Llywodraeth Cymru / Welsh Government

A487 New Dyfi Bridge

Environmental Statement – Volume 3: Appendix 10.1

Preliminary Sources Study Report

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1 Introduction

1.1 Background

The A487 trunk road is the principal south to north route along the west coast of Wales. The existing river crossing at Machynlleth (Pont ar Ddyfi) is the first upstream crossing of the Afon Dyfi and is located more than 14km from the estuary. The Afon Dyfi is subject to frequent flooding leaving the approach road from Machynlleth inundated and the trunk route severed several times each year. In these conditions traffic must use the next upstream Afon Dyfi crossing on the B4404, requiring a detour of some 18km.

Welsh Government proposes to replace the existing bridge carrying the A487 trunk road across the Afon Dyfi with a new viaduct structure positioned a short distance upstream of the old bridge. The name of the scheme is ‘The A487 New Dyfi Bridge’.

The scheme lies in the valley of the Afon Dyfi at National Grid Reference SH 745 017. It is some 0.5km north of the market town of Machynlleth in Powys and at the southern extremity of Snowdonia National Park. The location is presented in Figure 1.

The A487 trunk road at Pont-ar-Ddyfi has been the subject of a number of studies into the operation and serviceability of the existing route and alternative crossing points to the Afon Dyfi floodplain. In the last thirty years increased traffic and the continuing deterioration of the masonry structure has necessitated structural strengthening works and repairs to keep the bridge operational.

In November 2000 a Stage II Technical Appraisal Report was prepared. This report concluded that for the trunk road to remain accessible to traffic at all times then an alternative solution was required. The recommended option was to construct an offline multi span viaduct across the floodplain.

One previous geotechnical study has been undertaken for the scheme. This was carried out in 2001 by C.J. Associates Geotechnical Limited. A ground investigation was carried out as part of this study, which comprised boreholes, trial pits and associated laboratory testing. The location of the boreholes and trial pits are presented on Figure 2 and the laboratory testing in Reference 6 (Section 2 of this report).

Scheme design (KS3) of the scheme is to now be progressed, with construction proposed to commence in 2017. The following specific transport planning objectives (TPOs) have been identified:

- TPO1 – to improve reliability of crossing the Afon Dyfi for people, freight and emergency vehicles on the A487 strategic corridor.
- TPO2 – to improve efficient and reliable accessibility to key services including employment opportunities, healthcare and education.

- TPO3 – to maintain the role of Machynlleth as a vibrant and sustainable local centre.
- TPO4 – to preserve the long-term integrity of the Dyfi Bridge.
- TPO5 – to reduce the number of severe collisions and casualties on the A487 in the study area.
- TPO6 – to ensure that flood risk to third parties is not increased.
- TPO7 – to minimise the impact of transport improvements on the landscape, biodiversity, water resources and heritage.
- TPO8 – to increase the opportunity for efficient, safe and reliable travel by walking and cycling on the A487 corridor within the study area.

1.2 Proposal

Current proposals for the A487 New Dyfi Bridge scheme (Figure 3) comprise a 1050m long new section of single carriageway road, associated 240m long tie-in to the existing A487 in the south and access to existing fields, including a cattle pass underbridge next to the northern abutment. Flood bunds and associated ramp access is proposed in the southern end of the scheme and along the northern boundary of the existing Eco Park. Provision of field access and turning heads is also planned immediately to the south of the Pont-ar-Ddyfi.

The proposed route is to the south east of the existing route, which includes the Pont-ar-Dyfi Bridge. The proposed scheme includes a 730m long viaduct with approach embankments and a river bridge across the River Dyfi and associated floodplain. The existing A487 will be de-trunked between the two ends of the scheme, and the existing Pont-ar-Dyfi will be restricted to Non-Motorised Units only.

The preliminary design for the viaduct comprises 20 spans, predominantly of 34m length, with a 73m span across the main river channel, with a 50m backspan to the southwest; see Figure 3. The piers are proposed to be supported on piles. An approach embankment to the south, less than 5m in height, will be required over significant depths of soft alluvium.

2 Sources of information & desk study

The following sources have been used for the preparation of this report:

1. Cadair Idris, Sheet 149. 1:50,000 Solid and Drift Geology. (Keyworth, Nottingham: British Geological Survey). British Geological Survey, 1995.
2. SH70SW (Machynlleth). 1:10,000 Solid and Drift Geology. British Geological Survey, 1987.
3. SH70SE (Llanwrin). 1:10,000 Solid and Drift Geology. British Geological Survey, 1988.
4. Geology of the country between Aberystwyth and Machynlleth. Memoir of the British Geological Survey, Sheet 163 (England & Wales). Cave, R. & Hains, B.A., 1986.
5. A487 Dyfi Pinch Point, Flood Alleviation at Heol Y Doll Rail Bridge, Feasibility Report (Unpublished). Central Wales Infrastructure Collaboration (CWIC), 2014.
6. A487 Pont ar Dyfi Improvement. Site Investigation No M0525 Factual and Interpretive Report. Unpublished report to Powys County Council. CJ Associates Geotechnical Limited, 2001.
7. Afon Dyfi, Aberangell-Glan Dyfi. Geomorphological Investigation. GeoData Institute unpublished report reference C.4.13.1.B. Environment Agency, undated.
8. Geology of the country around Cadair Idris. Memoir of the British Geological Survey, Sheet 149 (England & Wales). Pratt, W.T., Woodhall, D.G. & Howells, M.F., 1995.
9. British Regional Geology of Wales, Chapter 9. Howells, M.F.. British Geological Survey, 2007.
10. Envirocheck Report, including historic 1:2,500 and 1:10,000 Ordnance Survey plans. Reference 1744/DYB.
11. Coflein online database. Royal Commission on the Ancient and Historical Monuments in Wales. Available from: http://map.coflein.gov.uk/. [Accessed: September 2015].
12. Welsh Government Aerial Photography Unit archives.
13. British Geological Survey (BGS) online viewer. Available from: http://mapapps.bgs.ac.uk/geologyofbritain/home.html. [Accessed: September 2015].
14. The Coal Authority online viewer. Available from: http://mapapps2.bgs.ac.uk/coalauthority/home.html. [Accessed: September 2015].

15. A487 Fishguard to Bangor Trunk Road Pont ar Ddyfi Improvement. Options Development Report. Powys Country Council, 2010.

3 Field studies

3.1 Site Walkover

A site walkover of the study area was completed on 14th August 2015 by two Chartered Geotechnical Engineers. A series of visual observations were made on the geology and geomorphology along the proposed route corridor and the neighbouring ground. The following paragraphs discuss the specific observations that were made. Chainages have been used as a point of reference as shown on the site constraints plan, Figure 4, along with the identified observations discussed below. Photographs are presented in Appendix A.

The proposed route leaves the existing A487, in a westerly direction at approximately Ch. 0+090m. At approximately 0+100m, there is a 290m long new section of road to tie-in the proposed route to the existing A487. This part of the scheme crosses fields and hedgerows.

At around Ch. 0+250m, the proposed route crosses over the existing A487. Drainage channels run along both sides of the existing A487 and are culverted under the access to the fields; see Photograph 1. Services also cross the A487 at this location including a high pressure gas main; see Photograph 2. Overhead power lines cross the A487 and run across the site in a north easterly direction; see Photograph 3.

Between Ch. 0+250m and Ch. 0+820m, the proposed alignment crosses fields and hedgerows; see Photograph 4. At around Ch. 0+290m the field is very marshy in places indicating impeded drainage; see Photograph 5. Marshy ground is also present between Ch. 0+450m and Ch. 0+480m; see Photograph 6, and around Ch. 0+765m to Ch. 0+795m; see Photograph 7. Also a number of ponds are present, see Photograph 8.

At Ch. 0+830m, the alignment crosses the existing footpath; see Photograph 9. It then crosses very uneven grassed area between Ch. 0+830m to Ch. 0+880m, potentially as a result of historic fill from the construction of the Millennium Bridge, which crosses the River Dyfi to the east of the proposed alignment.

Between Ch. 0+880m and Ch. 0+895m, the alignment crosses a gravel bank, associated with deposition within the River Dyfi; see Photograph 10. Downstream of the alignment stiff, grey brown, clayey silt over river terrace deposits comprising rounded gravels were exposed in the river bank; see Photograph 11. There also appeared to be some evidence of an old masonry wall, possibly historic river edge protection; see Photograph 12. Upstream of the Millennium Bridge, on the southern river bank, there were signs of significant instability with localised slumping; see Photograph 13.

On the northern bank of the river, between Ch. 0+780m and Ch. 0+800m, rock was shown outcropping; see Photograph 14. However just upstream, a retaining structure is present which supports the existing A487; see Photograph 15.

Between Ch. 0+895m and Ch. 0+920m the alignment crosses the River Dyfi.

Between Ch. 0+920m and Ch. 1+010m, the alignment crosses a field again, which is some 10m higher than the river. It appears that fill may have been placed on the southern area of the field as the ground was uneven and the drainage impeded, which is not expected for natural ground high above the river; see Photograph 16.

From around Ch. 1+010m the proposed alignment rejoins the existing A487. On the western side of the road, rock is shown outcropping; see Photographs 17 and 18. There is a public footpath which runs along the eastern side of the proposed alignment.

4 Site description

4.1 Topography

The proposed development lies in the scenic Dyfi Valley in a hilly part of mid-Wales to the east of Cardigan Bay. From the northern outskirts of Machynlleth, the proposed construction corridor traverses relatively flat to gently undulating ground associated with the floodplain of the River Dyfi. Much of this flat ground comprises grass pasture used mainly for grazing of sheep and cattle. Field boundaries are delineated by fences, hedgerows and trees.

In the vicinity of the proposed river crossing, the construction route crosses the National Cycle Network Route No. 8, a relatively new public footpath, bridleway, cycleway and bridge (see Photograph 9 in Appendix A) that runs for the most part along the south bank of the river. The scheme then crosses River Dyfi.

On the north bank of the river, the proposed route traverses a steep wooded slope, approximately 10m high, and continues on higher ground where bedrock out crops in a roadside cutting on the existing A487 carriageway.

The elevation of the floodplain section varies between 5m and 10mAOD whereas the northern valley side rises steeply to above 200mAOD.

4.2 Geology

The geology of the site has been reviewed from British Geological Survey (BGS) 1:50,000 Geological Sheet 149, 1:10,000 Geological Sheets SH70SW and SH70SE, BGS Memoir Sheet 163, BGS borehole online viewer and other published information listed in Section 2.

The bedrock comprises grey turbiditic mudstones and siltstones of the Borth Mudstone Formation of Silurian (Llandovery) age. The mudstone beds range from 0.2m to 0.6m thick and include a few thin sandstone and siltstone interbeds. It crops out in a roadside cutting on the A487 in the vicinity of the tie-in at the north-eastern end of the scheme; see Photograph 17. The best exposures are visible in nearby quarries, for example at Llwyngwern (NG: SH 759 044). Generally, the bedrock strata strike north-northeast and dip at moderate to steep angles; see Photograph 18.

The 1:10,000 scale published geology map shows an anticlinal (arch shape) axis, trending in a north to south direction, passing through the centre of the tie-in with the existing A487 at the northern end of the site. Cleavage / bedding dips to the east of the axis are recorded as being between 21° and 29° in a north easterly direction. Whilst to the west of the anticlinal axis the bedding is shown dipping at 55° to the west, towards a synclinal (bowl shaped) axis, also trending north to south. On the eastern side of the synclinal axis, the beds are shown dipping very steeply at 81° to the east.

Bedrock is overlain by glacial deposits recorded as glacial till (boulder clay) associated with the last glaciation affecting this area in Devensian time (10,000 years BP). However, within the floodplain of the Afon Dyfi valley there is a poor definition between the glacial deposits and the blanket cover of mixed alluvium associated with the river. In addition, the glacial deposits have frequently been modified by periglacial action and in places have been entirely removed by erosion. Typically, the glacial deposits comprise heterogeneous grey-brown clays, superficially weathered, to ochreous brown, with poorly sorted and locally derived gravel and boulders.

However the 1:10,000 scale geology map shows head deposits at the location of the tie-in at the northern end of the route.

Valley-fill and mixed alluvium of the floodplain include coarse to fine-grained gravels with impersistent interbedded sandy clays, clays and silts; see Photograph 11. River terrace deposits up to a few metres high are recorded elsewhere in the Dyfi valley and consist mainly of gravels; see Photograph 10. The flat tract of the floodplain is criss-crossed by historic river courses (palaeochannels) although these features have been greatly suppressed by successive cultivation.

Unusual deposits of alluvial fan materials and head occur on the north bank of the river and within the route corridor. Alluvial fans develop where a stream undergoes an abrupt change in gradient and, as a result, commonly lie at the confluence of tributary mountain streams with the main valleys. The alluvial fan materials consist mainly of crudely stratified debris, typically subangular to rounded pebbles and boulders with discontinuous lenses of gravelly and silty clay.

Patches of man-made ground are also present nearby. The largest patch of made ground surrounds Machynlleth railway station. However, smaller patches also exist in the vicinity of more recent engineering activities associated with the construction of the National Cycle Network route.

The drillers log for rotary borehole BH21 on the upper north bank (see Figure 2) provided the following description for the depth interval from ground surface to 8.80m – “Made ground of grey-brown clayey gravel”. However, this supposed area of made ground may actually correspond to the alluvial fan materials and head previously referred to above.

Within the proposed construction corridor there are no known areas of instability or landslides apart from those associated with normal erosion taking place along the river banks (see Photograph 13). No effects on the proposed development are anticipated.

The nearest significant fault is the Pennal Fault which runs east-west through the valley some 500m to the south of the river. It is a sub-vertical normal fault and downthrows some 150-200m to the north. No effects on the proposed development are anticipated.

The BGS have supplied the following estimated soil chemistry for the site:

- Arsenic 15 to 25mg/kg.
- Cadmium <1.8mg/kg.
- Chromium 60-90mg/kg.

- Lead <150mg/kg.
- Nickel 15-30mg/kg.

4.3 Hydrology & hydrogeology

National Resources Wales (NRW) classifies the Afon Dyfi (River Dyfi) as a 'Main River'. It is fast-flowing and meanders within the floodplain limits of approximately 1km in width. It generally flows in a south-westerly direction to the coast where it enters Cardigan Bay. The EnviroCheck Report records that it has a General Quality Assessment (GQA) Grade: River Quality A.

The superficial deposits are classified as Secondary A aquifers and the bedrock is classified as a Secondary B aquifer. Secondary A aquifers are described as permeable layers supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers. Secondary B aquifers are predominately lower permeability layers which may store and yield limited amount of groundwater due to localised features such as fissures, thin permeable horizons and weathering.

In the vicinity of the existing bridge, previous hydrological studies conducted in 2001, which can be found in the Options and Development Report (2010), indicate a 1 in 2 year flood event would result in the overtopping of the trunk road. At the bridge, the typical level of the Afon Dyfi ranges from 0.82mAOD to 2.08mAOD. Blocked drains and blocked drainage ditches combined with a low road vertical alignment has caused a persistent problem with flooding at the A487 Heol-y-Doll Rail Bridge (NG: SH 74418 01290), approximately 50m south of the southern end of the proposed development. To solve this problem, active consideration is being given to the construction of a pumping station. Significant implications exist for the highway drainage arising from the proposed development and in particular the position of outfalls.

The groundwater vulnerability map in the EnviroCheck report indicates the soil on site has a high leaching potential (H1) –soils which readily transmit liquid discharges because they are either shallow, or susceptible to rapid by-pass flow directly to rock, gravel or groundwater.

4.4 Geomorphology

The upper reaches and catchment area of the Dyfi drains from the Aran Mountains and the channel is generally entrenched downstream within gravel and rock bed with little floodplain sedimentation. In the middle reaches, the valley broadens progressively towards the estuary. Here, the valley bottom contains an accumulation of mixed sediments within which three main terraces have been distinguished. The floodplain consists predominantly of sands and gravels from the mobile channel with alluvial silt and clay overburden, with evidence of extensive floodplain reworking. The lower reaches of the Afon Dyfi broaden out into the Dyfi estuary.

The proposed development lies in the middle reaches of the Dyfi with the active channel and the flat floodplain being the most important features. During the walkover survey no evidence was found of the river terrace levels and little indication of former channel alignments (palaeochannels) were observed. Surface indications including reedy marsh, ponds and patches of wet ground are strong proof of the existence of these palaeochannels which are understood to have become obscured over time. However a review of the aerial photographs did reveal some evidence of the palaeochannels; see Section 4.6.2.

4.5 Man-made features

The existing Dyfi Bridge is a Grade II listed road bridge. It was built in 1533, repaired in 1681 and rebuilt in 1805. It is a 5-arch rubble bridge, featuring rounded arches with arch rings, voussoirs, thin pilaster buttresses between each arch and very low pointed cutwaters. Modern reinforcements have also been added and numerous repairs are evident (see Photograph 19).

The bridge has been repeatedly damaged over the years by vehicle impacts leading to lengthy closures for repairs. Closures have also been triggered by flooding. These closures have been problematic as alternative routes to cross River Dyfi involve long detours.

The old bridge has been the scene of a civil war battle in November 1644 between Cromwell's Army under Thomas Myddleton of Chirk and the Royalists. Hence there is the potential for archaeological interest in the area.

Within the development corridor the only recent development is the Welsh Millennium Bridge, a cable-stayed bridge over the Afon Dyfi, now part of the Dyfi Cycleway which in turn forms part of the National CycleNetwork. Opened in 2001, the new footbridge and cyclebridge is built on the site of the former Corris Railway bridge. Information regarding the construction of the foundations of the bridge has been requested from Powys Council. However no information has been received at the time of writing this report.

Information has been requested from Powys Council regarding the retaining structure supporting the existing A487 at the northern end of the scheme. No information has been received to date. However, when the information becomes available the report will be updated accordingly.

Natural Resources Wales operates a flow measurement station, approximately midway between the construction corridor and the existing Pont-ar-Dyfi Bridge.

4.6 Historical development

The site history has been reviewed from 1:2,500 and 1:10,000 historical maps purchased with the EnviroCheck report, dated from 1888 to 1995, and historic aerial photographs viewed at the Welsh Government archives, dated from 1946 to 1997.

4.6.1 Historic Maps

The 1:2,500 historical maps have been collected and are provided in Figure 5A to 5E. A summary of the findings of the aerial photographs view is included together with the site walkover findings in Figure 4.

The 1888/89 OS plan shows the study area to comprise predominantly fields; see Figure 5A. To the south west corner of the study area, a road is shown running from Machynlleth in the south to Dovey Bridge in the north along a similar alignment to the A487 today. A drain is shown on the eastern edge of the road. A track is present running in an eastern direction, which joins the main road at around Ch. 0+200m. To the south of the study area, the Machynlleth Railway Station and associated tracks are in place generally orientated in an eastern direction. Review of the Coflein database indicates that the station was constructed in 1863.

From the station, a single rail track runs in a north-easterly direction, crosses the river and is then in cutting until it is under the proposed alignment at around Ch. 1+090m. The Coflein database indicates this is the Corris narrow gauge railway which was constructed in 1889 and was on 500m-long embankment. To the north east of the study area, River Dovey runs in an east to west direction, with a footpath present on the southern bank. Shingle bars are present on the southern edge of the meander (Ch. 0+870m) and also in the centre of the river (Ch. 0+900m). Between Ch. 0+925m and Ch. 1+000m, the proposed alignment crosses fields. At Ch. 1+000m, it ties into the main road with the single track railway line running along the south-eastern side of the road. A county boundary crosses the site at around Ch. 0+480m. Spot levels record a ground level of 23.7ftOD at Ch. 0+200m, and 53ftOD around Ch. 1+000m. Quarries are shown to the south of the railway station and also to the north of Dovey Bridge.

There are no significant changes to the site by 1901; see Figure 5B. Two of the ponds in the south west of the site have been backfilled and a small rectangular water structure has been built to the north of the remaining pond. The shingle bars in the river now from around Ch. 0+880m to Ch. 0+930m have changed position indicating some changes in the river course. The fields at the north of the study area (Ch. 0+950m) are shown to be rough grassland. On the 1:10,000 scale OS plan the branch of the railway heading north east is shown as the Corris Railway.

There were no significant changes to the site between 1902 and 1974, by which time the Corris Railway had been dismantled; see Figure 5C, though there was still some evidence of its alignment on site. The historical plans for 1974 to 1975 show River Dovey to have cut into the northern bank at around Ch. 0+920m, increasing the width of the river. The shingle bars are also no longer shown, though they were visible during the site walkover. A flood bund, approximately 220m long, had been constructed along the southern bank of the river. The main road has been labelled A487. Along this road, spot levels of 7.3mOD and 15.8mOD are indicated in the southern and the northern end of the study area. The northern bank of the river is now shown as being wooded.

There were no significant changes to the site by 1987; see Figure 5D.

By 1995, the railway sidings north of the existing railway lines at the southern end of the site has been removed and the area is occupied by a garden centre and a garage; see Figure 5E. A large pond was also present at the eastern end of the flood bund at approximately Ch. 0+780m to Ch. 0+800m. The shingle bars are on the southern edge of the River Dovey, causing narrowing of the channel at this point (Ch. 0+880). There were no other significant changes to the site.

4.6.2 Aerial photographs

A study of recent aerial photographs for the proposed development revealed several geomorphological features of interest along the present river channel including gravel bars and eroding banks. In addition, several short curvilinear patterns were noted on the surface of the floodplain that could indicate the presence of buried channels (palaeochannels) beneath the floodplain. One such pattern correlates with a patch of wet ground identified during the walkover at Ch. 0+780m (see Figure 4).

Review of the aerial photographs from the Welsh Government archives further confirms the presence of palaeochannels. In particular, depressions in the ground are visible crossing the proposed alignment between Ch. 0+650m and 0+680m in 1946, 1952 and 1963. An area at lower elevation is also visible between 0+750m and 0+820m understood to correspond to an area flooded on a regular basis since 1953. The possible extents of an historical pond are present approximately 50m east of the Ch. 0+630m in 1946.

4.7 Potential geo-environmental and contamination issues

There are no known records of contaminated land within the proposed development corridor. However, it should be noted that the alignment of the former narrow-gauge Corris Railway follows an approximate line running from the Millennium Cycle Bridge in a south-western direction towards the Dyfi Eco Park Industrial Estate which lies immediately to the north of Machynlleth railway station. Due to the age of the steam railway, any potential contamination is likely to be ash and clinker.

The EnviroCheck Report has recorded the following additional information:

- There are two discharge consents within 250m of the site, the closest being 41m to the SW.
- There is one local authority pollution prevention and control 181m to the SW of the site.
- There has been one pollution incident into controlled waters 123m to the SW of site in October 1994.
- There has been one substantiated pollution incident registered 466m to the SW of site.

- There are two water abstractions within 1km of site, the closest being 771m to the NE.
- There is one historical landfill site within 1km of the site, the closest being 493m to the SW.
- There is a licensed waste management facility in the old station yard to the SW.
- There is a local authority recorded landfill site 493m to the SW.
- There are twenty three contemporary trade directory entries within 1km of the site, the closest active site being Dovey Auto Craft, garage services to the SW near to the railway station.

4.8 Mine related features

There are no known records of former mining activity within or in the immediate vicinity of the proposed development. No surface indication of mining operations have been noted during the site walkover survey.

The 1:10,000 scale geology map shows an adit, some 750m to the south of the site, trending in a southerly direction away from the site.

This is further confirmed by the review of the EnviroCheck report which findings are discussed report that there are seven BGS recorded mineral sites within 500m of the study area; all of them have ceased in operation. The closest is located 180m to the south.

The Coal Authority online viewer indicates that the site is not within a coal mining area. A shaft is indicated in the town of Machynlleth approximately 1km to the south of the scheme. Due to the distance, it is not deemed to be of concern.

5 Ground conditions

5.1 Previous Site Investigation

A site investigation was undertaken by CJ Associates in 2001. It comprised fifteen cable percussive boreholes to depths of between 9.50m and 26.10m, five of which were extended by rotary coring to depths of between 18.80m and 29.00m. Six rotary boreholes were drilled to depths of between 1.85m and 15.50m. A total of seventeen trial pits were excavated to depths of between 0.50m and 3.00m. The exploratory holes were not surveyed as part of the investigation work, therefore, accurate positions and levels are not available. Approximate exploratory hole locations, determined by overlaying plans, are shown on Figure 2 and the depths summarised in Table 1 below.

Table 1. Summary of previous exploratory holes

Cable percussive holes	Depth (m)	Rotary coring holes	Depth (m)	Trial Pits	Depth (m)
BH1	15.50			TP1	3.00
BH2	20.05			TP2	3.00
BH3	16.50			TP3	3.00
BH4	15.95			TP4	3.00
BH5	15.95			TP5	2.40
BH6	15.95			TP6	2.40
BH7	15.95			TP7	2.80
BH8	24.15	Extended	27.00	TP8	1.80
BH9	26.10	Extended	29.00	TP9	2.10
		BH10	4.50	TP10	2.70
		BH12	1.85	TP12	3.00
		BH13	4.30	TP13	1.80
BH14	16.45			TP14	2.20
BH15	16.45			TP15	2.60
BH16	20.45			TP16	3.00
BH17	21.95	Extended	25.90	TP17	2.40
BH18	20.50	Extended	22.90	TP18	0.50
BH19	9.50	Extended	18.80		
		BH20	11.20		
		BH21	15.50		
		BH22	12.00		

Boreholes BH3, BH4, BH5, BH6, BH7 and BH16 are located between Ch. 0+280m and Ch. 0+780m and no bedrock was encountered. Boreholes BH17, BH18 and BH19 are situated between Ch. 0+790m and the southern bank of River

Dyfi at Ch. 0+880m. These boreholes generally encountered rock at approximately 21m depth, with the exception of BH19, located on the gravel bank, which encountered rock at 15.60m depth indicating that the rockhead is rising to the north. Boreholes BH20, BH21 and BH22 were all located on the northern bank of the River Dyfi, between Ch. 0+920m and Ch. 0+980m. These encountered rockhead between 6.5m and 10.5m depth.

The BGS database has been reviewed and no further borehole logs were available for the area.

Enquiries have been made to obtain any available site investigation information for the National Resource Wales monitoring station and the Millennium Footbridge. However, no further information has been received at the time of writing this report.

5.2 Anticipated Ground Conditions

Based on the findings of the walkover survey discussed in Section 3 and the previous site investigation, the ground conditions anticipated are as follows:

- Cohesive Alluvial Deposits overlying
- Granular Alluvial Deposits overlying
- Bedrock

Glacial deposits have not been recorded on exploratory hole logs from previous site investigations, although interpreted to be present from the geological plans and the borehole records. It is interpreted that the granular deposits that are present typically from depths of between 2m and 4m are glacial in origin. It is noted that there is poor definition between these glacial deposits and the blanket cover of mixed alluvium within the Dyfi valley. Furthermore, the glacial deposits have frequently been modified by periglacial action. It is therefore possible that although glacial deposits have not been recorded on exploratory hole logs from previous investigations, the superficial deposits below the upper depths of alluvium may be glacial in origin, but have not been logged accordingly. The relatively high SPTs within the lower depths, commencing from 2m to 4m, correspond to this possibility.

The following sections describe the different stratigraphy in more detail.

It should be noted that the previous investigations were undertaken prior to the adoption of Eurocode 7, hence the descriptions are in accordance with BS5930. All SPT “N” values reported are uncorrected.

5.2.1 Cohesive Alluvial Deposits

The cohesive alluvial deposits generally comprised soft and soft to firm, grey brown, silty clay. These deposits were up to 3m deep and were generally encountered in exploratory holes across the floodplain.

SPT "N" values of less than 8 were recorded in the boreholes. This is consistent with the hand shear vane tests undertaken in the trial pits which recorded undrained shear strengths in the range of 20kPa to 58kPa, with an average value of 37kPa, and the undrained triaxial tests which recorded values of 12kPa to 48kPa, with an average value of 23kPa.

One dimensional consolidation tests were also undertaken. These recorded typical values of coefficient of volume change (m_v) of 0.35m^2/MN for stress changes of 40kN/m^2, and corresponding values of coefficient of consolidation (c_v) of around 4m^2/yr. For a stress change of 120kN/m^2, an mv value of 0.12m^2/MN and a c_v value of 17m^2/yr were recorded.

CBR values of 0.5% and 1% were recorded in the trial pits.

5.2.2 Granular Alluvial Deposits

The granular alluvial deposits generally comprised medium dense, grey, gravels with variable amounts of clay, silt and sand. Cobbles and boulders were also recorded in varying proportions. BH4 recorded quartz cobbles between 13.50m and 13.80m depth.

SPT 'N' values in the range of 16 to 42 were recorded in the boreholes, with typical values of 25 increasing to 40 with depth, confirming a typical medium dense consistency.

There was very little testing undertaken on the granular deposits, however CBR values of greater than 10% were recorded in the trial pits.

5.2.3 Bedrock

The bedrock generally comprised moderately strong to strong, grey, slightly weathered siltstone (turbiditic mudstone).

Between Ch. 0+580m and Ch. 0+800m, bedrock was encountered at depths of 23.70m in BH8, 25.80m in BH9, 21.70m in BH17, 20.40m in BH18 and 15.60m in BH19. On the northern bank, it was encountered in six boreholes at depths of 0.50m in BH10 in the west, 0.60m in BH12, 0.30m in BH13, 6.80m in BH20, 10.10m in BH21 and 7.40m in BH22, located in the east – close to the proposed road alignment. The bedrock then outcrops in a roadside cutting on the A487 a short distance to the north.

Very poor core recoveries were recorded on the borehole logs. However, the accompanying photographs show very good total core recovery, but with low solid core recovery (SCR) and RQDs due to the vertical discontinuities of the rock; see photograph 18. No laboratory testing was undertaken on the rock.

5.2.4 Groundwater

Groundwater was generally encountered in exploratory holes upon reaching the granular gravel deposits. However, the water table is anticipated to be shallow and in certain places at or near ground level for at least part of the year. In addition, the bulk of the route corridor is considered likely to suffer inundation at ground level, due to regular flooding.

6 Preliminary engineering assessment

6.1 Structure foundations

The preliminary design for the structure comprises 20 spans, predominantly of 34m length for the main viaduct, with a larger 73m span for the river crossing, and a 50m backspan to the southwest; see Figure 3. The piers and abutments are proposed to be supported on piles. The approach embankment in the south will be less than 5m in height, over significant depths of soft alluvium.

Based on the review of ground conditions, the piles are anticipated to be either friction piles or, where the rockhead is at shallow depth, rock socketed. In areas where the piles are to be socketed, the base of the pile will need to penetrate rock to develop sufficient capacity. It is anticipated at this stage that a 3m to 4m rock socket will be required to withstand the expected pile loads.

The viaduct piers are proposed in a ladder pier arrangement with two columns. The current foundation proposal is to support each pier column with a large diameter mono-pile, eradicating the need for construction of pile caps within the floodplain. For piers where higher loads are applicable, such as the river crossing and backspan, and where greater lateral loads will be applied at the abutments, pile groups are proposed. For these locations smaller diameter mini pile groups with pile caps are anticipated.

The large diameter mono-piles currently under consideration are up to 1500mm in diameter, with smaller diameter piles of around 750mm under consideration where pile groups are required. It is anticipated that the larger diameter piles will be installed using bored techniques, and the smaller diameter piles using CFA techniques. It should be noted that CFA techniques may not be suitable if a rock socket is required.

Whilst access and space for the rigs is not an issue, there are a number of overhead cables which would need to be considered. In addition, between Ch. 0+280m and Ch. 0+880m, the ground conditions comprise up to 3m of soft clay overlying granular deposits, hence the construction of a piling mat and temporary access routes between the pile positions would need to be considered carefully.

The effect of the loadings from a piling rig on the stability of the slope above the river at Ch. 0+940m would need to be considered carefully.

The arisings from the piles would predominantly consist of granular deposits, and could potentially be used for the construction of the approach embankment. However, for CFA piles, the arisings from the bottom of the auger would contain concrete and would therefore not be suitable for use as embankment fill, and would require off-site disposal.

The control of groundwater during the piling operations would need to be considered due to the proximity of the River Dyfi, classified as ‘Grade A’ by NRW.

Based on the above, the main considerations to be addressed to enable development of the foundation design for the viaduct and river crossing will include the following:

- An understanding of the strength and stiffness parameters of the soils over the full lengths of the proposed piles, with particular consideration of the softer material associated with the palaeochannels
- The depth to bedrock at the various foundation locations
- The strength and stiffness parameters of the bedrock, at locations where piles will extend into the rock

6.2 Embankments

The approach embankment in the south will rise to approximately 5m in height at around Ch. 0+210m. The previous site investigation has indicated that there is up to 3m of soft clay within the floodplain, which could result in large settlements. There are a number of options which could be considered to address the potential effects which are discussed below.

1. The design could allow the embankment to settle in a controlled manner that is acceptable to the temporary works and finished road construction. This could comprise programming construction of the embankment early on so that residual settlements are acceptably small by the time of the proposed thrust launching work for the decks of the viaduct, and subsequent construction of highway drainage and road surfacing. However, a considerably time may be required after construction for completion of sufficient settlement to make this option viable. Stability of the embankment against potential bearing capacity failure would need to be considered, and it is possible that the embankment may need to be constructed in stages.
2. The soft deposits could be dug out and replaced with general fill. The depth of the soft material could be less than 3m in places, however this would need to be investigated further. One issue which would require careful consideration is whether potential groundwater ingress would be practical to manage for this option. If the groundwater level is high, and the surrounding and underlying soil is sufficiently permeable, pumping and dewatering may be required, and compaction of fill may prove difficult.
3. Ground improvement could be carried out for of the upper layer of softer soil. Options include mass improvement using a binder material intermixed with the existing soil, the use of vibro-stone columns / vibro concrete columns or an alternative form of ground improvement down to the stiffer granular deposits. For these options, the load could be spread across the improved formation through the use of geogrid reinforcement, to limit any residual differential settlements. Residual settlements would be low, hence reducing any risks associated with differential settlement of the embankment and at the interface with the viaduct structure.

4. A piled raft could be constructed from the existing ground surface, to reduce or eradicate total and differential settlements of the embankment.

In summary, for the earthworks embankment between Ch. 0+060m and Ch. 0+210m, the main consideration is settlement associated with the soft silty alluvium of the floodplain and selection of the most appropriate engineering response to the existing problem. The presence of palaeochannels associated with reworking of the floodplain may give rise to sudden and extreme variations within the soils present beneath the floodplain.

6.3 Highway Drainage

The use of soakaways is currently proposed for drainage of surface water run-off from the scheme. Discretely positioned soakaways would not be functional during periods when groundwater levels are high, which is frequently the case during periods of wet weather. Therefore, consideration should be given to the use of linear soakaway systems that lead to discharge points in existing drainage systems and watercourses. These would function as soakaways when groundwater levels are low, and as linear drains to the discharge points when groundwater levels are high and the surrounding ground is saturated.

Highway drainage measures will be required in relation to drainage outfall at the southern end of the scheme in order to avoid exacerbating flooding issues at A487 Heol-y-Doll Rail Bridge.

Where the proposed alignment joins the existing A487 in the south, any existing edge of road drainage will need to be culverted beneath the new embankment.

7 Comparison of project options and risks

The following list of geotechnical, geo-environmental, historical and other factors have been identified as being likely to influence the project:

- Soft silty alluvium on the floodplain with the potential to cause excessive settlements.
- Lateral variability of the ground conditions due to the possible presence of palaeochannels, with the potential to cause differential settlements.
- Variable depths from surface to bedrock, which will determine the choice of technique for the construction of the pier foundations.
- Proximity to the National Cycle Network Route No. 8 and Welsh Millennium Bridge.
- Steep slopes and unusual alluvial fan and head deposits on north bank.
- Water table anticipated to be shallow and in certain places at or near ground level for at least part of the year.
- Outfall arrangements for highway drainage at the southern extremity.

A Geotechnical Risk Register is presented in Appendix B, which assesses the risks of the primary hazards. The consequences of these risks to the project are determined, and details of how to manage the risks are given.

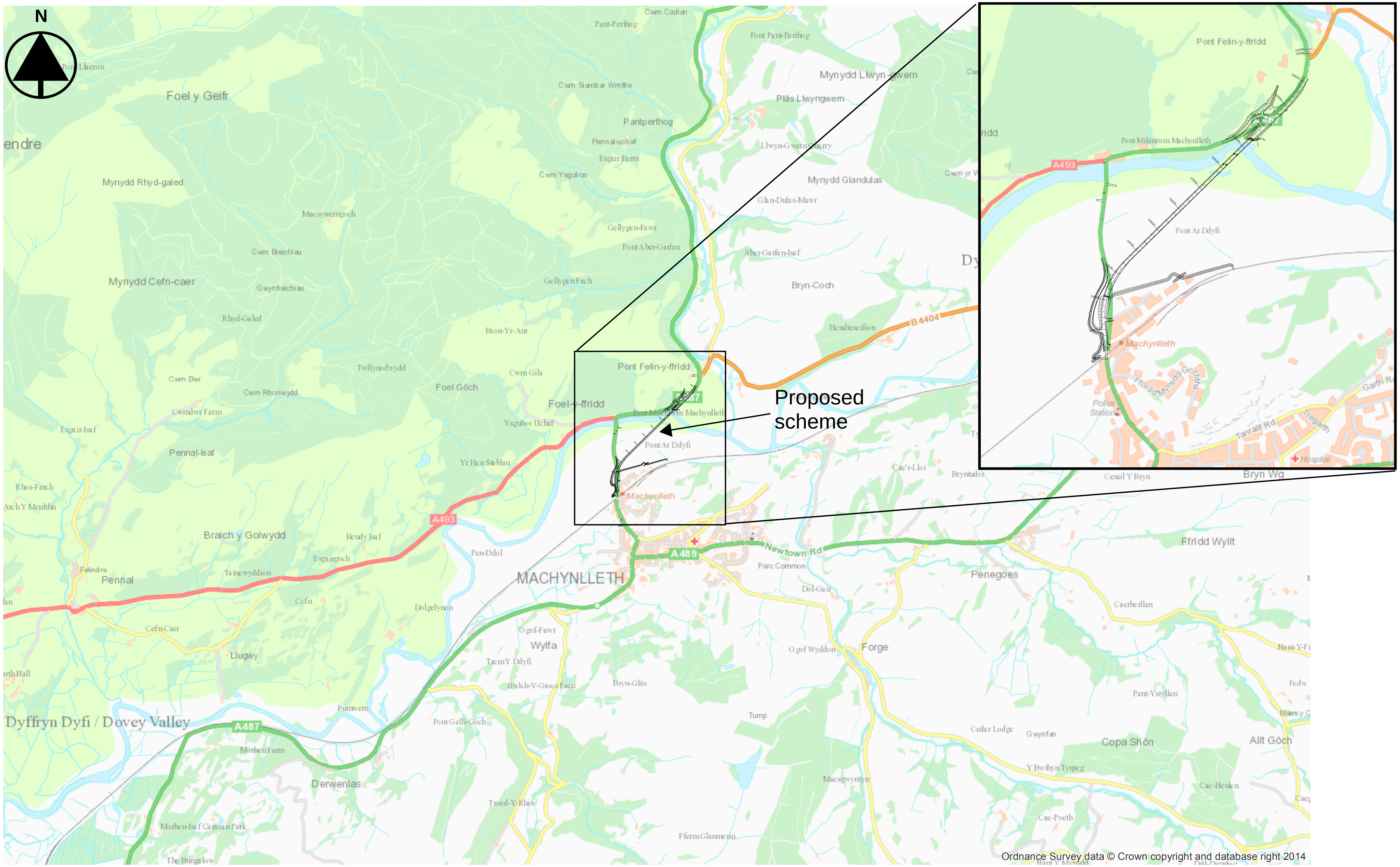
The Geotechnical Risk Register is a living document and will be updated as the scheme is progressed.

8 Drawings and photographs

No formal design drawings have been prepared at this stage. Figures have been prepared and are presented in this report.

Photographs of the site have been taken as part of the site walkover survey. These are presented in Appendix A.

Figures

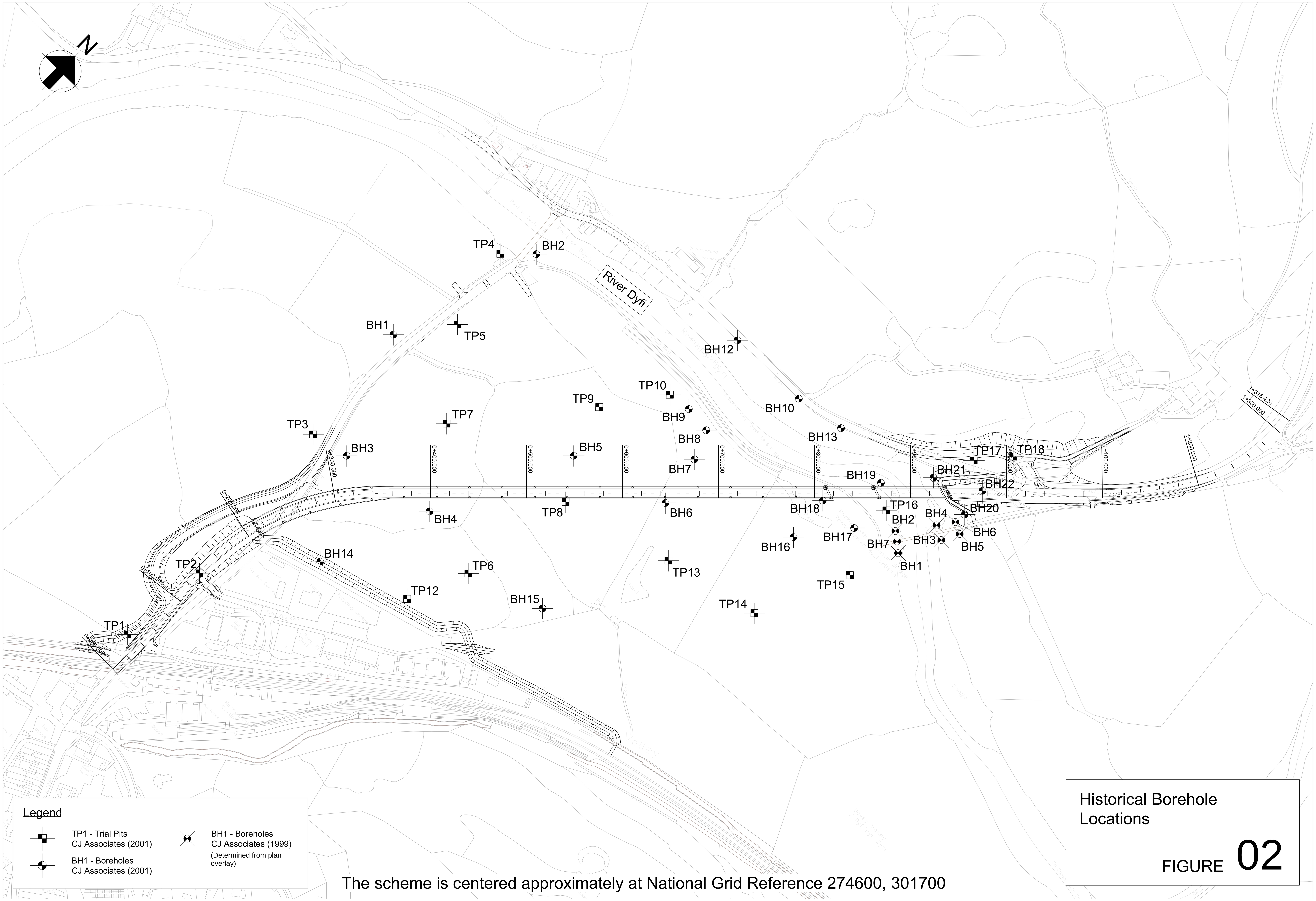


The scheme is centred approximately at National Grid Reference 274600, 301700

Site Location

244562

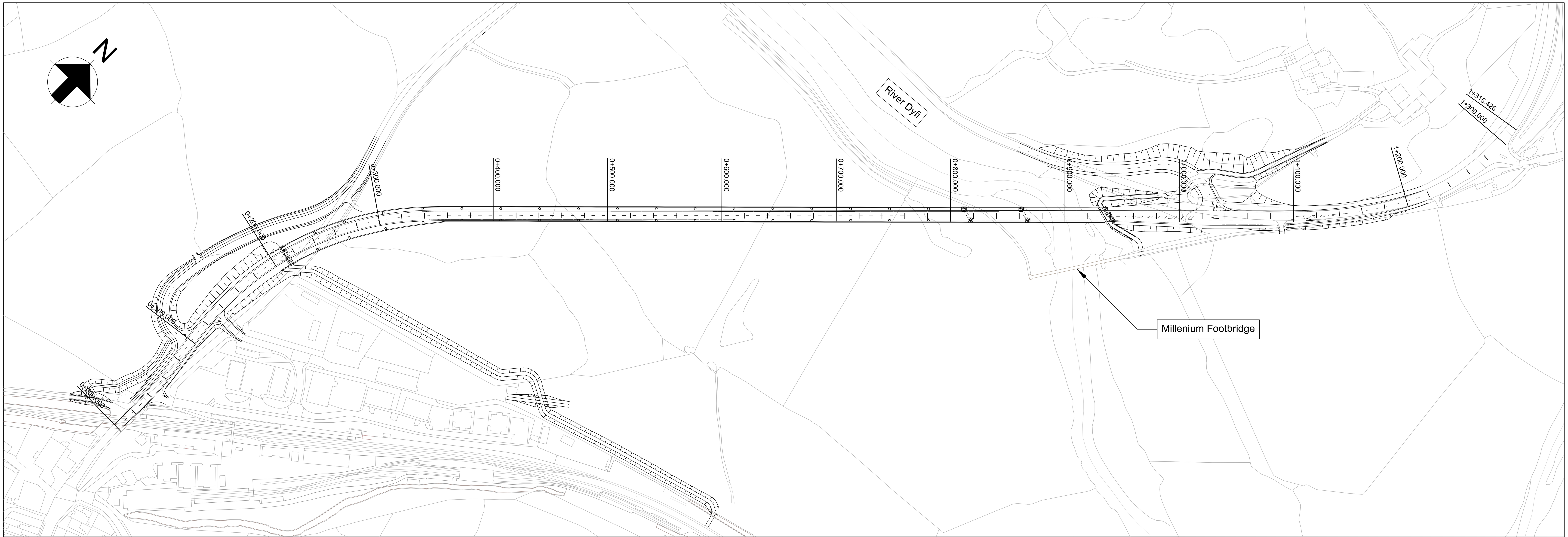
FIGURE **01**



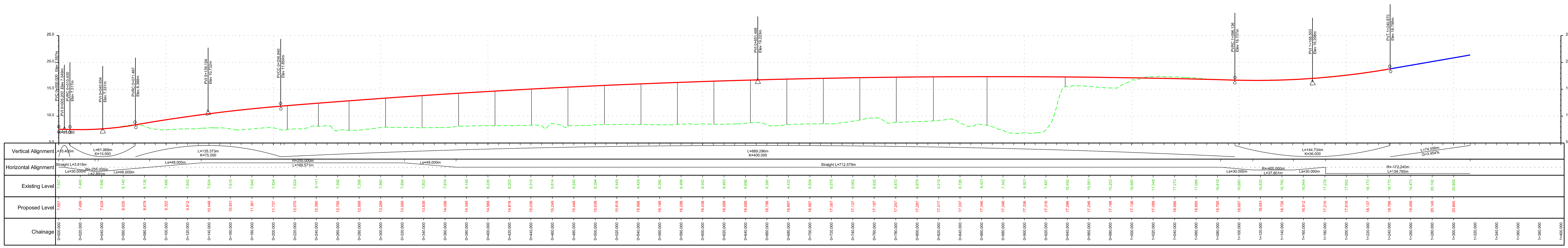
The scheme is centered approximately at National Grid Reference 274600, 301700

Historical Borehole Locations

FIGURE 02



The scheme is centered approximately at National Grid Reference 274600, 301700



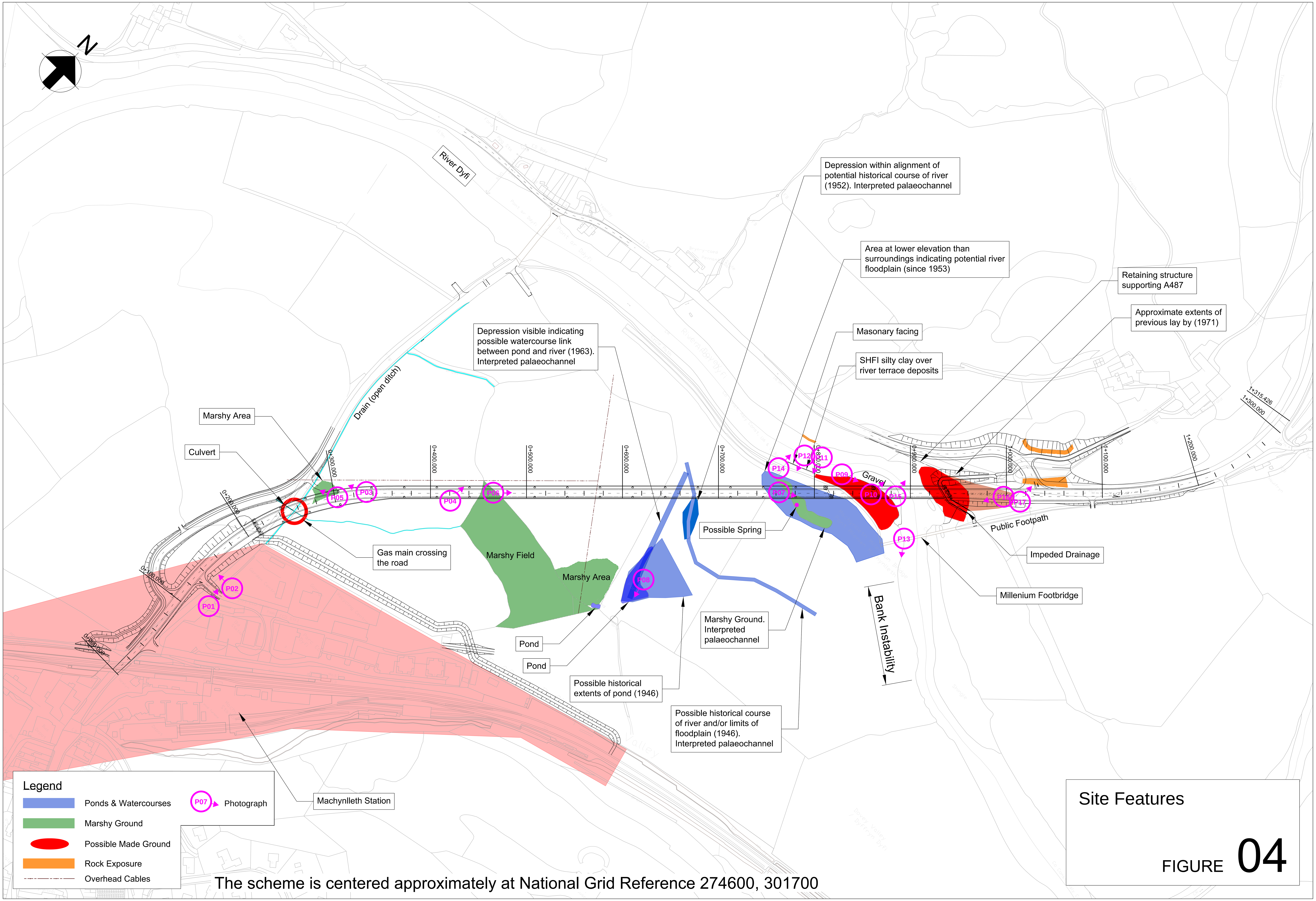
Profile Legend

Existing Ground Level

Proposed Ground Level

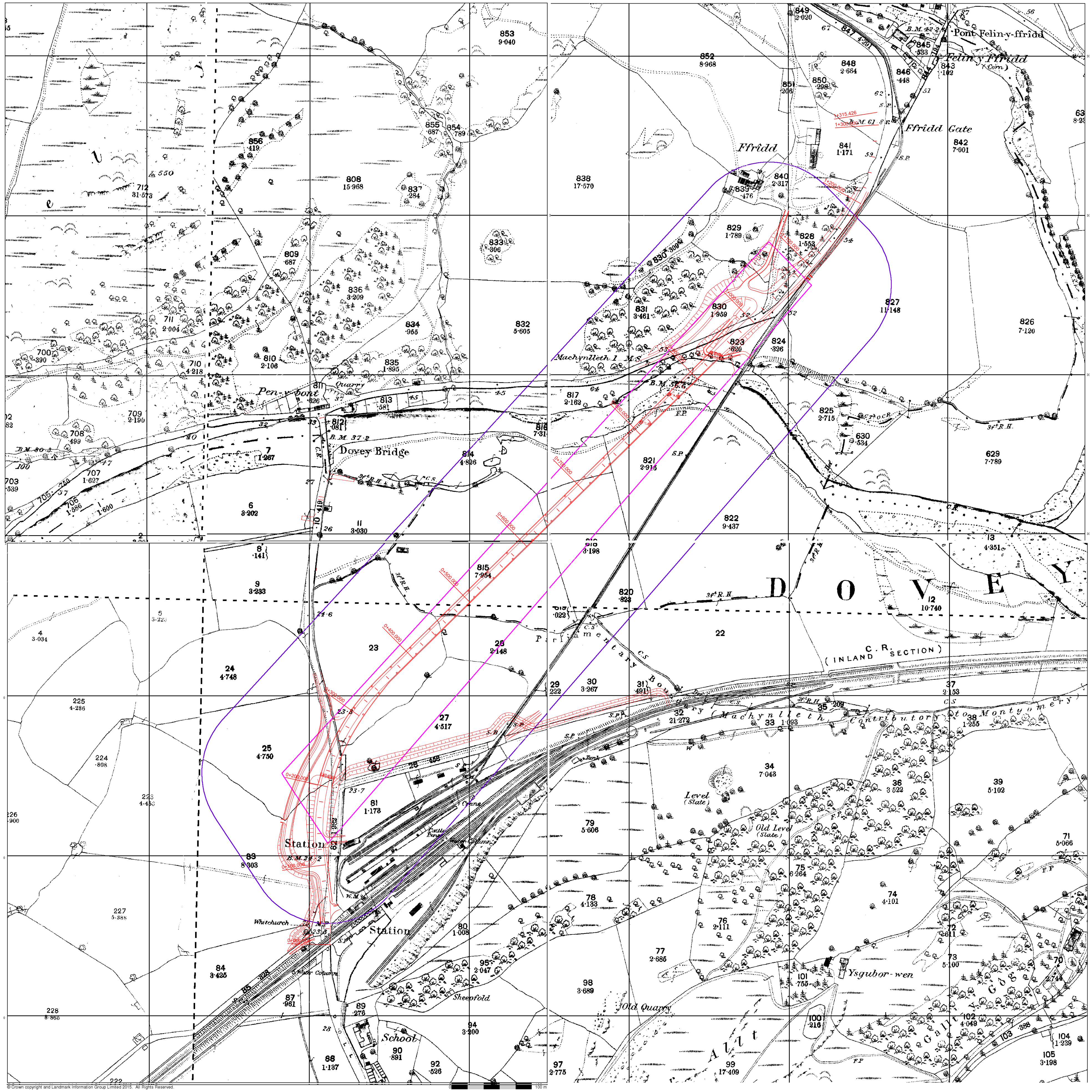
Proposed Scheme

FIGURE 03



N
River Dyfi
Drain (open ditch)
Depression within alignment of potential historical course of river (1952). Interpreted palaeochannel
Area at lower elevation than surroundings indicating potential river floodplain (since 1953)
Retaining structure supporting A487
Approximate extents of previous lay by (1971)
Masonary facing
SHFI silty clay over river terrace deposits
Depression visible indicating possible watercourse link between pond and river (1963). Interpreted palaeochannel
Marshy Area
Culvert
Gas main crossing the road
Marshy Field
Marshy Area
Pond
Pond
Possible historical extents of pond (1946)
Possible Spring
Marshy Ground. Interpreted palaeochannel
Possible historical course of river and/or limits of floodplain (1946). Interpreted palaeochannel
Bank Instability
Gravel
Public Footpath
Impeded Drainage
Millenium Footbridge
Machynlleth Station
P01
P02
P03
P04
P05
P06
P07
P08
P09
P10
P11
P12
P13
P14
P15
P16
P17
0+100.000
0+200.000
0+300.000
0+400.000
0+500.000
0+600.000
0+700.000
0+800.000
0+900.000
1+000.000
1+100.000
1+200.000
1+300.000
1+315.426
Legend
Ponds & Watercourses
Marshy Ground
Possible Made Ground
Rock Exposure
Overhead Cables
P07 Photograph
The scheme is centered approximately at National Grid Reference 274600, 301700
Site Features
FIGURE 04

The scheme is centred approximately at National Grid Reference 274600, 301700



N

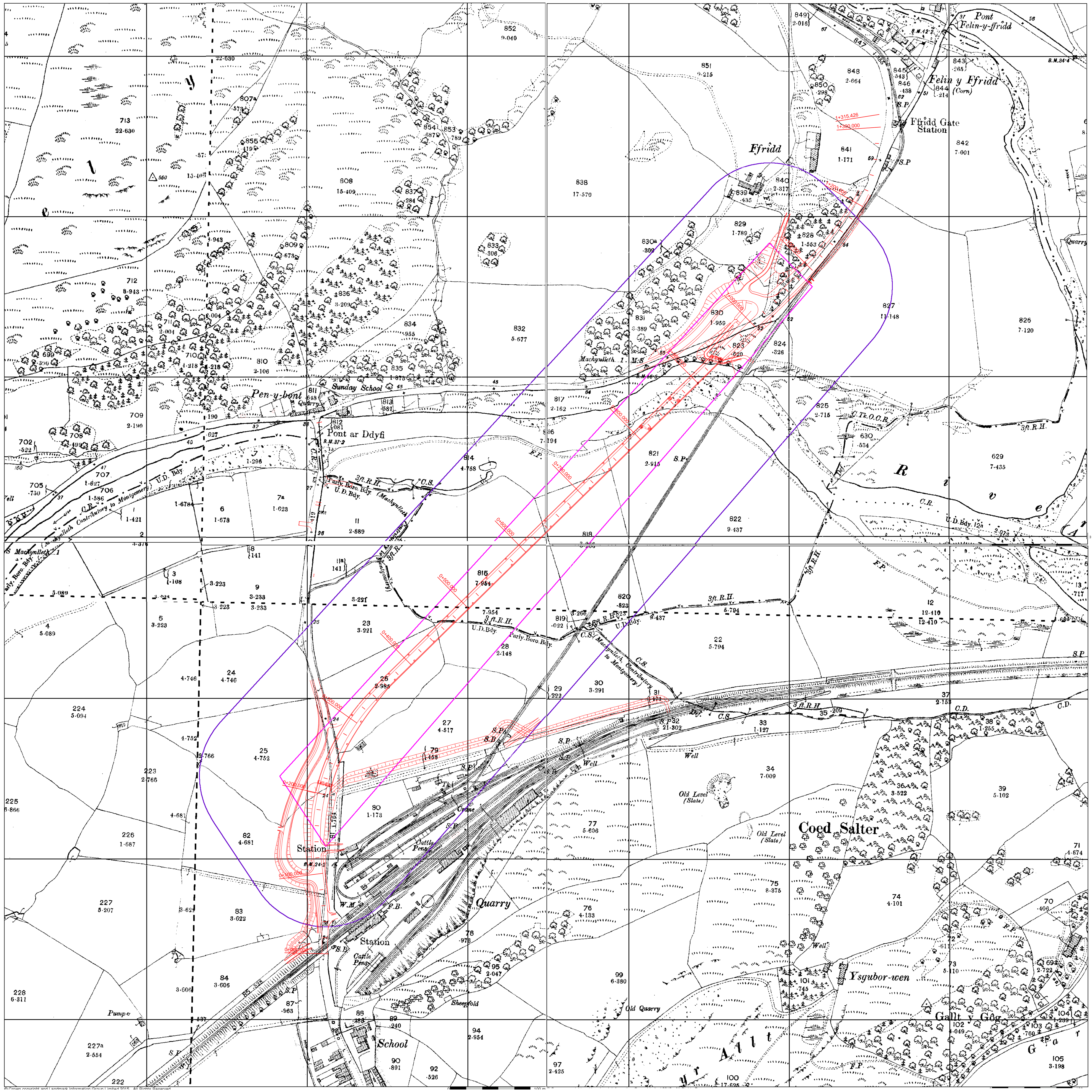
For full details of these extracts from historic OS plans, refer to the original master copies contained within the Landmark Envirocheck Report for the scheme.

Site History 1889 (not to scale)

244562

FIGURE 5A

The scheme is centred approximately at National Grid Reference 274600, 301700



N

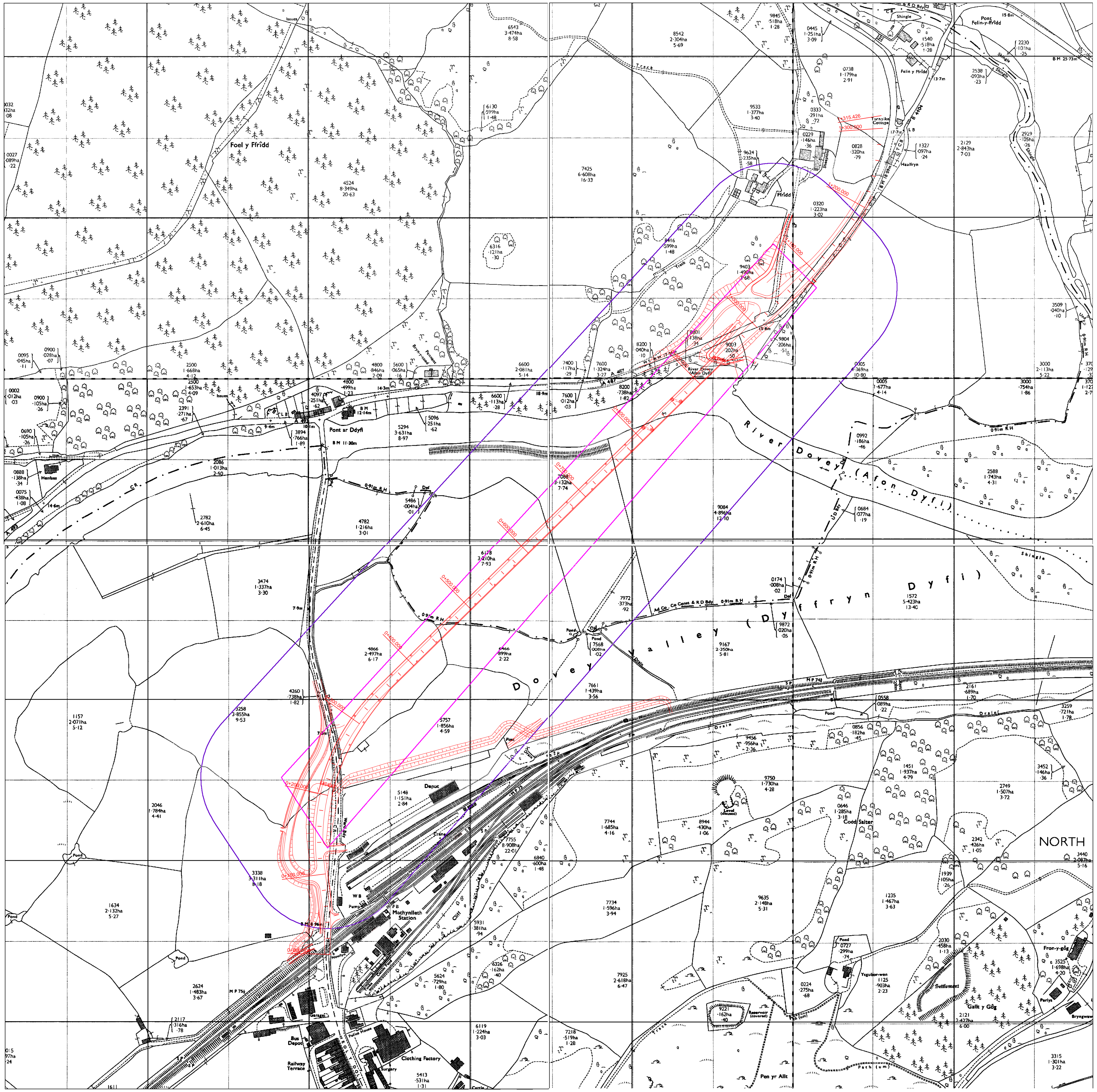
For full details of these extracts from historic OS plans, refer to the original master copies contained within the Landmark Envirocheck Report for the scheme.

Site History - 1901
(not to scale)

244562

FIGURE 5B

The scheme is centred approximately at National Grid Reference 274600, 301700



N

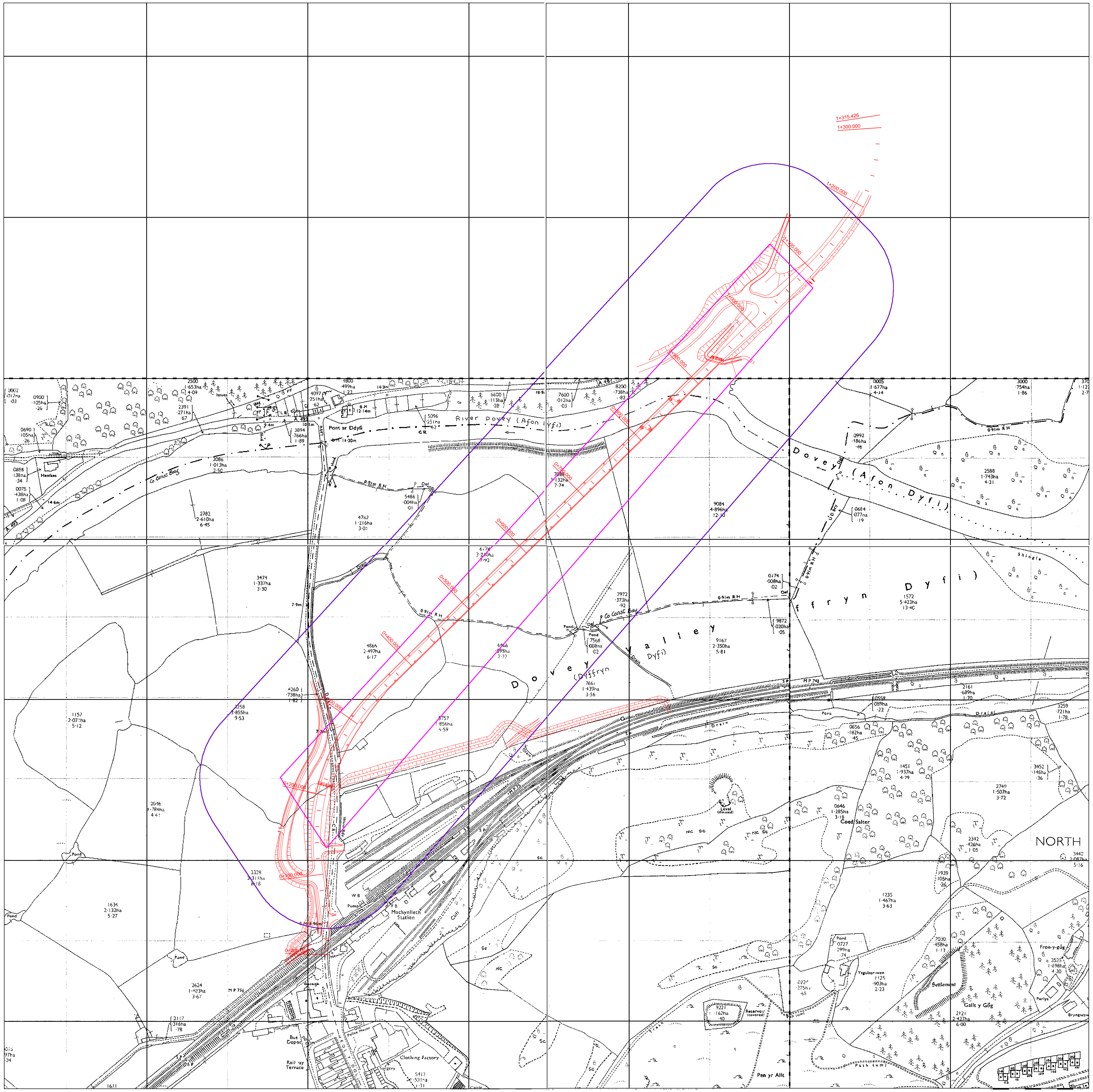
For full details of these extracts from historic OS plans, refer to the original master copies contained within the Landmark Envirocheck Report for the scheme.

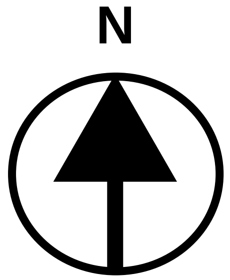
Site History - 1974/75 (not to scale)

244562

FIGURE 5C

The scheme is centred approximately at National Grid Reference 274600, 301700





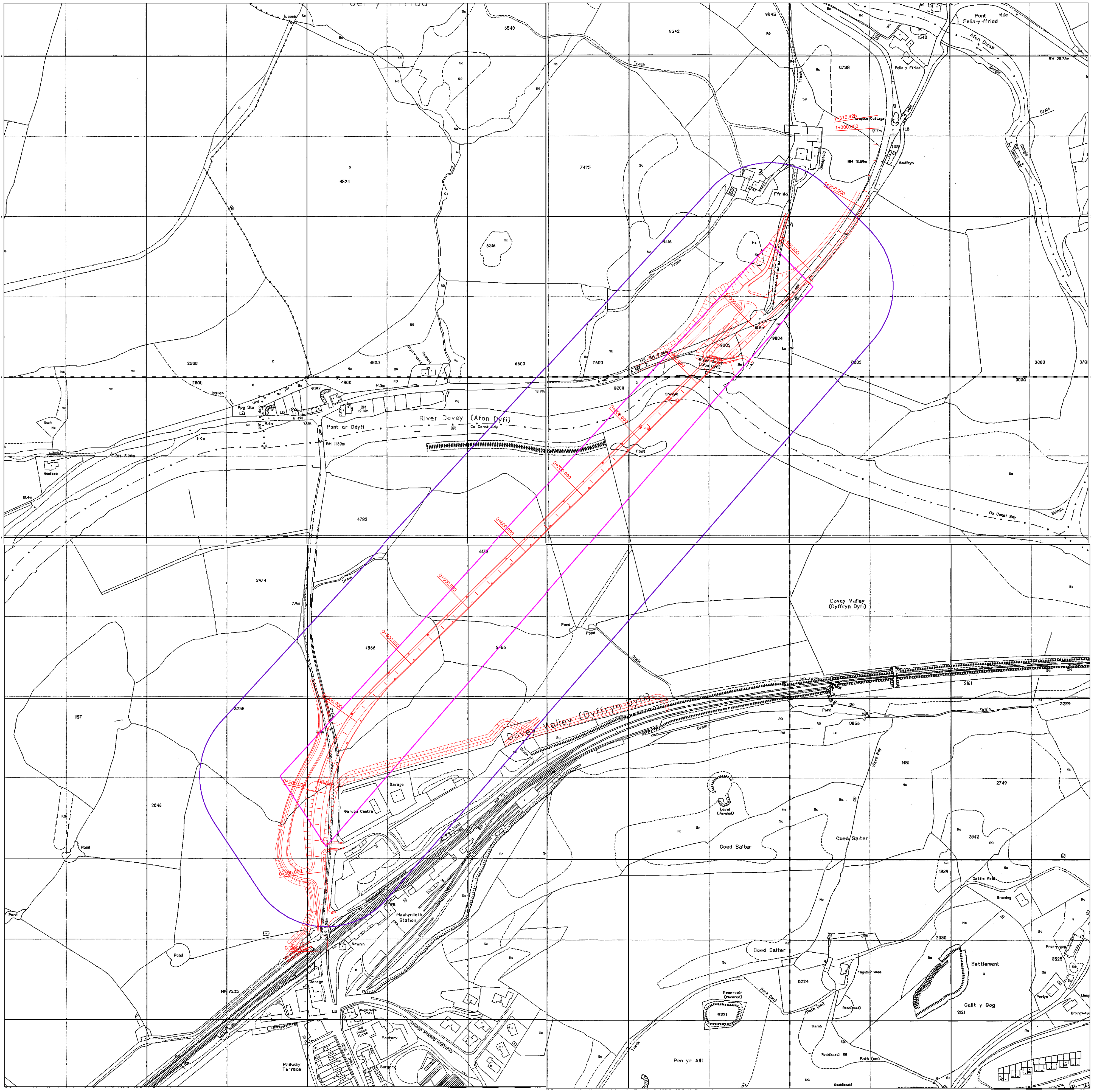
For full details of these extracts from historic OS plans, refer to the original master copies contained within the Landmark Envirocheck Report for the scheme.

Site History - 1987
(not to scale)

244562

FIGURE **5D**

The scheme is centred approximately at National Grid Reference 274600, 301700



N

For full details of these extracts from historic OS plans, refer to the original master copies contained within the Landmark Envirocheck Report for the scheme.

Site History - 1995
(not to scale)

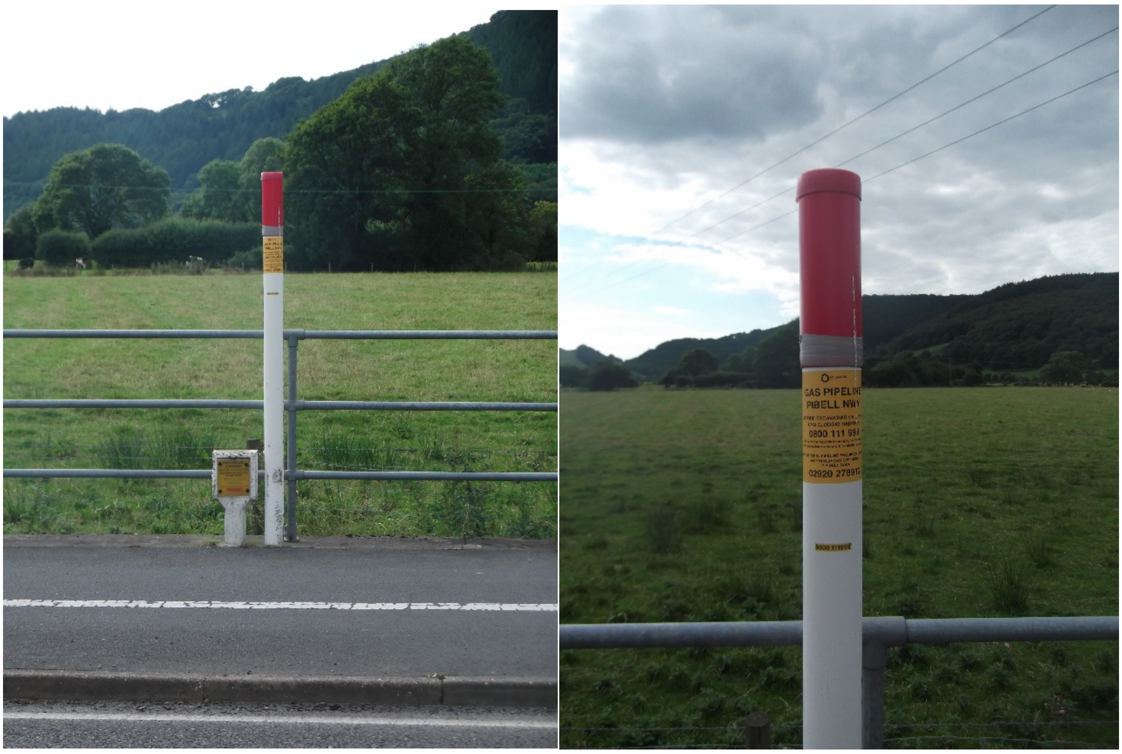
244562

FIGURE 5E

Appendix A

Site walkover survey photographs

Photograph 1 – Culvert passing under A487 at Ch. 0+250m



Photograph 2 – High pressure gas mains crossing the road.

Photograph 3 – Overhead power lines crossing A487

Photograph 4 – Ch. 0+420m looking north along the proposed alignment

Photograph 5 – Marshy ground at Ch. 0+290m, also showing overhead cables

Photograph 6 – Marshy field at Ch. 0+450m to Ch. 0+480m.

Photograph 7 – Marshy area between Ch. 0+765 to Ch. 0+795m, possible spring present.

Photograph 8 – Pond east of Ch. 0+620m

Photograph 9 – Uneven ground on the western side of the footpath at Ch. 0+830m to Ch. 0+830m

Photograph 10 – Gravel bank associated with River Dyfi

Photograph 11 – Exposure in the riverbank downstream of the alignment

Photograph 12 – Historic river edge protection works

Photograph 13 – Showing instability upstream of the Millennium Footbridge

Photograph 14 – Rock outcropping on the opposite bank at about Ch. 0+790m

Photograph 15 – Retaining structure supporting the existing A487

Photograph 16 – From Ch. 1+000m looking along the alignment towards Ch. 0+940m

Photograph 17 – Ch. 1+010m where the proposed alignment rejoins the existing A487

Photograph 18 – Vertical discontinuities in the rock cutting at around Ch. 1+100m

Photograph 19 – Showing repairs to existing Dyfi Bridge

Appendix B

Geotechnical Risk Register

HD22 Managing Geotechnical Risk: Geotechnical Risk Register for A487 New Dyfi Bridge – Rev B

Probability (P)	
1 in 10	5
1 in 100	4
1 in 1000	3
1 in 10000	2
1 in 100000	1

Impact (I)		Time	Cost
Very High	5	>10 weeks on completion	>20%
High	4	> 1 week on completion	5-20%
Medium	3	>4 weeks: < 1 week on completion	2-5%
Low	2	1-4 weeks: none on completion	0.5-2%
Very Low	1	< 1 week to activity: none on completion	<0.5%

Risk rating (R) = Probability (P) x Impact (I)

		I	I	I	I	I
		5	4	3	2	1
P	5	25	20	15	10	5
P	4	20	16	12	8	4
P	3	15	12	9	6	3
P	2	10	8	6	4	2
P	1	5	4	3	2	1

Risk ratings	
1 to 4	***Trivial***, but no action required
5 to 8	***Tolerable***, but must consider solutions or improvements
9 to 12	***Substantial*** and work must not start until risk has been reduced
13+	***Intolerable*** and work must not start until risk has been reduced

Geotechnical Risk Assessment

Item	Hazard	Risk	Construction Stage			Consequences	Mitigation	Following Mitigation Stage		
			Probability	Impact	Risk Rating			Probability	Impact	Risk Rating
1.	**Flooding**	High rainfall and rainstorms	5	3	15	Programme delay Cost impact	Proposed design for the majority of viaduct piers comprises a monopile for each pier column, hence, removing the need for construction of a pile cap in the flood plain. Installation of the viaduct deck will be through thrust launching from the southern embankment, rather than craning from the flood plain. Due consideration given to the prevailing ground and weather conditions when scheduling site works. Monitoring of rainfall and weather forecasts. Contingency plans for wet weather working.	5	2	10
2.	**Landslide of north bank due to construction works**	Concentrated loads placed at top of slope or on marginally stable ground	5	5	25	Rapid ground movements H&S risk to site workers Additional construction work Cost impact	(5.0m of poorly compacted made ground on the northern bank is interpreted from preliminary ground investigation) Consider location of north abutment to minimise effect on the stability of the slope during construction. Consider digging out a few meters of the top of the slope to create the rig working platform. This would reduce the overall height of the slope and will push back the position of the working platform away from the crest of the slope. Potential to restrict construction works so that loading of slopes is limited during the construction works. Possible slope inspections / monitoring during the construction works.	4	2	8

Item	Hazard	Risk	Construction Stage			Consequences	Mitigation	Following Mitigation Stage		
			Probability	Impact	Risk Rating			Probability	Impact	Risk Rating
3.	**Landslide of north bank due to loss of toe support to slope**	Removal of toe support to slopes Erosion of toe of slope	3	3	9	Slow ground movements H&S risk to road users Future performance Potential for additional future maintenance	(5.0m of poorly compacted made ground on the northern bank is interpreted from preliminary ground investigation) Position and structural form of the north abutment to accommodate potential ground loss if no slope stabilisation measures are incorporated. Slope stabilisation measures or replacement of the potentially unstable made ground, if required. Suitable temporary surface water management and drainage measures.	3	2	6
4.	**Long term instability of north bank**	Steep slopes	3	4	12	Instability H&S risk to site workers Future performance Potential for additional future maintenance	Ground investigation will be carried out at the pre-construction stage, prior to detailed design. Due consideration of stability as part of detailed design. Suitable long term drainage and slope stability measures to be adopted as part of the design, if necessary.	2	4	8
5.	**Slope instability of side road, north of river bridge**	Steep slope	3	4	12	Damage to slopes and carriageway H&S risk to road users Reputational damage for scheme	Ground investigation will be carried out at the pre-construction stage, prior to detailed design. Geological mapping, in particular, mapping of bedding and fracture plane orientations in rock to enable Suitable assessment of stability of rock masses in slope faces, as part of slope stability design.	2	4	8
6.	**Differential settlements**	Palaeochannels beneath floodplain	3	2	6	Localised instability Future performance Potential for additional future maintenance	Detailed geotechnical desk study completed, with review of geological records, historic plans, historic aerial photographs and geotechnical site walkover to identify potential features. Key Stage 3 investigation has not revealed any different ground conditions across the floodplain. Detailed ground investigation of each pier location will be carried out at the pre-construction stage, prior to detailed design. Detailed design to allow for potential differential settlements. A programme of geotechnical inspections of formations for embankments to be considered during excavation works.	2	1	2
7.	**Differential settlements**	Pockets of soft wet ground	4	2	8	Localised defects in the carriageway Future performance Potential for additional future maintenance	Due consideration given to the prevailing ground and weather conditions when scheduling site works. Key Stage 3 Ground Investigation has not revealed any soft / wet areas below 3m depth except in the area of the pond near TP16. Detailed ground investigation of each pier location will be carried out at the pre-construction stage, prior to detailed design. Detailed design to allow for potential differential settlements. A programme of geotechnical inspections of formations for embankments to be considered during excavation works.	3	2	6

Item	Hazard	Risk	Construction Stage			Consequences	Mitigation	Following Mitigation Stage		
			Probability	Impact	Risk Rating			Probability	Impact	Risk Rating
8.	**Large settlements of southern tie-in and southern embankment**	Poor ground conditions	5	2	10	Excessive settlement Differential settlement at interface between embankment and viaduct Additional construction work to remediate issues Cost impact Programme impact Future performance Potential for additional future maintenance	Detailed geotechnical desk study completed, with review of geological records, historic plans, historic aerial photographs and geotechnical site walkover to identify potential features. Key Stage 3 ground investigation has been undertaken and further detailed ground investigation will be carried out at Key Stage 6, prior to detailed design. Key Stage 3 ground investigation has revealed soft material to a depth of 2.75m beneath the embankment footprint. This can be accommodated using conventional geotechnical solutions. Develop appropriate design, options include: allow programme allowance for settlement; accelerate settlements through surcharge and/or vertical band drains; dig and replace soft ground; mass ground improvement; stone columns; piled rafts. Consideration of settlement monitoring during the works, as verification of the design, with appropriate contingency measures should displacements differ from anticipated values. Programme construction of embankment, temporary works and completion of drainage and pavement, to account for anticipated settlements.	3	1	3
9.	**Large settlements of viaduct foundations**	Unanticipated / variable ground conditions, for example, due to historic infilled watercourses	3	4	12	Excessive differential settlement between pier positions Future performance Potential for additional future maintenance	Detailed geotechnical desk study. Key Stage 3 ground investigation has been completed which has not revealed any unusual ground conditions. Further ground investigation will be undertaken at each pier position to confirm specific ground positions at each pier location during the Key Stage 6 investigation. Range of possible ground conditions to be considered in detailed design.	1	4	2
10.	**Stability failure of embankment**	Construction loading and poor ground conditions	3	3	9	Bearing capacity failure of embankment Additional construction work to remediate issues Cost impact Programme impact	Refer to Point 8 of this Risk Register. Due consideration of stability as part of detailed design. Excavation of shallow soft soil beneath embankment, or design of ground improvement/support measures. Consider requirement for formation inspections prior to construction of embankment to verify stability design assumptions.	1	3	3

Item	Hazard	Risk	Construction Stage			Consequences	Mitigation	Following Mitigation Stage		
			Probability	Impact	Risk Rating			Probability	Impact	Risk Rating
	Delays due to unexpected ground conditions	Ground conditions differ from those indicated in the project ground investigations	4	3	12	Construction delayed Revisions to design required	Detailed site investigations will be carried out at Key Stage 3 and Key Stage 6 (prior to detailed design), at the pier and embankment formation locations. Potential variations in conditions to be considered as part of detailed design. Consider requirement for geotechnical inspections to verify ground conditions during the construction phase. Programme and cost contingencies.	3	3	9
	Siltation of watercourses due to surface water runoff during construction	Site clearance operations	4	3	12	Impacts on ecology Potential for action by regulators Delays to programme Damage to reputation of delivery team	Design allows for thrust launching from the southern embankment to minimise construction works, and vehicle tracking across the flood plain. For the majority of pier columns, a mono-pile is proposed, to avoid the need to construct pile caps in the flood plain. Appropriate drainage measures and phasing of site clearance to be adopted during the construction phase.	1	3	3
	Buried obstructions impact on foundation construction	Historic buildings, rail lines, bridge foundations, backfilled drainage channels and ponds	3	2	6	Changes to construction method Delays to construction	Review of site history form historic plans, geological plans, historic aerial photographs, site walkover and ground investigation works.	2	2	4
	Biohazard – impact on site workers and third parties	Potential historic animal burial pits in local farmland, and risk of anthrax, foot and mouth etc	2	5	10	Health of site workers and third parties	Review of site history form historic plans, geological plans, historic aerial photographs, site walkover and ground investigation works Inform risk to site workers. Adopt an appropriate watching brief during construction.	1	5	2
	Unidentified contamination – impact on site workers and third parties	Potential for areas of made ground of unknown origin – in particular at the north abutment to the river span and near the industrial estate in the south	4	2	8	Health of site workers and third parties Potential impact on ecology and watercourses	Review of site history form historic plans, geological plans, historic aerial photographs, site walkover and ground investigation works. Inform risk to site workers. Adopt an appropriate watching brief during construction.	3	2	3
	High groundwater ingress into pile bores and difficult construction	High groundwater level in valley floor in combination with potentially high permeability ground conditions	4	4	16	Delays to construction Washout of concrete during pile construction leading to lack of long term pile integrity Unstable pile bores	Key Stage 3 ground investigation has revealed high groundwater levels. Rising head tests attempted but not able to lower groundwater level. Furtehr testing to be attempted. Further testing and monitoring during Key Stage 6 ground investigation. Adopt appropriate piling techniques that can accommodate the identified conditions. Concrete mix to be considered carefully.	3	4	12
	Delays due to archaeological features encountered during construction	Ffrydd Round Barrows – scheduled ancient monuments archaeological interest are present to the east of the proposed northern abutment to	3	5	15	Delays to construction	Desk study review of archaeological features ahead of site work. Archaeological trial pitting to be considered ahead of the construction phase.	2	5	10

Item	Hazard	Risk	Construction Stage			Consequences	Mitigation	Following Mitigation Stage		
			Probability	Impact	Risk Rating			Probability	Impact	Risk Rating
		the river crossing. The site is believed to lie within an area where a battle took place during the English Civil War (1644).					A watching brief to considered for the main works to help spot potential features at the earliest opportunity.			

Notes: 1. A 'Hazard' is a condition or physical situation with a potential for an undesirable event.

2. A 'Risk' is an uncertain event or set of circumstances that should it occur would have an effect on achieving the project objectives.

3. Mitigation Measures include:

- Avoid the risk – by eliminating the uncertainty or using an alternative approach.
- Transfer the risk – by transferring the liability of the risk to another party.
- Mitigate the risk – by reducing the risk to an acceptable level by making it less likely that the risk event will occur.
- Accept and manage the risk – by assuming the risk as reasonable given the cost or effect on time or quality and even life.

Appendix C

Annex A – Ground investigation proposals

C1 Objectives and format of investigation

The purpose of the investigation is to provide information to confirm and amplify the geotechnical and geomorphological findings of the Preliminary Sources Study. The main areas which need further investigation are as follows:

- Soft silty alluvium on the floodplain as well as palaeochannels.
- Variable depths from surface to bedrock for pier foundations.
- Steep slopes and unusual alluvial fan and head deposits on north bank.
- Groundwater conditions.

Works are anticipated to be limited to the proposed development construction corridor.

C2 Special problems to be investigated

The following special problems require resolving during ground investigations:

- Depth to bedrock where pier foundations require a rock socket.
- Soil and rock parameters for pile design.
- Bedding plane and fracture orientation of rock, where side road cutting is proposed in the north.
- Strength and stiffness of sub-soil conditions below area of earthworks embankment.
- Groundwater levels where excavations will be required.

C3 Proposed investigation

The proposed investigation described below is based on the scheme proposals as of October 2015. At the time of writing this report, Phase 1 of the investigation undertaken in early 2016 has already been completed and therefore the corresponding section below is not amended. However, the chainages are updated to reflect the new scheme proposals as of March 2016.

It is proposed to undertake the site investigation in two phases, which correspond to Key Stage 3 (Scheme Design) and Key Stage 6 (Detailed Design).

The following exploratory works are proposed for specific areas during each phase.

<u>Phase 1</u>

Between Ch. 0+0m and Ch. 0+955m, 5No. CP boreholes with rotary coring follow-on. It is proposed that the boreholes will extend at least 5m below pile base level. This may or may not require rotary coring, depending on rockhead level. Standard penetration test will be undertaken at 1.0m to 1.5m intervals and UT100 samples taken in the cohesive deposits with SPT follow-on, especially in the area of the embankment.

Approximately 27 trial pits will be excavated along the full length of the proposed alignment.

For the earthworks embankment stretch and the piled viaduct section, the trial pits will identify variability of soft silty alluvium in the near surface zone including palaeochannels.

For the earthworks at the northern tie-in to the existing A487, road provision is made for 3 trial pits to investigate sub-soil conditions.

Between Ch. 0+210m and Ch. 0+755m, if bedrock is not encountered within 30m, consideration may be given to undertake a geophysical survey to determine the rockhead profile.

Samples will be taken for physical and chemical testing.

Phase 2

It is proposed to undertake a borehole at each pier position. The boreholes will be cable percussive. Where proposed piles will extend into bedrock, the cable percussive boreholes will be extended with rotary cored follow-on. Again at this stage the anticipated depth is 25m to 35m. This will be reviewed following the completion of Phase 1.

Samples will be taken for physical and chemical testing.

C4 Site and working restrictions

Special care and attention is required when working near watercourses. In addition, groundwater expected to be encountered at shallow depths should not be contaminated.

The study area borders Snowdonia National Park to the north and the Dyfi Site of Special Scientific Interest lies approximately 4.5km to the southwest.

Some temporary traffic management will be required to allow the drilling rigs to gain access onto the site from the existing A487 road to the northeast and the southwest. Gated access is available onto the site at both the southern and northern ends. However a post and wire fence will need to be taken down at around Ch. 0+360m to gain access to the exploratory holes between Ch. 0+460m and Ch. 0+640m.

Traffic management will also be required when working in the vicinity of the National Cycle Network Route with special provisions for cyclists and walkers.

There are a number of services in the area including a high pressure gas main at the southern end of the site. Overhead cables also cross the site.

C5 Specialist consultation

A Flood Defence Consent is required for any intrusive works that may be required within 7m of a watercourse.

Part of the site lies within the Snowdonia National Park, however, no formal approval for the ground investigation work is required through the Snowdonia National Park Authority.

C6 Programme, cost and contract arrangements

It is anticipated that fieldwork will commence in late October 2015 with the fieldwork due to take 6 to 8 weeks in duration depending on the number of rigs used. The estimated cost of Phase 1 and Phase 2 combined is £60,000 to £70,000 + VAT if carried out as a continuous investigation as is currently proposed.

It is anticipated that the works will be carried out under the Thomas Telford Specification for Ground Investigation (2012), and the ICC Conditions of Contract for Ground Investigations.

C7 Reporting

A factual report will be prepared by the ground investigation contractor. The HD22 Ground Investigation Report will be compiled by Arup and submitted for Geotechnical Certification.