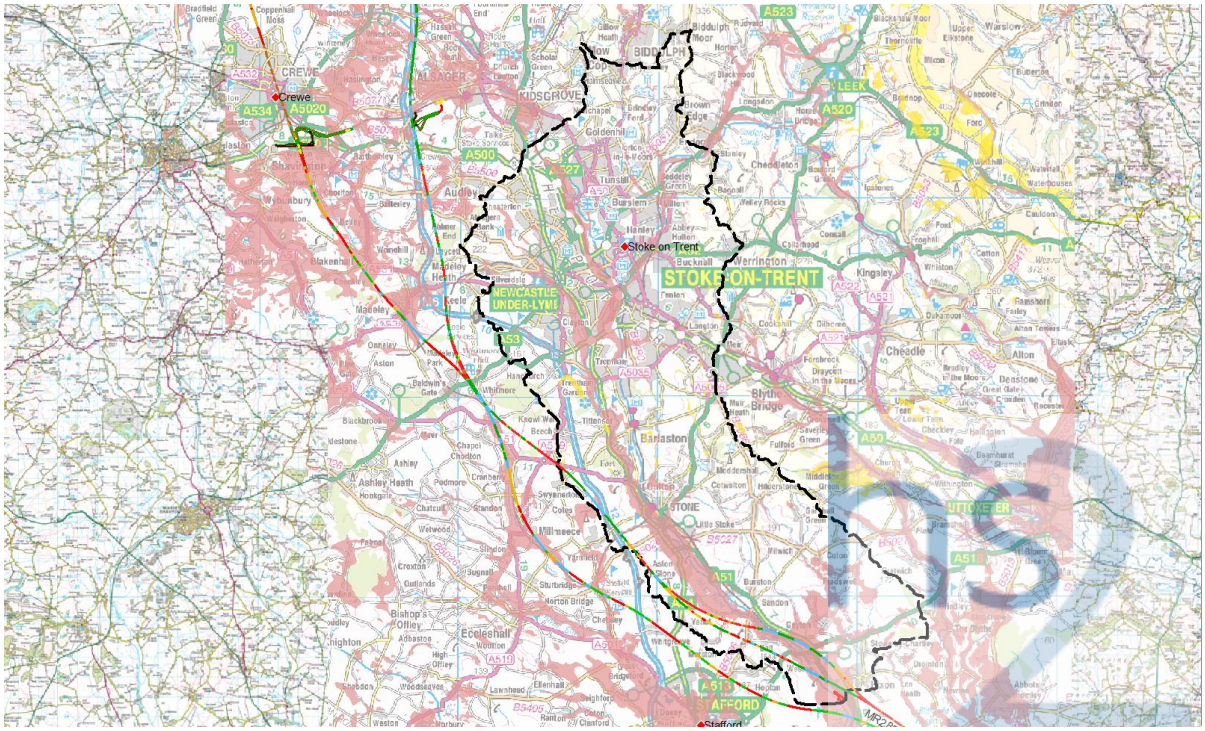
1. no likely significant effect;
2. a likely significant effect; or
3. it cannot be concluded that there will be no likely significant effect.

The following route options either would or may result in a significant effect to Pasturefields Salt Marsh SAC, since a significant effect is either considered likely or cannot be ruled out on the basis of information currently available. Were any of these options to be progressed, an appropriate assessment of the site would be required under Regulation 21 of the *Conservation of Habitats and Species Regulations 2010*.

Route option ref	A significant effect is considered likely because:	It cannot be concluded that no significant effects will occur because:
MR94D05B 1 MR94D01 1 MR28D02A 1/ MR94D01A 1		Three routes are considered, two which pass the site to the North-East and the other which passes to the South. In all cases, the exact extent of the contributing catchment and saline geostrata are unknown and will require detailed desktop studies and possibly intrusive investigation to determine these. From the information available it is highly likely that the salt water comes from an area to the North-East of the site. For the routes which pass to the North, by far the biggest risk to this site occurs during the construction phases and therefore careful control will be required in order to ensure that the aquifer and upstream watercourses (fee Figures 1 and 2) do not become polluted during construction.

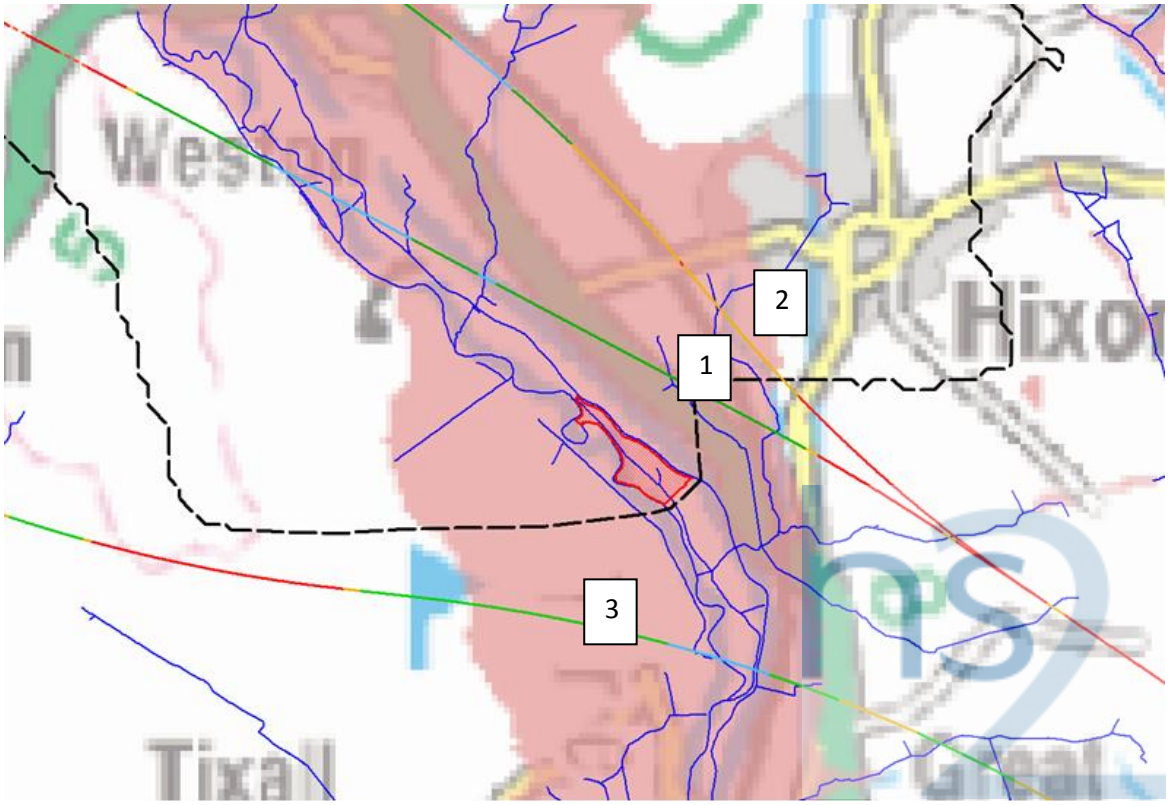
Route option ref	A significant effect is considered likely because:	It cannot be concluded that no significant effects will occur because:
MR94D05B 1 MR94D01 1/ MR94D01A 1		The routes to the North (label 1 and 2, Figure 2) present the greatest risk due to relatively close proximity and the fact that the available geological information suggests that groundwater flows which feed the salt marsh come from an area between Stowe on Chartley and Weston. The highest likelihood of pollution from both surface-water and groundwater flows is from the route immediately to the north (label 1). From discussions with Natural England, detailed analysis is likely to be required in order to quantify the risk of any impact on the salt marsh for these routes. Particular care will be required for construction of viaduct foundations (when crossing the River Trent) in order to ensure that the superficial aquifer does not become polluted. It might be necessary to employ techniques such as liquid nitrogen ground freezing in such situations. Best-practice techniques will also need to be employed for any works within the vicinity of the SAC to mitigate risks of pollution due to flooding during the construction period.
MR28D02A 1		The route to the South (label 3, Figure 2) does not intersect the contributing surface-water catchment of the saltmarsh and there are no sections of route in cut through the superficial aquifer which could affect flows into the saltmarsh. There will be some below-ground work for construction of viaduct foundations (when crossing the River Trent); however it is unlikely that this will affect the source of groundwater flow which feeds the salt marsh. Provided that best practice construction techniques are employed to ensure that the aquifer is not polluted during construction; and that the viaduct is designed so that it does not impede flood flows (which could cause flows to back up and increase the frequency of flooding on the site), there should be no significant impact on the hydrology of the site.

Figure 1 – Hydrological Catchment (large scale)



Key: Red line = Site Boundary, Black dotted line = FEH Surface Water Catchment, Pink shading= BGS Superficial Aquifer

Figure 2 – Hydrological Catchment (small scale)



Key: Red line = Site Boundary, Black dotted line = FEH Surface Water Catchment, Pink shading= BGS Superficial Aquifer

APPENDIX 4
MSG Technical Note – Foundation Sketches for 10m Embankment on River Terrace Deposits

Technical note

To	***From:***	***Our reference***
Tony Walker	Tom Hickson	PJP/LP/TH/282302RTSfoundations
Cc	***Office***	***Date***
Ken Leitch, Lee Parry, Peter Colliver	FNG, Croydon	15/05/2012
Subject	Foundation sketches for 10m embankment on River Terrace Deposits	

1. Introduction

Further to the issue of the memo (from Eddie Shaw-Smith and Peter Colliver) on 17 February 2012 (High Speed 2 HRA Screening for SAC Sites – Pasturefields Salt Marsh) this document provides sketches on the likely engineering design in relation to the foundation design for a typically 10m high embankment constructed on River Terrace Deposits (RTD) at Pasturefields, near Hixon, Staffordshire.

The purpose of the note is to aid in the understanding of the impact the alignment may or may not have on the source-pathway-receptor model for the saline ground water at the salt marsh.

2. General description

The description of the Pasturefields site is detailed in the previous technical note (ref: PJP/LP/PC/PSM). Four typical foundation options are provided in this note. The options are as follows:

Figure 1: The first is a conventional embankment, in which competent material with suitable allowable bearing pressures are presumed close to the surface. This sketch is likely to be used where significant thicknesses of RTD are encountered, or no dissolution features / brine flow paths are present beneath the embankment.

Figure 2: The second sketch is a likely foundation arrangement if the RTDs includes layers of unsuitable material (i.e. soft and compressible). The sketch also illustrates a foundation solution where dissolution features are present in the bedrock, but are not considered part of the brine flow path.

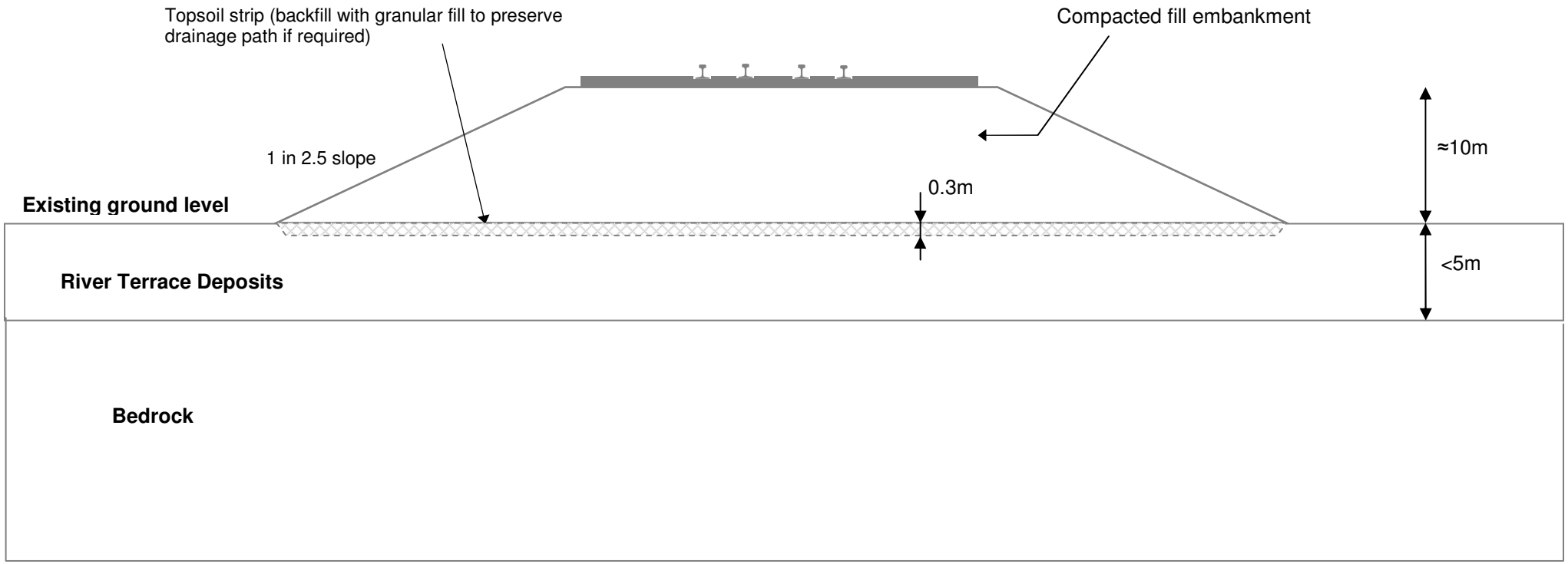
Figure 3: The third sketch is a typical foundation layout that could be utilised if a confined brine flow path were to be encountered. The sketch option takes into account the River Terrace Deposits being unsuitable to bear the founding pressures induced from the embankment above a brine flow path and transfers the loads directly to competent bedrock.

Figure 4: The fourth sketch provides a solution for founding over a wide brine flow path. A multispan viaduct could be used to transfer loadings to sufficient depth abating any potential collapse in the flow path. Even though piles will penetrate the brine pathway the intrusion will be small compared with the overall size.

3. Conclusion

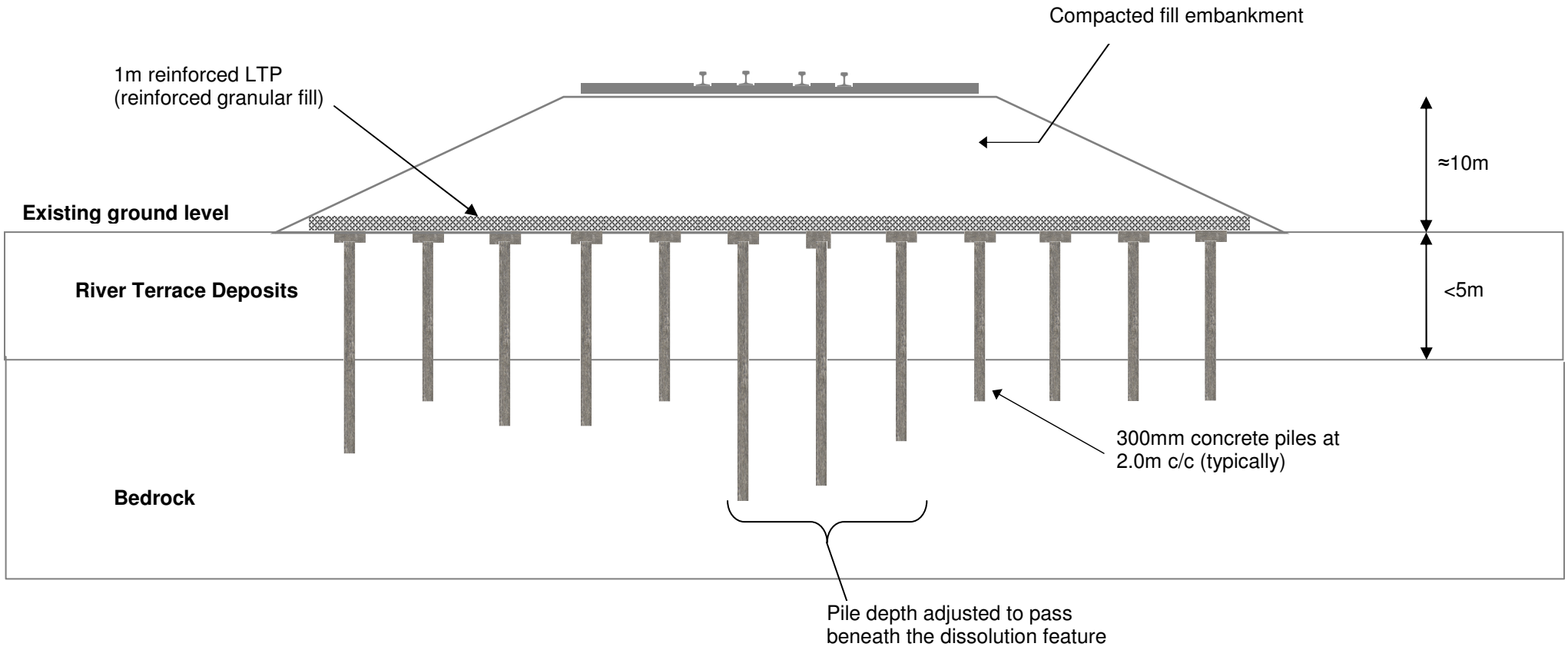
The sketch options provided in this technical note are typical foundation solutions for varying ground conditions for a raised alignment over possible dissolution features and brine flow paths at Pasturefields. It should be noted that the options are reliant on the position of the brine flow path having been identified, rather than providing a solution to an unknown extent of any potential brine flow path / dissolution feature over a given area.

Figure 1. Conventional Embankment



Notes: 1. This solution is to be adopted where Terrace Deposits are strong enough to support embankment loading (e.g. sands and gravels) and there are no dissolution features at depth.

Figure 2. Pile Supported Embankment



Notes: 1. This solution is to be adopted where Terrace Deposits contain soft, compressible layers or dissolution features are present in the bedrock.

Figure 3. Crossing confined brine flow path

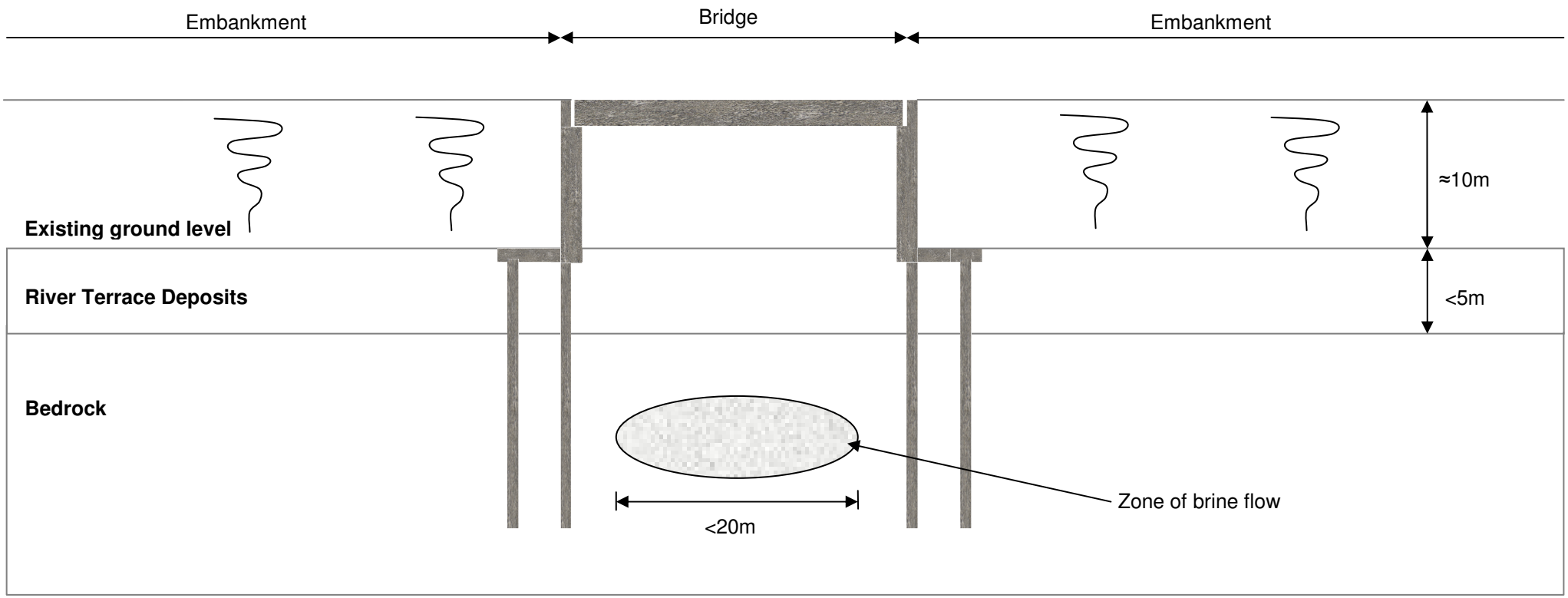
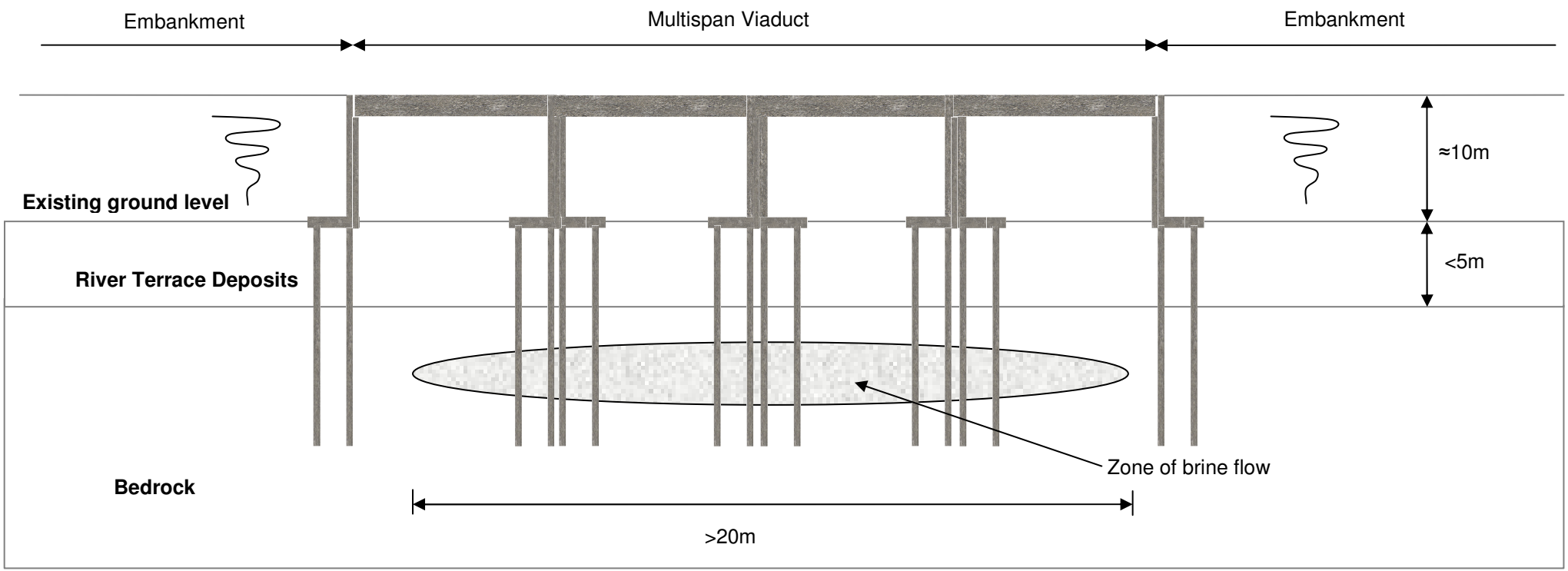


Figure 4. Crossing extensive brine flow path



Notes: 1. Depending on the extent of the flow path a piled embankment option could be considered.

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