A46 Newark Bypass

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7.56 Detailed Quantitative Risk Assessment

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7.56 DETAILED QUANTIATIVE RISK ASSESSMENT

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1 Introduction

1.1 Scheme proposal

1.1.1 The Scheme comprises on-line widening of the A46 for the majority of its length between Farndon roundabout and the A1. A new section of offline dual carriageway is proposed between the western and eastern sides of the A1, before the new dual carriageway ties into the existing A46 to the west of Winthorpe roundabout.

1.1.2 A detailed Scheme description is contained within Chapter 2 (The Scheme) of the Environmental Statement [APP–046].

1.2 Background

1.2.1 A Phase 2 Contaminated Land Generic Quantitative Risk Assessment (GQRA) [APP-164 to APP-169] was previously produced to support the proposed development of the Scheme. The GQRA findings indicated that ground investigations (GI) to date have recorded limited evidence of contamination across most of the Order Limits, as confirmed by laboratory testing. However, a localised area of soil contamination was identified in the center of the Scheme near Nether Lock at WS46 and S3BH05. The GQRA concluded that this area posed a Low Risk to human health site end users and to controlled waters due to the depth of recorded contamination and an absence of proposed works in the vicinity.

1.2.2 Since the submission of Chapter 9 (Geology and Soils) of the Environmental Statement [REP3-009] and the GQRA [APP-164 to APP-169], the Environment Agency (EA) has requested a Detailed Quantitative Risk Assessment (DQRA) for the contamination hotspot at WS46 and S3BH05 to assess risks to controlled waters. For further details, refer to The Applicant’s Response to Relevant Representation for the EA [REP1-010], specifically the response to RR-020.

1.3 Objectives

1.3.1 The objective of this report is to supplement the initial GQRA findings and assess whether the contamination source identified at the location of exploratory holes WS46 and S3BH05 poses a risk to controlled waters if left in situ. It will include generating Remedial Targets (RTs), also referred to as Site Specific Acceptance Criteria (SSACs), which are concentration limits protective of controlled waters.

1.4 Scope of works

1.4.1 The following scope of works has been undertaken to achieve the above objective:

- Review the existing Contaminated Land Risk Assessment [APP-164 to APP-169] in relation to the contamination hotspot at the location of exploratory holes WS46 and S3BH05.
- Review the laboratory test data and monitoring results from available historical ground investigations and produce a list of contaminants of concern for the hotspot area.
- Carry out a DQRA for controlled waters using the Environment Agency’s Remedial Targets Methodology (RTM).
- Update the conceptual site model, pollutant linkages and source-pathway-receptor risk assessment.

1.5 Limitations and responsibilities

1.5.1 To the extent that this document is based on information obtained in previous or recent ground investigations, persons using or relying on it should recognise that such investigation can examine only a fraction of the subsurface conditions. In any ground investigation there remains the risk that pockets or ‘hotspots’ of contamination or other ground hazards may not be identified, because investigations are necessarily based on sample at localised points. Certain indicators or evidence of hazardous substance or conditions may have been outside the portion of the subsurface investigated or monitored, and thus may not have been identified or their full significance appreciated.

1.5.2 Should the presence of asbestos or toxic mould be suspected during the course of the study, it is recommended that a specialist contractor is appointed to address the issues and to provide advice on risk or remedial measures.

2 Site setting

2.1 Site location and description

2.1.1 The Order Limits for the Scheme is presented in Figure 2.1 (Location Plan) of the Environmental Statement Figures [APP-004].

2.1.2 A localised area of soil contamination was identified during Scheme GI works in the centre of the Scheme near Nether Lock. The contamination was identified in boreholes WS46 and S3BH05 for aromatic hydrocarbons C10-12, arsenic and polycyclic aromatic hydrocarbons (PAHs). For the purposes of this report, this contamination hotspot will hereinafter be referred to as the ‘Site’. The location of the Site is shown in Figure 9.2 (Potential Sources of Contamination) of the Environmental Statement Figures [AS-048].

2.1.3 The Site is situated parallel to the Nottingham to Lincoln railway line to the west and the existing A46 to the east (Figure 2-1). To the north of the Site lies Crankley Point Sewage Treatment Works and access road. The current land use consists of dense vegetation, including shrubs and trees. At the location of borehole S3BH05, 200mm of granular fill material has been laid by National Rail, to facilitate maintenance access to the railway line.

Figure 2-1 Location Plan

2.1.4 The Site is located in a relatively flat, low-lying area, approximately – 10 mAOD with the bank of the River Trent situated at approximately 8mAOD in this area. The topography is shown in Figure 9.1 (Topography) of the Environmental Statement Figures [AS-047].

2.2 Site history

2.2.1 Available historical mapping and aerial imagery for the Site does not identify any buildings/structures or sources of contamination directly at the location of WS46 and S3BH05. The Envirocheck Report[1] Site history is contained in Appendix A.

2.2.2 The potential source of the contamination identified at the Site is likely the historical Quibell Brothers chemical manure factory, which was present adjacent to the south of the Site. This factory is reported[2,3] to have produced a number of products from the late 1890s to early 1900s including; chemical manure (production process used hydrocarbons to extract grease from bones), sheep dip powder and liquid sheep dip (both made through arsenical preparation), a carbolic dip in the form of a solid paste containing carbolic acid, and also a disinfectant called ‘kerol’. During the enabling and construction earthworks of the existing A46 (1988 -1991), it is possible that a small volume of site won material from the demolition location of the adjacent chemical manure factory was deposited at the Site. On review there are no other likely credible sources in the area.

2.3 Published geology

2.3.1 The superficial deposits overlying the Site comprise Alluvium, as shown in Figure 9.3 (Superficial Deposits) of the Environmental Statement Figures [AS-049][4].

2.3.2 Alluvium is a general term for the unconsolidated detrital material deposited by a river or stream. Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present. According to the 1985 Geotechnical Report[5], the Alluvium underlying the Site is highly variable in the local area with the potential for deep alluvial channels.

2.3.3 The bedrock geology at the Site consists of the Mercia Mudstone Group (MMG), as shown in Figure 9.4 (Bedrock Geology) of the Environmental Statement Figures [AS-050].

2.3.4 MMG is described in the BGS Lexicon as “Dominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite-bearing units in some basinal areas. Thin beds of gypsum/anhydrite widespread; sandstones are also present”.

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[1] Landmark Information Group, Envirocheck Report (order no:172582399_1_1 dated 9/07/2018, Atkins received June 2018)

[2] Quibells Brothers Ltd, Available at: [redacted] (last accessed November 2024).

[3] Nottingham County Council, Inspire Archive: Croid's Glue Factory, Winthorpe Road, Newark on Trent, 1948 Available at: [redacted]) (last accessed November 2024).

[4] British Geological Survery, GeoIndex (onshore) Available at: [redacted] (last accessed November 2024).

[5] Exploration Associates, “A46 Newark Relief Road Report on Supplementary Site Investigation,” 1985.

2.4 Hydrogeology

2.4.1 Both the Highways Agency Geotechnical Data Management System (HAGDMS) website[6] and Magic Maps[7] were used to determine the aquifer designation of the Site.

2.4.2 The Superficial Deposits (alluvium) are designated as a Secondary A Aquifer, as indicated in Figure 9.5 (Superficial Deposits Aquifer Designation) of the Environmental Statement Figures [AS-051]. Magic Maps[8] provides designation for Secondary A Aquifer: 'Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers'.

2.4.3 The Mercia Mudstone Group is designated as Secondary B Aquifers, as indicated in Figure 9.6 (Bedrock Geology Aquifer Designation) of the Environmental Statement Figures [AS-052]. Magic Maps[8] provides designation for Secondary B Aquifer: 'Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers'.

2.4.4 The Environment Agency has provided information on groundwater sources[9] within the study area. Based on the current known information, the closest groundwater abstraction well to the Site (contamination hotspot) is the 'Kelham – Waterhole (C)', located approximately 1.70km to the west and operated for spray irrigation.

2.4.5 Neither the Scheme nor the specific Site are located within a designated groundwater source protection zone (SPZ), or Drinking Water Safeguard Zone for groundwater (or surface water). The Scheme is located within a Water Framework Directive (WFD) drinking water protected area which is designated as "probably not at risk".

2.5 Hydrology

2.5.1 The surface water baseline of the Scheme is described in detail in Chapter 13 (Road Drainage and the Water Environment) of the Environmental Statement [APP–057] and the surface water receptors

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[6] National Highways "Highways England Geotechnical Data Management System v.5.12.0". [Online]. Available: [redacted] Last accessed November 2024

[7] Defra, Magic (2021). Interactive Map [online] Available: MAGIC (defra.gov.uk) Last accessed November 2024

[8] Defra, Magic (2021). Interactive Map [online] Available: MAGIC (defra.gov.uk) Last accessed November 2024

[9] In response to Request for information EMD-294943 submitted November 2023.

are shown on Figure 13.1 (Surface Water Plan) of the Environmental Statement Figures [AS-073].

2.5.2 The River Trent is located approximately 165m to the west of the Site.

2.5.3 The River Trent flows in a north-easterly direction. The flow dynamics of the river are smooth, with exception of the Newark Trent Weir and, the Nether Lock and Weir adjacent to the Nether Lock Viaduct. At these locations the flow dynamics are disrupted but the river does return to a smooth flow state after. The WFD catchment area associated with the southern section of the River Trent, which the Scheme crosses, is 'Trent from Soar to The Beck waterbody [GB104028053110]'[10]. This waterbody is a heavily modified waterbody (HMWB) with a length of approximately 71.2km and catchment area of approximately 139.7km^2. According to the Cycle 3[11] (2019) data, the overall status of the waterbody is 'Moderate', ecological status is 'Moderate', chemical status is 'Fail' with nine 'Reasons for Not Achieving Good (RNAG)' identified.

2.6 Proposed works

2.6.1 The Works Plans [REP3-002] show there are no works planned directly at the location of the hotspot. Table 2.1 summarises the closest works to the Site.

Table 2.1 Summary of work plans closest to the Site

Work no.	**Description**	**Approximate distance from Site (m)**
68	As shown on sheet 4 of the Works Plans, a temporary works area with office and welfare units of approximately 500 square metres north-west of the new Nether Lock Rail Bridge.	70
69	As shown on sheet 4 of the Works Plans, the construction of an access track approximately 210 metres in length and passing place, commencing at Quibell's Lane.	20
70	As shown on sheet 4 of the Work Plans, the construction of an extension to the existing Sewage Treatment Works underpass under the new northbound carriageway of the A46.	60
71	As shown on sheet 4 of the work plans, a temporary compound of approximately 23,000 square metres south of the existing A46.	105

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[10] Environment Agency, Catchment Data Explorer, Trent from Soar to The Beck Water Body, Available at: Trent from Soar to The Beck | Catchment Data Explorer | Catchment Data Explorer Accessed November 2024

[11] RBMP are prepared in 5 year cycles, the latest issue of the Humber RBMP is Cycle 2, although data is now being collected by the Environment Agency to inform Cycle 3. The latest available data is therefore referred to within this ES chapter as 'Cycle 3

2.6.2 Additionally, the widening of the A46 and proposed drainage at the toe of the existing embankment are located approximately 20m to the east of the Site.

2.6.3 Furthermore, the General Arrangement Plans [AS-007] indicate that there will be no changes to the landscape at the Site. The area is labelled as ‘existing vegetation retained’.

3 Ground investigation

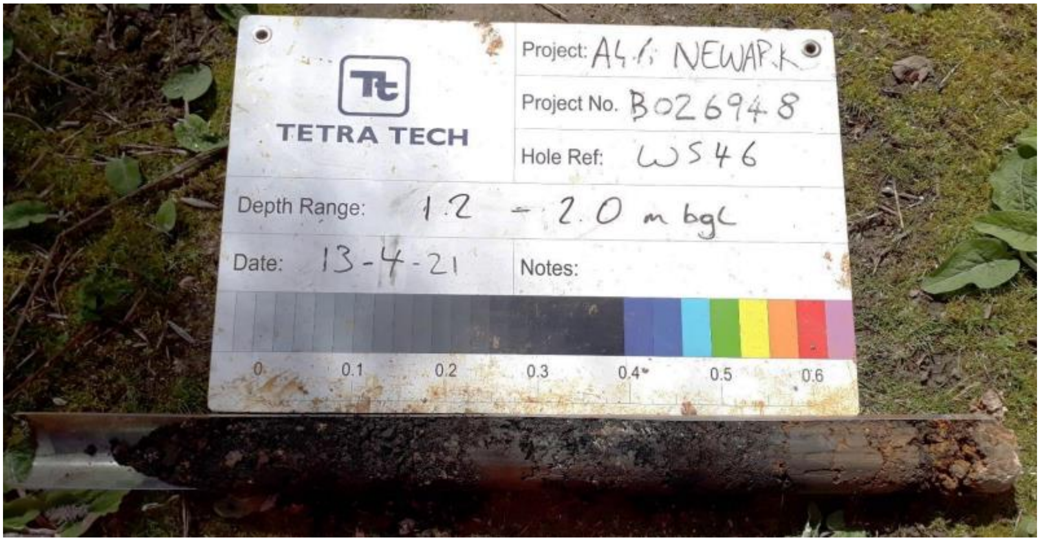
3.1.1 A comprehensive review of the GIs undertaken to date for the Scheme is detailed in the GQRA [APP-164 to APP-169]. To date, two Scheme-specific GIs have be undertaken at the Site. For the purposes of this report, the key information relevant to the Site is summarised below.

3.2 A46 Newark Bypass, Tetra Tech GI (2021 – 2022)

3.2.1 A Scheme specific GI (Main Alignment GI) was completed between April 2021 and July 2021 (with subsequent monitoring of groundwater and ground gas between November 2021 and February 2022), by TetraTech on behalf of the Applicant, under the instruction of Atkins.

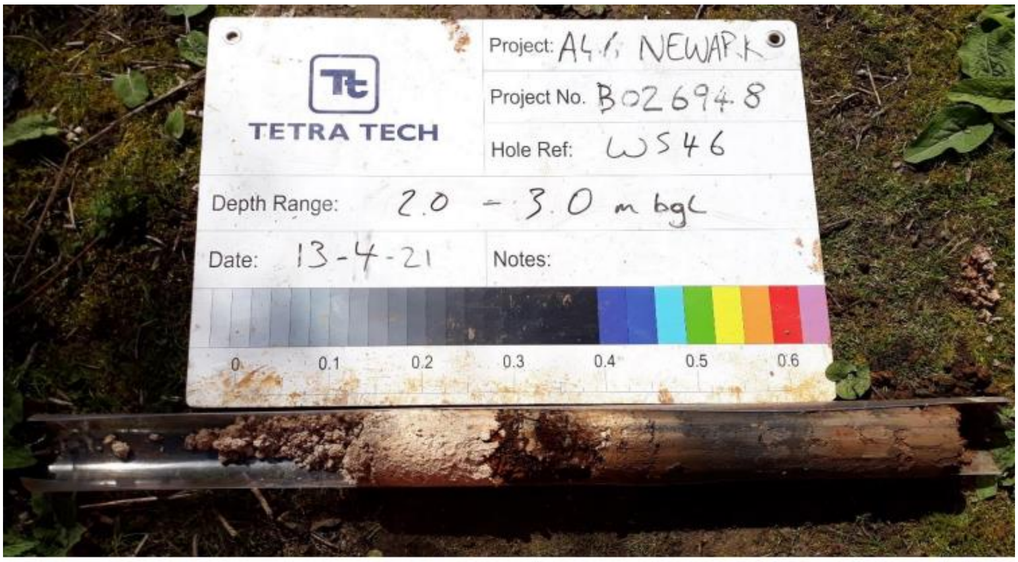
3.2.2 During the GI visual and olfactory evidence of contamination was recorded within Site soils at exploratory hole location WS46. The log photographs for WS46 are shown in Figures 3.1 and 3.2 below. The contamination was identified at the base of the Made Ground layer in the Alluvium between 2.5 and 3.5 metres below ground level (mbgl), where the ground was described as cream slightly sandy clayey sand, where a ‘chemical odour’ was observed. The cream sandy clayey sand layer is shown in the log in Figure 3.2 below.

Figure 3.1 WS46 photographic log 1.2 – 2.0 mbgl



Source – TetraTech, “A46 Newark Northern Bypass Factual GI Report” 2022

Figure 3.2 WS46 photographic log 2.0 – 3.0mbgl



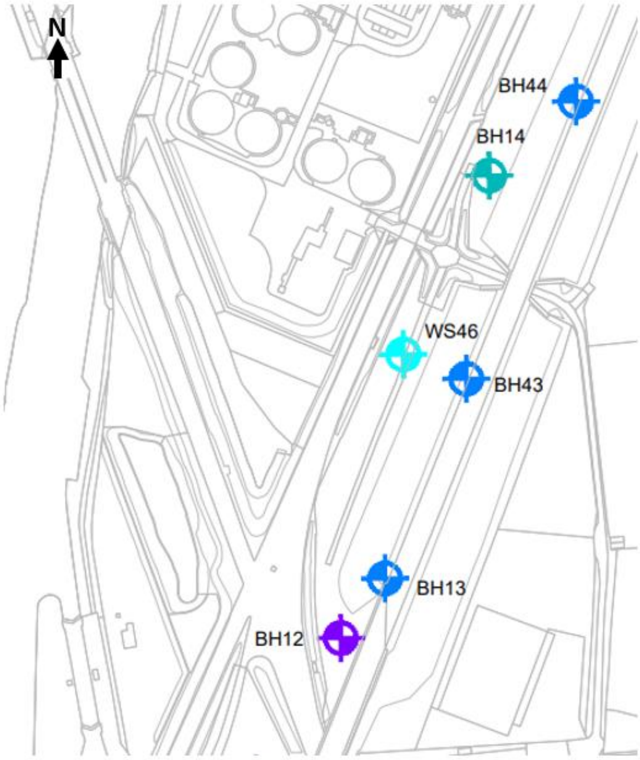
Project: A46 NEWARK
Project No. B026948
Hole Ref: WS46
Depth Range: 2.0 - 3.0 m bgl
Date: 13-4-21
Notes:

Source – TetraTech, “A46 Newark Northern Bypass Factual GI Report” 2022

3.2.3 It should be noted that no contamination was observed at other exploratory hole locations, including BH43, BH13 and BH12 in the vicinity of WS46. The locations of these other exploratory holes are illustrated below. No exploratory hole data are available to the west of the Site due to the presence of the existing railway line. However, the contamination identified at WS46 is unlikley to be present to the west of the Site, as the railway lines (historical Great Northern Railway and Midland Railway line) pre-date the potential source of the contamination (the former chemical manure factory). In addition, the construction of the initial A46 did not take place to the west of the railway (Midland Railway) line and therefore deposition of excavated material at this location following demolition of the chemical manure factory and during A46 earthworks is unlikely. The railway line and land to the west of the railway is outside the Site and the Order Limits.

3.2.4 Exploratory hole logs and laboratory chemical test data are included in the Tetra Tech Factual Report appended to the GQRA [APP-164 to APP-169].

Figure 3.3 Tetra Tech Exploratory holes near WS46



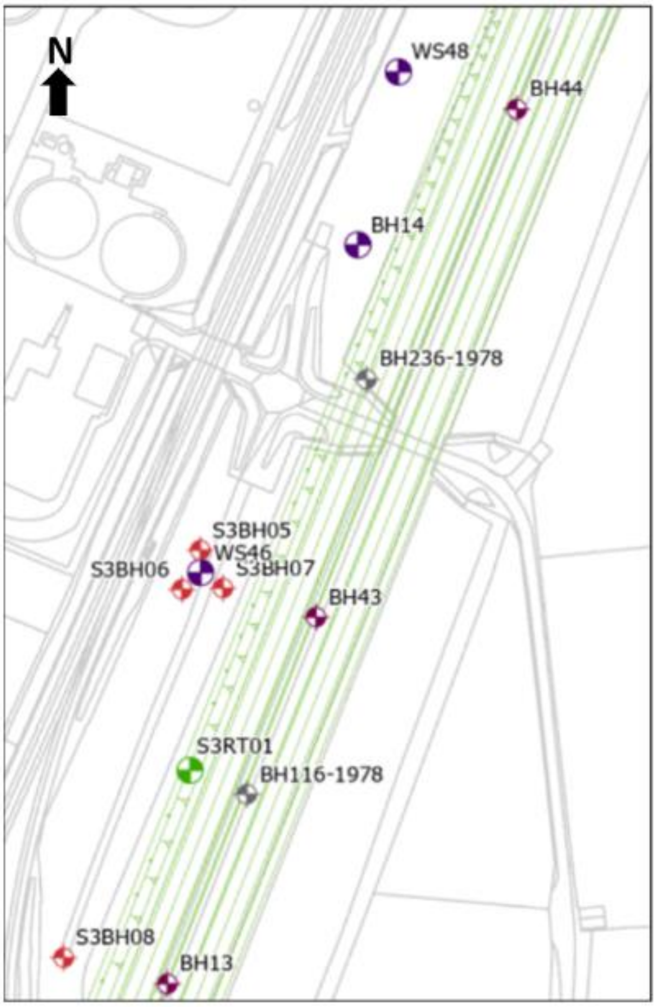
Source – TetraTech “A46 Newark Nothern Bypass Factual GI Report” 2022, not to scale

3.3 A46 Supplementary GI Strata Geotechnics Ltd (SGL) (2022 – 2023)

3.3.1 A supplementary GI was completed within the Order Limits by Strata Geotechnics Ltd (SGL) on behalf of the Applicant, between October 2022 and May 2023. Procurement of the ground investigation contractor was undertaken by Skanska as part of their early works contract. SGL were appointed by Skanska to carry out the ground investigation, with Mott MacDonald undertaking a technical supervisory role. The supplementary GI aimed to provide geotechnical and geo-environmental data to address gaps identified through the examination of historical GIs. Additionally, it sought to delineate the contamination identified at exploratory hole WS46 on the Site.

3.3.2 The delineation locations comprised three machine excavated trial pits and three windowless sample exploratory hole with triangulation around the hotspot to the north, south/south east at approximately 12 – 14m spacing, to 5m bgl depth, limitations with the railway line to the west and existing embankment further east. The locations of the delineation boreholes (BHs) around WS46 are illustrated below and in Figure 9.2 (Potential Sources of Contamination) of the Environmental Statement Figures [AS-048].

Figure 3.4 – Supplementary GI delineation around WS46



Proposed works in green, not to scale
Source – Mott MacDonald Ground Investigation Report Nether Lock Viaduct Exploratory Hole Plan [APP-169]

3.3.3 The supplementary GI identified further visual and olfactory contamination at one of the delineation exploratory holes (S3BH05) to the north of WS46. The presence of a soft white paste/chalky textured material, similar to that noted at WS46 was present, with a strong chemical odour between 1.20 – 2.80 metres below ground level. Whilst both phases of GI recorded visual and olfactory evidence of contamination, free phase product was not encountered.

3.3.4 Observations from the GI do not suggest that contamination is widespread across this area, with delineation exploratory holes S3BH06, S3BH06R, S3BH07 and S3BH07R adjacent to the south and east of WS46 respectively, recording low photoionization detector (PID) readings, no chemical odour, and an absence of the soft white pastey/chalky substance that was identified in WS46/S3BH05. Additionally, a trial pit (S3BH05R) located approximately 1 meter north of S3BH05 showed no evidence of contamination. Based on information gathered to date, it is understood that the contamination is confined to a small area.

3.4 Encountered geology

3.4.1 The encountered geology at the Site, as observed in exploratory hole WS46 and delineation boreholes (S3BH05 – S3BH07), is summarised below in Table 3.1.

Table 3.1 Encountered geology (Nether Lock Viaduct ground model)

Stratum	**Typical Description**	**Depth to top (mbgl)**	**Typical thickness (m)**
Topsoil	Soft dark brown sandy slightly gravelly CLAY with frequent roots and rootlets (<35x470mm). Sand is fine to coarse. Gravel is angular to rounded fine to coarse of quartz, sandstone, quartzite. Present at S3BH07R only.	0.00	0.50
Made Ground	Dark brown gravelly slightly silty SAND. Occasional coal and clinker. Silt is fine to coarse. Gravel is fine to coarse angular to sub-rounded of clinker, brick, coal sandstone, and slag.	0.00	1.20 – 2.90
Made Ground with strong chemical odour	Cream slightly sandy clayey fine and medium sub-angular of sandstone GRAVEL. Sand is fine to coarse	1.20 – 2.20	1.30 – 1.60
Granular Alluvium	Consisting of sand and gravel with gravel being generally sub angular to sub rounded.	2.50 – 3.00	3.30[1]
Mercia Mudstone	Underlying the superficial deposits recorded as weak grey Mudstone	5.80	Base not proven

Source – Data inferred from TetraTech Factual Report and SGL Factual Report
[1] Base only proven in WS46 where weathered Mercia Mudstone was encountered.

3.4.2 For the wider Site area, a ground model was developed for Nether Lock Viaduct, as detailed in the Mott MacDonald Ground Investigation Report which is appended to the GQRA [APP 169].

3.5 Groundwater

Groundwater strikes

3.5.1 During drilling and excavation, water strikes were recorded at 3.50 mbgl in WS46. Out of the six delineation holes, only S3BH07R encountered groundwater during GI at a depth of 3.40 mbgl.

Groundwater monitoring

3.5.2 For the purpose of this report, groundwater monitoring data from the TetraTech GI has been used to infer the groundwater conditions at the Site, as the TetraTech GI includes the closest groundwater installations to the Site. This groundwater data has been plotted on GIS to generate a groundwater contour map for the Scheme. The groundwater monitoring data is contained in Appendix B, and the groundwater contour map is included in Appendix C of this report.

3.5.3 The groundwater hydraulic gradient is predominantly influenced by topography across the Scheme. Groundwater levels within the Alluvium align with the topographic gradient of the River Trent valley. At the Site, groundwater is identified to flow from BH12 to BH14 in a northerly direction. Statistical analysis of flow directions from other monitoring wells suggests that groundwater likely flows in a northwesterly direction, towards the River Trent as shown on the Groundwater Contour Map in Appendix C of this report.

3.5.4 Six rounds of groundwater monitoring data adjacent to the Site (BH11, BH12, and BH14) show that the groundwater fluctuates between 2.1 mbgl and 3.7 mbgl in the Made Ground and Granular Alluvium stratum.

4 Summary of Generic Quantitative Risk Assessment

4.1 Background

4.1.1 For the purposes of this report, the information on controlled waters at the Site from the GQRA has been reiterated and further discussed here as it pertains to the assessment.

4.1.2 The GQRA [APP-164 to APP-169] should be consulted for the human health assessment. Notable soil exceedances of the thresholds informing this assessment were identified at WS46 at a depth of 2.3m for aromatics >C10 <C12 and naphthalene, and at S3BH05 at depths of 1.65m for arsenic, dibenz[a,h]anthracene, benzo[b]fluoranthene, benzo[a]pyrene, and 2.9m for arsenic. The Environmental Health Officer (EHO) approved leaving the material in situ, on the basis that this contamination is at depth and contingent upon the submission of a verification report demonstrating that no works took place. This is detailed in commitment GS6 in Table 3- 2 (Register of Environmental Actions and Commitments) in the First Iteration Environmental Management Plan [REP2-010]

4.1.3 The GQRA is based on the principles set out in Land Contamination: Risk Management (LCRM) (Environment Agency, 2020), British Standard 10175 (BSI, 2011 (as amended)), and National House Building Council, Environment Agency, and Chartered Institute of Environmental Health report (NHBC, EA, CIEH, 2008). Further information relating to regulatory legislation, drivers, and contamination assessment criteria are provided in Appendix D. Background to the contaminated land risk methodology is presented in Appendix E of this report.

4.2 Contaminant concentration guideline values

Controlled waters criteria

4.2.1 Laboratory data for both leachate extract from soil, groundwater and surface water samples have been compared with Environmental Quality Standards (EQS) for annual average surface freshwater due to the presence of surface water receptors (River Trent) and underlying (Secondary B and Secondary A aquifers). It should be noted that there are no UK Environmental Quality Standard (EQS) specifically for Total Petroleum Hydrocarbon Criteria Working Group (TPH CWG) banding.

4.2.2 It should be noted that the Scheme is not located within an EA designated groundwater source protection zone (SPZ) and is located outside all WFD designated groundwater nitrate vulnerable zones (NVZ) and drinking water safeguard zone. Subsequent review of the EA records indicated that ground water abstraction in the Scheme Order Limits and Study Area was for non-potable water usage. Additionally, the nearest groundwater abstraction well is approximately 1.70 km to the west of the Site.

4.3 Laboratory analysis of leachate – risks to controlled waters

4.3.1 Results from leachate extract from soil laboratory analysis were screened against Environmental Quality Standards (EQS) for Surface Freshwaters, due to the proximity of surface water receptors. Note that a direct comparison of leachate testing results with the selected assessment criteria is a conservative method, as it overestimates the availability of determinants to dissolve.

4.3.2 A total of eight exceedances of the EQS were recorded at WS46 during the Tetra Tech GI comprising heavy metals and inorganics. The exceedances in leachate extracted from soil samples are marginally above the EQS. The results are summarized below in Table 4.3.

Table 4.3 Summary of leachate extract from soil exceedances Tetra Tech

Determinant name	Location ID	Sample depth (mbgl)	Stratum	EQS (mg/l)	Result (mg/l)
Arsenic	WS46	2.30	Made Ground	0.05	0.0669
Chromium hexavalent				0.0034	0.0463
Copper				0.001	0.0728
Lead				0.0012	0.0486
Mercury				0.00007	0.000869
Nickel				0.004	0.015
Sulphate				400	1040
Zinc				0.0123	0.0193

4.3.3 A total of 25 exceedances of the EQS were recorded at the Site in the delineation boreholes (S3BH05 – S3BH07) during the SGL GI comprising heavy metals and inorganics. The exceedances in leachate extracted from soil samples are marginally above the EQS. The results are summarised below in Table 4.4. For both leachate collected from WS46 and the SGL boreholes, the exceedances are for inorganics only and particularly metals/metalloids.

Table 4.4 Summary of leachate extract from soil exceedances SGL

Determinant name	Location ID	Sample depth (mbgl)	Stratum	EQS (mg/l)	Result (mg/l)
Ammoniacal Nitrogen as N	S3BH05R	1.65	Made Ground	0.2	0.36
		3.20	Granular Alluvium		0.84
	S3BH05	3.20			2.6
Arsenic	S3BH05	1.65	Made Ground	0.05	0.069
Cadmium	S3BH05	1.50		0.00008	0.00009
		2.50			0.00011
		3.20	Granular Alluvium		0.00024
	S3BH07	2.00	Granular Alluvium		0.00022
Copper	S3BH05	1.50	Made Ground	0.001	0.0018
		1.65			0.002
		3.20	Granular Alluvium		0.027
	S3BH05R	1.50	Made Ground		0.015
		1.65			0.014
		2.50			0.013
		3.20	Granular Alluvium		0.023
	S3BH06R	1.20	Made Ground		0.022
	S3BH07R	2.00	Granular Alluvium		0.02
Lead	S3BH05R	2.50	Made Ground	0.0012	0.0019
Nickel	S3BH05R	3.20	Granular Alluvium	0.004	0.026
Sulphate as SO4	S3BH05R	1.50	Made Ground	400	412
		1.65			754
		2.50			631
Zinc	S3BH05R	1.65		0.0123	0.015
		3.20	Granular Alluvium		0.051
	S3BH07R	2.00			0.016

4.4 Laboratory analysis of groundwater – risk to controlled waters

4.4.1 During the Tetra Tech GI, no installation was placed in WS46, resulting in no groundwater samples being collected from the Site.

4.4.2 As part of the supplementary GI, three installations were placed in the delineation boreholes (S3BH05, S3BH06, S3BH07). However, during groundwater monitoring, the wells did not yield sufficient water to achieve proper purging according to standard groundwater sampling protocols. The insufficient yield of water from the wells during groundwater monitoring suggests that the groundwater at the Site is either present at very low levels or is not readily accessible in the delineation boreholes (S3BH05, S3BH06, S3BH07). This could indicate that the aquifer has low permeability in this area. Consequently, only one grab water sample was obtained. This sample is not considered representative of the background conditions and has been excluded from the assessment.

4.4.3 The closest locations sampled for groundwater include BH11, located approximately 240 meters from the Site and upgradient of the groundwater flow; BH12, approximately 155 meters from the Site and also upgradient; and BH14, approximately 106 meters from the Site and downgradient of the groundwater flow direction.

4.4.4 Groundwater samples obtained from BH14, located downgradient of the source, recorded PAH levels below the limit of detection during the November 2021 monitoring. Hydrocarbon levels were also below the limit of detection in both the November 2021 and February 2022 monitoring.

4.4.5 A total of 26 exceedances were recorded adjacent to the Site comprising inorganics, heavy metals and PAHs which are summarised below in Table 4.5.

Table 4.5 Summary of groundwater exceedances

Determinant name	**Location ID**	**Response zone strata**	**EQS (mg/l)**	**Result (mg/l)**	**Date**
Ammoniacal Nitrogen	BH11	Made Ground/Granular Alluvium	0.20	0.558	Aug-21
	BH12	Granular Alluvium		0.827	Aug-21
	BH14			0.373	Aug-21
Anthracene	BH12		0.0001	0.000197	Aug-21
Benzo(a)pyrene	BH11	Made Ground/Granular Alluvium	0.00000017	0.0000361	Aug-21
	BH12	Granular Alluvium		0.00151	Aug-21
	BH14			0.0000241	Aug-21

Determinant name	Location ID	Response zone strata	EQS (mg/l)	Result (mg/l)	Date
Cadmium	BH11	Made Ground/Granular Alluvium	0.00008	0.000146	Feb-22
				0.000152	Aug-21
				0.000115	Nov-21
Copper	BH12	Granular Alluvium	0.00231	0.0164	Aug-21
Cyanide	BH11	Made Ground/Granular Alluvium	0.001	0.9	Aug-21
Fluoranthene			0.0000063	0.0000479	Aug-21
	BH12	Granular Alluvium		0.002	Aug-21
				0.0000097	Nov-21
	BH14			0.000018	Feb-22
				0.0000354	Aug-21
Iron	BH11	Made Ground/Granular Alluvium	1.00	2.2	Nov-21
Phenol	BH12	Granular Alluvium	0.0077	0.16	Aug-21
Sulphate as SO4			400	1550	Feb-22
				1770	Aug-21
	BH14			1520	Feb-22
				1850	Aug-21
				1580	Nov-21
Zinc	BH11	Made Ground/Granular Alluvium	0.0123	0.159	Feb-22
	BH12	Granular Alluvium		0.0304	Aug-21

4.4.6 For the majority of determinants in groundwater the exceedances of the EQS were noted both upgradient and downgradient of the Site, suggesting that the exceedances represent broader background concentrations in the aquifer rather than being attributable to the hotspot. It should be noted that similar marginal exceedances in groundwater samples were noted across the wider Scheme area (detailed in the GQRA [APP-164 to APP-169] [APP 164 – 169]. These widespread exceedances indicate that the elevated levels are consistent with regional background conditions.

4.4.7 This is supported by the chemical status of the ‘Trent from Soar to The Beck’ water body was marked as ‘Fail’ in 2019[10], classified as ‘High’ for arsenic, chromium (VI), copper, iron, manganese, phenol, toluene, and zinc. It also failed on priority substances such as mercury and its compounds.

4.4.8 Although groundwater is impacted, the correlation between soil leachate exceedances and groundwater exceedances at the Site is slight. Notably, only copper, zinc, and ammoniacal nitrogen as N have exceeded the EQS threshold values in both leachate and groundwater samples. These determinants are not considered to be associated with the contaminant material identified in the soil and are therefore unlikely to originate from the hotspot.

4.5 Revised Conceptual Model

4.5.1 As part of the GQRA (Appendix 9.2 of the Environmental Statement Appendices [APP-164-169]), following GI a revised Conceptual Site Model was developed for the Site. Below is a summary of the potential sources, pathways, receptors, and pollutant linkages identified based on the information gathered to date.

Table 4.6 Revised Conceptual Site Model (controlled waters)

Source	Pathway	Receptor	Mitigation	Consequence	Probability	Risk	Comment
Hotspot (WS46, S3BH05) identified contamination during GI at Nether Lock.	Lateral migration of dissolved phase contaminants in groundwater to surface water; Lateral migration of dissolved phase contaminants via preferential pathways such as drains; Migration of contaminants in surface water runoff.	**Controlled Waters**: On-site surface water features (River Trent)	Environmental protection measures	Mild	Low Likelihood	Low	One area of the Scheme (Nether Lock) identified isolated exceedances of EQS that were not generally notable for the wider Scheme area values for the following determinants: arsenic, chromium, chromium hexavalent and mercury in leachate extract from soil samples. However, the exceedances of the EQS were not noted in nearby groundwater and surface water samples. It should be noted that direct comparison of leachate testing results with the selected assessment criteria is a conservative method, as it overestimates the availability of determinants to dissolve. At the hotspot location groundwater flow direction is noted as in a northerly direction away from the River Trent and a drainage ditch will intercept run-off from the proposed embankment. There is also hard engineering between the contamination hotspot and the River Trent comprising 7m depth sheet piles at 78m in length, forming an impermeable barrier. Therefore, a significant risk to
		Controlled Waters: Off-site surface water features (River Trent, Old Trent Dyke, Broadgate Lane Feeder Slough Dyke (the fleet), Newark on Trent Marina, Farndon Marina, Farndon Ponds, Nottingham Piscatorial society waterbodies,		Mild	Low Likelihood	Low	

Source	Pathway	Receptor	Mitigation	Consequence	Probability	Risk	Comment
		Smeaton lakes camping site, ponds north of British Sugar Factory, ponds at Staythorpe Power Station field drains, unnamed ponds and smaller unnamed watercourses)					water quality from Site soils is considered unlikely. As with Scheme area works there is also a risk of sediment run off into the water courses which could deteriorate the water quality. Environmental protection measures detailed within the First Iteration Environmental Management Plan [REP3-022] and Second Iteration Environmental Management Plan should be adhered to, to prevent risk to surrounding water courses.
	Leaching or dissolution of contaminants in soils and subsequent migration of contaminants in groundwater; Vertical migration of dissolved phase contaminants to	**Controlled waters:** Groundwater in underlying Secondary A Superficial aquifer and Secondary B Bedrock aquifer	Piling Risk Assessment (included in this CSM).	Mild	Low Likelihood	Low	One area of the Scheme (Nether Lock) identified isolated exceedances of the EQS that were not generally notable for the wider Scheme area for the following determinants: arsenic, chromium, chromium hexavalent, and mercury in leachate extract from soil samples. However, the exceedances were not noted in nearby groundwater and surface water samples. It should be noted that direct comparison of leachate testing results with the selected assessment

Source	Pathway	Receptor	Mitigation	Consequence	Probability	Risk	Comment
	the underlying groundwater.						criteria is a conservative method, as it overestimates the availability of determinants to dissolve. For the majority of determinants in groundwater the exceedances of the EQS were noted both upgradient and downgradient of WS46 and S3BH05, suggesting that the exceedances represent broader background concentrations in the aquifer rather than being attributable to the hotspot. No excavation works are anticipated at this location; therefore the adjacent proposed works are unlikely to create new or worsen existing potential contaminant pathways into the superficial deposits.

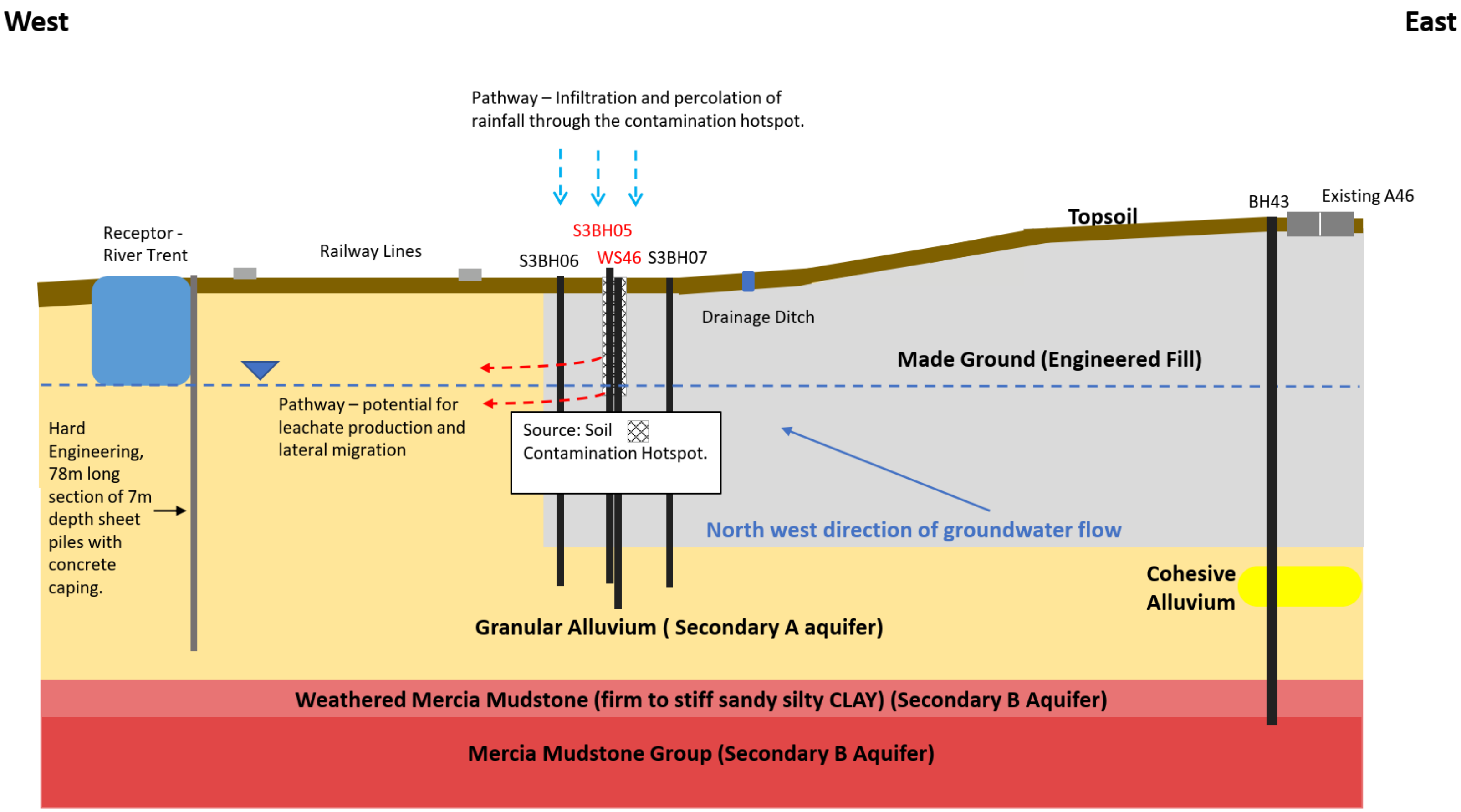
5 Detailed Quantitative Risk Assessment

5.1.1 A revised hydrogeological Conceptual Site Model (CSM) has been created for the DQRA to ensure a comprehensive understanding of the Site, its environmental settings, and the Source-Pathway-Receptor concepts. Subsequent groundwater monitoring data has been used for the DQRA, since the GQRA was written this has further informed groundwater flow at the Site.

5.1.2 It should be noted that this assessment only considers the risk to controlled waters and does not address the risk to human health, as this falls outside the scope of this report.

5.1.3 Based on the available information, the schematic cross section shown in Figure 5.1 has been developed to demonstrate the hydrogeological conceptual model.

Figure 5.1 Hydrogeological conceptual site model



5.2 Source

5.2.1 The only source of contamination considered within this model is the Made Ground between 2.20 – 2.50mbgl within WS46 and between 1.65 and 2.85mbgl within S3BH05.The laboratory test data provided shows concentrations of aromatic hydrocarbons >C10 <C12, arsenic, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and naphthalene in excess of the GACs. These contaminants are considered to be the contaminants of concern at the Site. No free phase contamination was identified.

5.2.2 The GI data indicates that concentrations of the more volatile and mobile hydrocarbons; Benzene, Toulene, Ethylbenzene and Xylene (BTEX) compounds are not present.

5.3 Pathways

5.3.1 The pathways considered in this model include the vertical and lateral migration of water within the saturated zone of the Granular Alluvium. Migration within the unsaturated zone is deemed unlikely, as groundwater monitoring data (BH11, BH12 and BH14) indicate that groundwater levels fluctuate between 2.1 mbgl and 3.7 mbgl in the Made Ground and Granular Alluvium strata. Testing results show that contamination is present at depths of 1.65 mbgl to 2.90 mbgl, which is within the saturated zone. Therefore, any leachate migrating from the hotspots is likely to enter directly into the groundwater.

5.4 Receptors

5.4.1 The identified receptor for this model is the River Trent, located approximately 165 meters west of the Site. Although the Granular Alluvium is classified as a Secondary A Aquifer, it is not considered a receptor because there are no potable abstractions within the Study Area, and the Site is not located within a Source Protection Zone.

5.5 Assumptions

5.5.1 During the Ground Investigation (GI), contamination was identified in two boreholes (WS46 and S3BH05). Results from the ground investigation (GI) indicate that contamination is not widespread in this area. The delineation exploratory holes—S3BH05R to the north, S3BH06 and S3BH06R to the south, and S3BH07 and S3BH07R to the east—did not record any evidence of contamination. The contaminant source area was determined on information gathered to date based on the assumption that contamination exists between

(WS46 and S3BH05), a distance of 6m. The width was established using the observed results of the triangulation around WS46. The spacing of the triangulation boreholes to the east and west was approximately 6m, and since these boreholes were clean, this distance was used as the measurement. Consequently a contaminated area of approximately 36 m^2 has been estimated.

5.5.2 It is assumed that the only pathway for the contamination is through the saturated zone. The relationship between the River Trent and the groundwater has not been proven. However, a conservative assumption has been made that the water body is fed by groundwater and is not isolated within the Alluvium.

5.5.3 An assumption was made that the average of the Potential Evapotranspiration (PET) data from January and August 2024 is representative of yearly conditions at the Site.

5.5.4 The methodology applies to soils that are already contaminated. In this case, the contamination is declining because the source is considered to have been deposited potentially 33 - 36 years ago with source generation as old as 114 to 134 years. Consequently, any impacts will diminish over time, e.g. via dilution, natural attenuation and degradation, further reducing the risk.

5.5.5 Soil leachate testing for PAHs was not conducted, resulting in the absence of leachate data for assessing organic contaminants. This approach is consistent with RTM guidance on PAHs, which highlights their hydrophobic nature and poor leachability, potentially leading to an underestimation of their presence in leachate. Therefore, soil data will be utilised for the assessment of PAHs.

5.5.6 The contamination identified at WS46 and S3BH05 is unlikley to be present to the west of the Site, as the existing railway line to the west of WS46 and S3BH05, pre-dates the potential source of the contamination (the former chemical manure factory).

5.6 Input parameters

5.6.1 To model the migration and natural attenuation of contaminants present in the soils and leachate, Mott MacDonald has used the Environment Agency’s RTM [12] to conduct a DQRA.

5.6.2 The RTM was selected because the hydrogeological Conceptual Site Model (CSM) conservatively assumes there is no unsaturated zone between the contamination source in the Made Ground and the water table. The RTM model calculates the maximum concentration within the source that is unlikely to exceed a threshold at a given receptor. It

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[12] Environment Agency 2006. Remedial Targets Methodology, Hydrogeological Risk Assessment for Land Contamination

breaks down the model into different levels, ranging from leachates formed within the unsaturated zone to a controlled water receptor downgradient. The model incorporates algorithms to quantify the concentration and natural attenuation by dispersion, dilution, and attenuation within an aquifer, affecting compounds along the flow path from the source. The RTM model is tiered into three levels:

- At Level 1 the model predicts porewater concentrations based on the results of the soil concentration analyses and the partitioning between the solid and liquid phases. Comparison of leachate values with an environmental threshold is a Level 1 assessment.
- At Level 2, the model simulates migration through the unsaturated zone to the water table with consideration of attenuation processes within the soil (degradation and absorption) and predicts the effects of dilution by groundwater flow below the Site.
- At Level 3 the model simulates the fate and transport of dissolved compounds to identified compliance points or receptors downstream of the point of contaminant entry into the saturated zone, taking into account dilution, degradation, retardation and dispersion within the aquifer.

5.6.3 The model requires a range of parameters to characterise the soils through which the contaminants are migrating as well as the properties of the groundwater flow to determine how far and fast the water is moving within the sub-surface. These have been detailed in Table 5.1 below. Where Site specific parameters could not be determined, proxy values have been adopted based on literature values of materials with similar properties.

Table 5.1 RTM model input parameters

Parameter	**Units**	**Value**	**Source**
Level 1 Soil: Source zone partitioning – Contamination hotspot – Made Ground/Granular Alluvium			
Water filled soil porosity	Fraction	0.215	Calculated using Site-specific GI data (Tetra Tech 2022 and SGL 2023)
Air filled soil porosity	Fraction	0.11	
Bulk density of soil zone material	g/cm^3	20	
Fraction of organic carbon	Fraction	0.0051504	
Level 2 Soil: Vertical migration to water table – Granular Alluvium			
Infiltration	m/d	0.00063	Calculated using Met Office rainfall data[13] and EA Potential Evapotranspiration

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[13] Met Office, Climate Averages, Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcrhe9cy8 Accessed November 2024

Parameter	Units	Value	Source
			(PET) dataset 2024[14].
Area of contaminant source	m^2	36	Determined using online mapping tools
Length of contamination source in direction of groundwater flow	m	6	Determined using online mapping tools
Saturated aquifer thickness	m	2.95	Calculated using Site-specific data (Tetra Tech 2022 and SGL 2023)
Hydraulic conductivity of aquifer in which dilution occurs	m/d	0.00005644	SGL Factual Report 2023
Hydraulic gradient of water table	Fraction	0.00271264	Calculated using Site-specific data (Tetra Tech 2022)
Width of contaminant source perpendicular to groundwater flow	m	6	Determined using online mapping tools
Background concentration of contaminant in groundwater beneath Site	mg/l	0.00	Contaminants assumed not to be present within the aquifer
Level 3 Soil: Aquifer – Granular Alluvium			
Bulk density of aquifer materials	g/cm^3	1.99	Calculated using Site-specific data (Tetra Tech 2022 and SGL 2023)
Effective porosity of aquifer	Fraction	0.3	McWorter, D.B. and Sunada, D.K., 1977. Ground-water hydrology and hydraulics. Water Resources Publication.
Distance to compliance point	m	1650	Determined using online mapping tools based on worst case distance from source (WS46 and S3BH05) to River Trent.

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[14] Environment Agency, Potential Evapotranspiration Dataset, 2024, Available at: Environment Agency Potential Evapotranspiration Dataset Accessed November 2024

Parameter	Units	Value	Source
Time since pollutant entered groundwater	Days	1.00E+99	Conservative assumption to achieve steady state

5.6.4 The following model settings have been used:

- Analytical solution – Ogata Banks (in line with RTM guidance)
- Dispersivities – 10%, 1% band 0.1% of pathway length (in line with RTM guidance).

5.6.5 The model has been run for the identified contaminants of concern for which there are relevant freshwater environmental quality standards identified during the most recent investigations. These determinants were all identified within soil samples recovered from Site and are considered to be the only contaminants that would be associated with the Made Ground and not representative of the local geology:

- Aromatics >C10 <C12
- Arsenic
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Dibenz(a,h)anthracene
- Naphthalene

5.6.6 The input parameters for the contaminants of concern can be found in Table 5.2.

Table 5.2 Contaminant input parameters

Contaminant	Parameter	Value	Units	Source
Aromatics >C10 <C12	Compliance criteria	0.01	mg/l	UK Drinking Water Standards (England) 2016[1]
	Organic carbon partition coefficient	2512	l/kg	Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWG), 1999. Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach,

Contaminant	**Parameter**	**Value**	**Units**	**Source**
				Volume 5, Table 1.
	Henrys Law Constant	0.14	Dimensionless	Environment Agency, 2008, Soil Guideline Values
	Half life (water)	200.89	days	Howard et al. 1991. Environmental Degradation
	Soil concentration	46900	mg/kg	Tetra Tech Factual Report 2022
Arsenic	Compliance criteria	0.05	mg/l	WFD (Standards & Classification) Directions (England and Wales) 2015
	Partition coefficient	500	l/kg	Nathanail et al 2015: "The LQM / CIEH S4ULs for Human Health Risk Assessment ", Copyright Land Quality management Limited reproduced with permission: Publication No. S4UL3389
	Henrys Law Constant	0	Dimensionless	*Elemental arsenic is not volatile*
	Half life (water)	9E+99	Days	*Arsenic does not degrade*
	Soil leachate concentration	0.0669	mg/l	Tetra Tech Factual Report 2022
Benzo(a)pyrene	Compliance criteria	0.00000017	mg/l WFD (Standards & Classification) Directions	(England and Wales) 2015
	Organic carbon	128825	l/kg	Environment Agency, 2008,

Contaminant	Parameter	Value	Units	Source
	partition coefficient			Soil Guideline Values
	Henrys Law Constant	0.00000176	Dimensionless	Environment Agency, 2008, Soil Guideline Values
	Half life (water)	1059.22	Days	Howard et al. 1991. Environmental Degradation
	Soil concentration	78	mg/kg	SGL Factual Report 2023
Benzo(b)fluoranthene	Compliance criteria	0.00000017	mg/l	WFD (Standards & Classification) Directions
	Organic carbon partition coefficient	104713	l/kg	Environment Agency, 2008, Soil Guideline Values
	Henrys Law Constant	0.00000205	Dimensionless	Environment Agency, 2008, Soil Guideline Values
	Half life (water)	1219.94	Days	Howard et al. 1991. Environmental Degradation
	Soil concentration	94	mg/kg	SGL Factual Report 2023
Dibenz(a,h)anthracene	Compliance criteria	0.00000017	mg/l	There is no specific EQS for this determinant. As a conservative approach, the highest EQS from other PAHs has been applied, based on the Water Framework Directive (Standards & Classification) Directions (England and Wales) 2015.

Contaminant	Parameter	Value	Units	Source
	Organic carbon partition coefficient	1912000	l/kg	RAIS Database (Risk Assessment Information System)
	Henrys Law Constant	5.7645	Dimensionless	Environment Agency, 2008, Soil Guideline Values
	Half life (water)	259	Days	Howard et al. 1991. Environmental Degradation
	Soil concentration	14	mg/kg	SGL Factual Report 2023
Naphthalene	Compliance criteria	0.002	mg/l	WFD (Standards & Classification) Directions (England and Wales) 2015
	Organic carbon partition coefficient	646	l/kg	Environment Agency, 2008, Soil Guideline Values
	Henrys Law Constant	0.00662	Dimensionless	Environment Agency, 2008, Soil Guideline Values
	Half life (water)	259	l/kg	Howard et al. 1991. Environmental Degradation
	Soil concentration	19000	mg/kg	Tetra Tech Factual Report 2022

1 No EQS for the aromatics, therefore UK DWS threshold applied

5.7 Sensitivity analysis

5.7.1 To assess the Site’s sensitivity to various parameters, a sensitivity analysis evaluated the impact on remedial targets for the contaminants of concern. The analysis focused on naphthalene, as this contaminant is considered the most mobile due to its high solubility in water. This process ensures that the most sensitive parameters are appropriately conservative. Each parameter’s value was adjusted by ±10%, and the modified Level 3 Remedial Target

(RT) was compared to the original. The results are summarised in Table 5.3.

Table 5.3 Summary of sensitivity analysis for naphthalene

Parameter	RT after a 10% reduction	Change from original RT (%)	Sensitivity (Low/Moderate /High)	RT after a 10% increase	Change from Original RT (%)	Sensitivity (Low/Moderate /High)
Water filled soil porosity	1.91E+11	0	Low	1.91E+11	0	Low
Air filled soil porosity	1.91E+11	0	Low	1.91E+11	0	Low
Bulk density of soil zone material	1.91E+11	0	Low	1.91E+11	0	Low
Infiltration	1.07E+12	460.21	High	4.37E+10	- 77.12	High
Area of contaminant source	1.91E+11	0	Low	1.91E+11	0	Low
Length of contaminant source in direction of groundwater flow	1.07E+12	460.21	High	4.37E+10	-77.12	High
Saturated aquifer thickness	4.26E+10	-77.70	High	8.26E+11	332.46	High
Hydraulic conductivity of aquifer in which dilution occurs	1.91E+11	0	Low	1.91E+11	0	Low
Hydraulic gradient	1.91E+11	0	Low	1.91E+11	0	Low
Width of contaminant source perpendicular to groundwater flow	2.13E+11	11.52	Moderate	1.74E+11	- 8.90	Moderate
Bulk density of aquifer materials	1.91E+11	0	Low	1.91E+11	0	Low
Effective porosity of aquifer	3.75E+10	-80.37	High	9.03E+11	372.77	High
Distance to compliance point	3.06E+10	-83.98	High	1.09E+12	815.97	High

The original Level 3 Remedial Target is 3.27E+11 mg/kg
Sensitivity Ratings: Low = <1%, Moderate 1-15%%, High >15%

5.7.2 The following parameters have been identified as having ‘High’ sensitivity:

- Infiltration
- Length of contaminant source in direction of groundwater flow
- Saturated aquifer thickness
- Effective porosity of aquifer
- Distance to compliance point

Discussion

5.7.3 Infiltration is identified as one of the most sensitive parameters. This parameter is likely to change over time due to the impacts of climate change. However, the value used in the model is based on Site specific published data including EA 1km^2 PET 2024 grid data and Met Office Midlands District 1991 – 2020 rainfall data. Therefore, it is considered to be appropriate for the Site and suitably conservative as a 10% increase did not result in an exceedance of the RT.

5.7.4 The length of contamination source in direction of groundwater flow is also highly sensitive. The values for the contaminant source length have been determined based on Site specific values and are unlikely to change from the chosen input parameters. Furthermore, the RT is -77.21% lower when the length is increased by 10%. The revised RT is 7.30E+10 which is still six orders of magnitude higher than the GI testing results of 19,000 mg/kg.

5.7.5 The value for the saturated aquifer thickness is also highly sensitive. It has been determined based on Site specific values and extensive GI across the Scheme. Therefore, this value is unlikely to change from the chosen input parameters. When increased by 10%, the RT was not exceeded.

5.7.6 The effective porosity of the aquifer was identified as a highly sensitive model input. Although there is no Site-specific value for this parameter, extensive GI across the Scheme has provided a comprehensive understanding of the area’s geology. A review of all exploratory logs for the Granular Alluvium described it as Sand (coarse). Consequently, literature[15] was used to accurately characterise the material’s effective porosity. When increased by 10%, the RT was not exceeded.

5.7.7 The distance to the compliance point is based on site-specific data obtained using online mapping tools calculated using worst case scenario. When this distance was reduced by 10%, the Remedial Target (RT) was not exceeded. Furthermore, even if the distance parameter is reduced to 100 meters, the RT target remains 2.54 orders of magnitude higher. It should be noted that if the distance to the compliance point is used in line with the assessed groundwater flow direction (as shown in Appendix C of this report) then the distance is considered to be 250m. Therefore, the value of 1650 meters is considered appropriate for the assessment.

5.7.8 It should be noted that the model does not fully account for the presence of a hard engineering barrier separating the river from the shallow groundwater. This barrier consists of a 78-meter-long section

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[15] McWorter, D.B. and Sunada, D.K., 1977. Ground-water hydrology and hydraulics. Water Resources Publication.

of 7-meter-deep sheet piles with concrete capping[16] , situated between the River Trent and the contamination hotspot. This structure presents a ‘cut-off’ wall between groundwater and the River Trent, that will likely further impede the migration of groundwater directly to the River Trent at this location, as the only pathway for impacted groundwater to enter the watercourse would be through any gaps in the connection joints. This factor has not been fully accounted for in the model and would likely further reduce the risk.

5.7.9 Furthermore, the insufficient yield of water from the wells during groundwater sampling suggests that the groundwater at the Site is either present at very low levels or is not readily accessible in the delineation boreholes (S3BH05, S3BH06, S3BH07).

5.8 Modelling outputs

5.8.1 Model outputs are presented in Table 5.4. The full Remedial Targets Worksheets for each contaminant of concern is contained in Appendix F of this report.

Table 5.4 Summary of the Remedial Target Methodology outputs

Determinant	Units	Maximum concentration	Level 3 Remedial Target	Remedial Target Exceeded
Aromatics >C10 <C12	mg/kg	46900	2.76E+14	No
Arsenic	mg/l	0.0669	1.57	
Benzo(a)pyrene	mg/kg	78	414	
Benzo(b)fluoranthene	mg/kg	94	120	
Dibenz(a,h)anthracene	mg/kg	14	4.80E+10	
Naphthalene	mg/kg	19000	1.91E+11	

5.8.2 Using the input parameters detailed in Table 5.1 and Table 5.2, modelling of the contaminant migration has demonstrated that the concentrations of aromatics >C10 <C12, arsenic, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, naphthalene would have no measurable impact on the controlled water receptor. These were all found to be attenuated and degraded within the aquifer and would not migrate as far as the River Trent.

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[16] British Geological Survey, GeoIndex, Reference SK85NW256. Available at: BGS ID: 15933855 : BGS Reference: SK85NW256 Accessed November 2024

6 Conclusions

6.1.1 The GQRA [APP 164 – 169] showed marginal exceedances of the EQS in leachate samples (WS46 and delineation boreholes) and groundwater samples upgradient of the Site (BH11 and BH12) and downgradient of the Site (BH14). Although groundwater is impacted, the correlation between soil leachate exceedances and groundwater exceedances at the Site is slight. Notably, only copper, zinc, and ammoniacal nitrogen as N have exceeded the EQS threshold values in both leachate and groundwater samples. These determinants are not considered to be associated with the contaminant material identified in the soil and are therefore unlikely to originate from the hotspot.

6.1.2 A Detailed Quantitative Risk Assessment has been undertaken to determine whether the contamination source identified at the location of WS46 and S3BH05 poses a risk to controlled waters. The assessment utilises site-specific GI data and the Remedial Targets Methodology model developed by the Environment Agency, focusing on a range of polycyclic aromatic hydrocarbons, aromatic hydrocarbons and arsenic, identified as potential contaminants of concern during Site investigation.

6.1.3 Where possible, Site-specific values for the aquifer properties were used. In cases where these values were unavailable, literature values accepted by the Environment Agency were adopted, with the most conservative values applied where applicable.

6.1.4 This modelling has determined that the Made Ground at the Site (WS46 and S3BH05) is unlikely to have a significant impact on the quality of the River Trent. Therefore, it is not considered to represent an existing or ongoing significant risk, provided no intrusive works are conducted at the location of exploratory holes WS46 and S3BH05.

6.1.5 Given that no excavation works are proposed at the Site (WS46 and S3BH05), which has been delineated and assessed as being unlikely to have a significant impact on the quality of the River Trent, it is proposed to leave the material in-situ. Therefore no remediation is required. Commitment GS4 in Table 3-2 (Register of Environmental Actions and Commitments) in the First Iteration Environmental Management Plan [REP3-022] stipulates that the location of the contamination hotspot will be recorded and documented by the Detailed Design Consultant and shared to the Principal Contractor (PC). Before construction commences, the PC will install fencing and signage, clearly identifying and restricting access to the WS46 hotspot area.

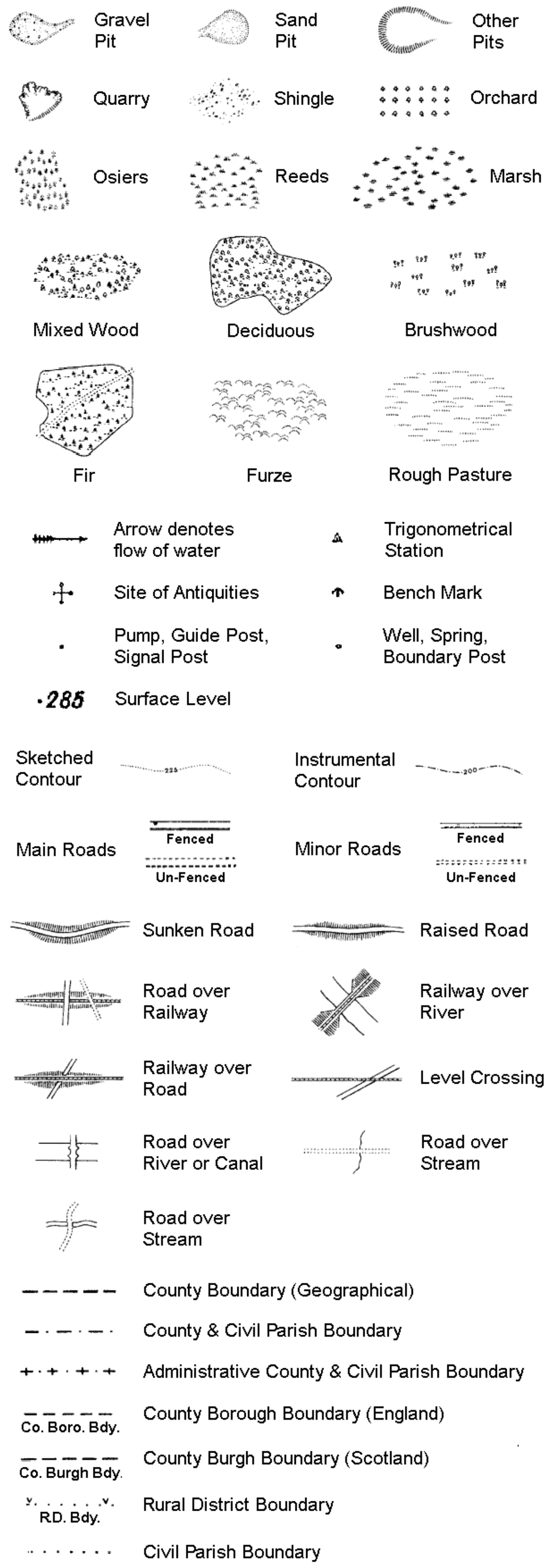
6.1.6 As detailed in commitment GS6 in Table 3-2 (Register of Environmental Actions and Commitments) in the First Iteration Environmental Management Plan [REP3-022], a verification report is required to be produced on completion of the earthworks and landscaping. This verification report will confirm that no excavation works have taken place at the location of the contamination hotspot at WS46.

7 Appendices

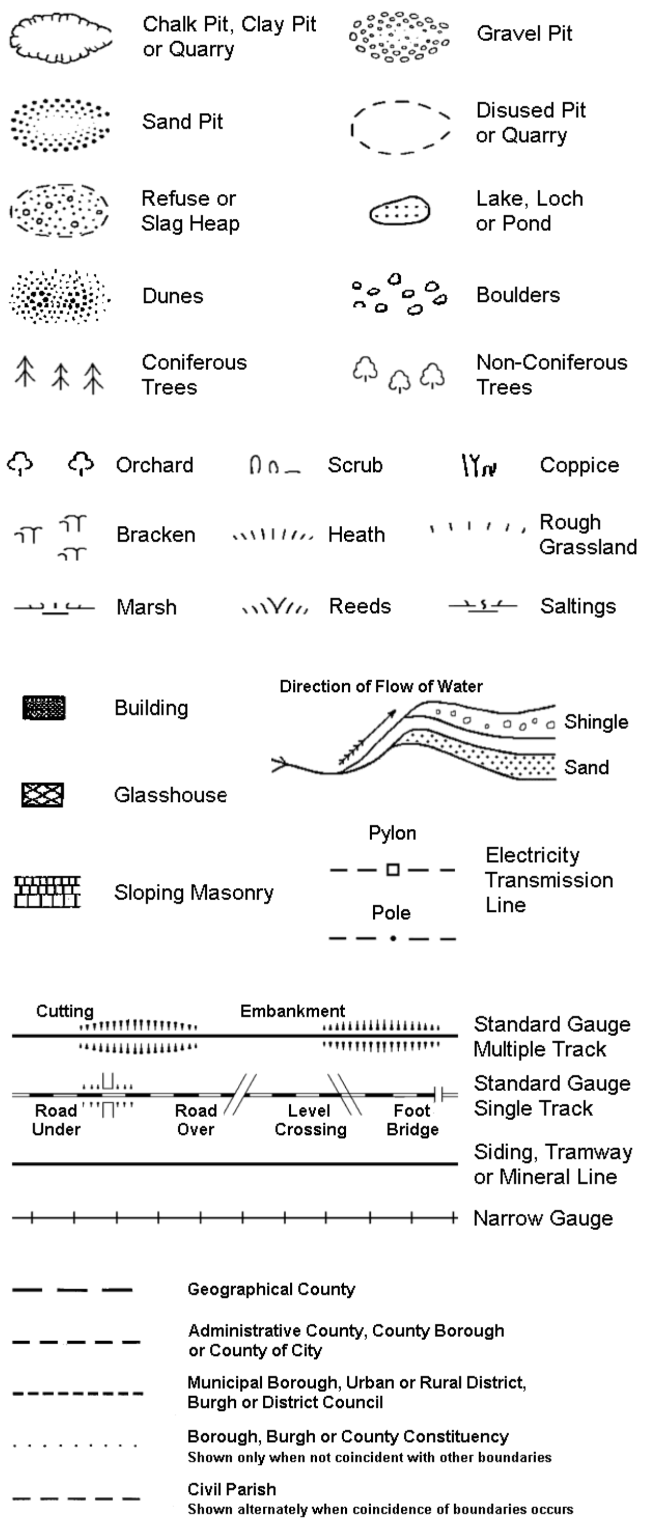
A. Envirocheck Report Site History

Historical Mapping Legends

Ordnance Survey County Series 1:10,560

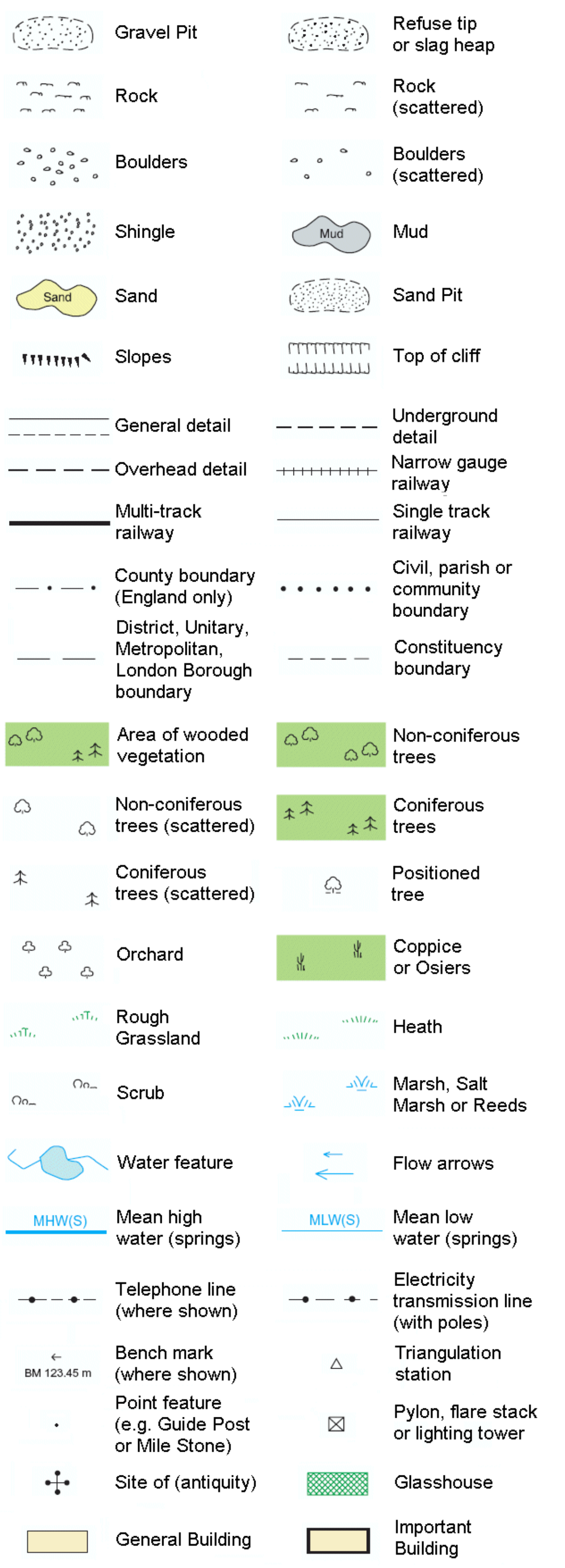


Ordnance Survey Plan 1:10,000



BP, BS	Boundary Post or Stone	Pol Sta	Police Station
Ch	Church	PO	Post Office
CH	Club House	PC	Public Convenience
F E Sta	Fire Engine Station	PH	Public House
FB	Foot Bridge	SB	Signal Box
Fn	Fountain	Spr	Spring
GP	Guide Post	TCB	Telephone Call Box
MP	Mile Post	TCP	Telephone Call Post
MS	Mile Stone	W	Well

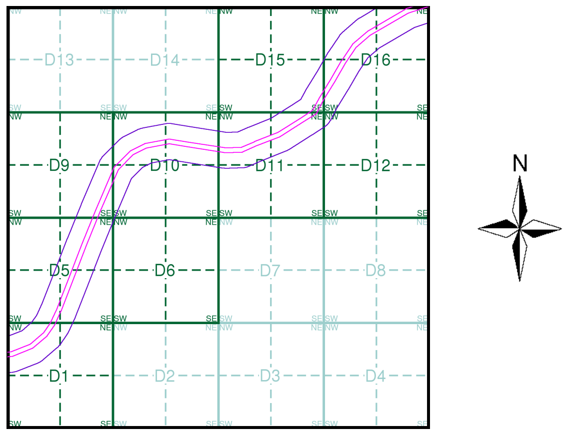
1:10,000 Raster Mapping



Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Nottinghamshire	1:10,560	1884	2
Nottinghamshire	1:10,560	1900 - 1901	3
Nottinghamshire	1:10,560	1921	4
Nottinghamshire	1:10,560	1921	5
Nottinghamshire	1:10,560	1938	6
Historical Aerial Photography	1:10,560	1948	7
Ordnance Survey Plan	1:10,000	1955 - 1956	8
Ordnance Survey Plan	1:10,000	1966 - 1969	9
Ordnance Survey Plan	1:10,000	1971 - 1973	10
Ordnance Survey Plan	1:10,000	1971	11
Ordnance Survey Plan	1:10,000	1986	12
Ordnance Survey Plan	1:10,000	1992	13
Ordnance Survey Plan	1:10,000	1992	14
10K Raster Mapping	1:10,000	2000	15
10K Raster Mapping	1:10,000	2006	16
VectorMap Local	1:10,000	2018	17

Historical Map - Slice D



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National Grid Reference: 480890, 355770
Slice: D
Site Area (Ha): 21.45
Search Buffer (m): 1000

Site Details

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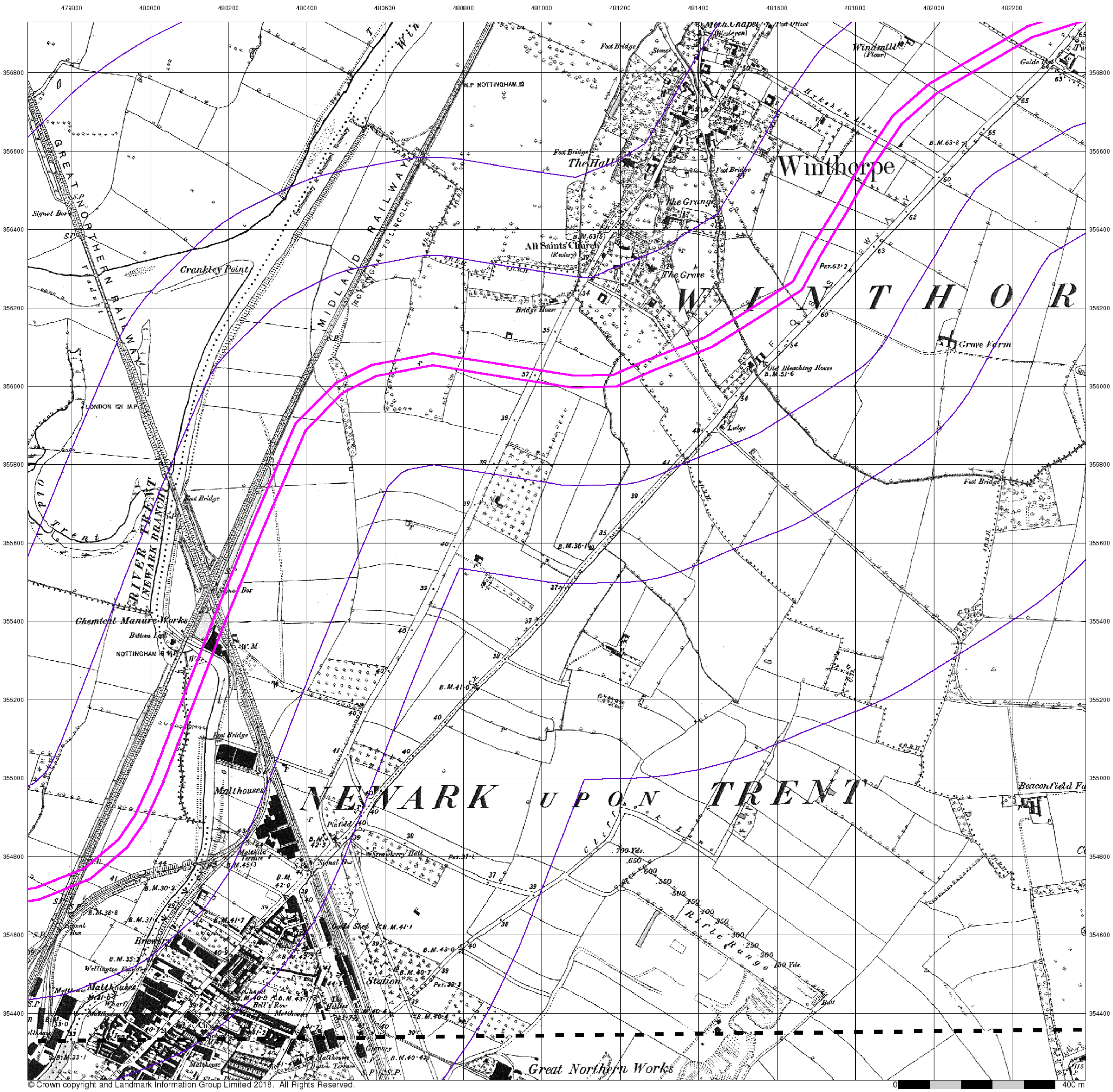
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



0 400 m

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Nottinghamshire

Published 1884

Source map scale - 1:10,560

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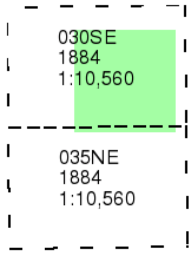
Map Name(s) and Date(s)



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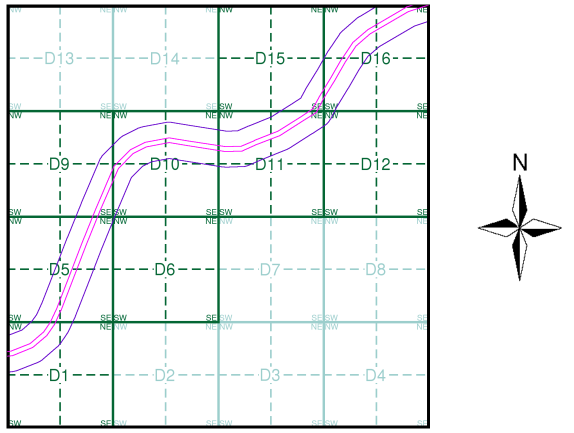

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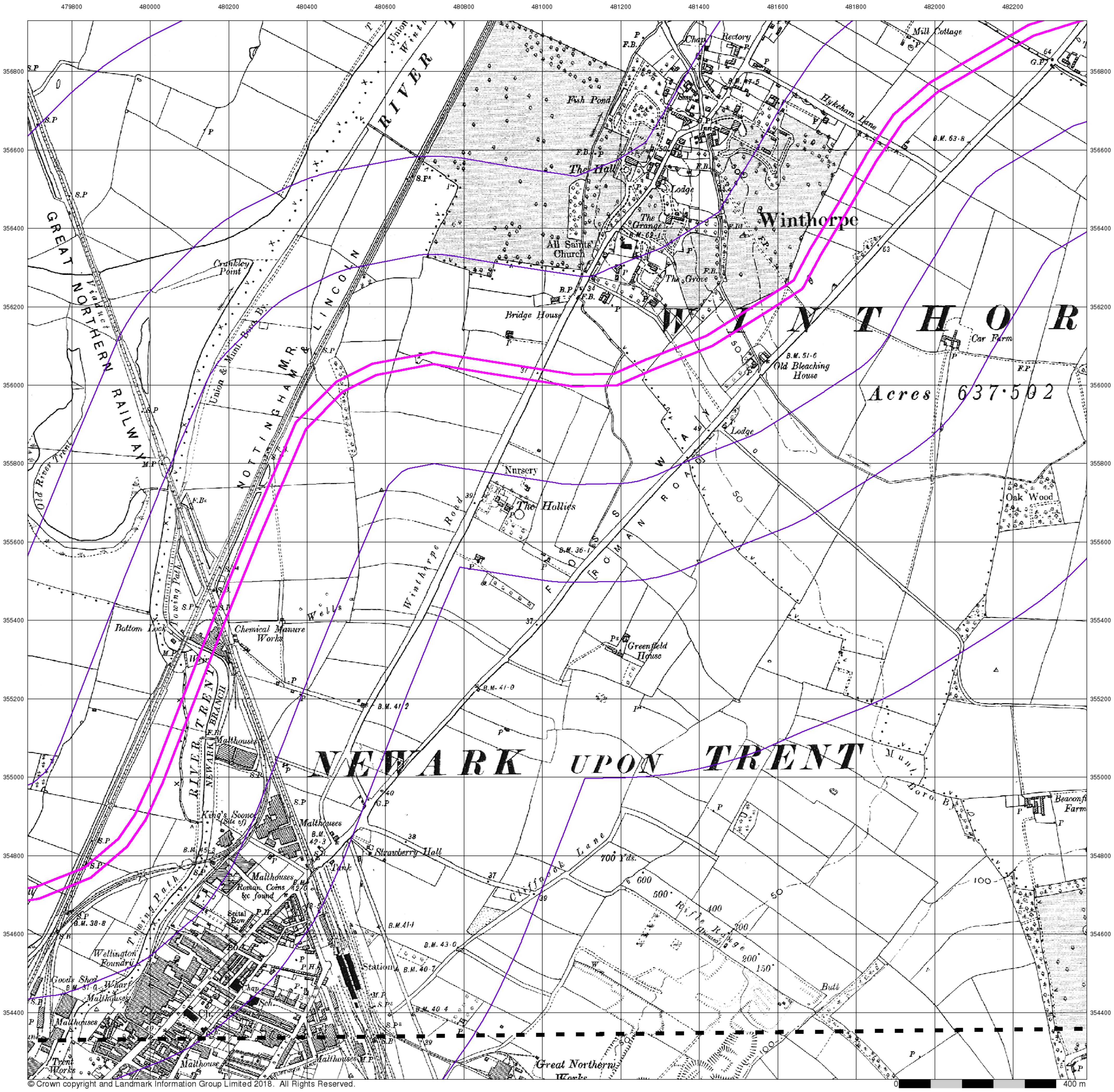

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Published 1900 - 1901

Source map scale - 1:10,560

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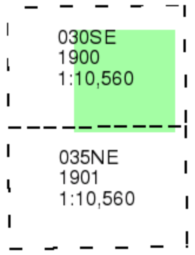
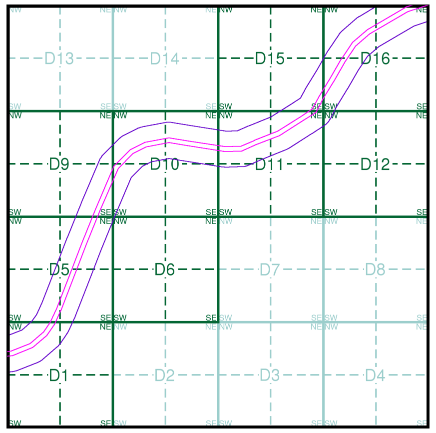


Historical Map - Slice D



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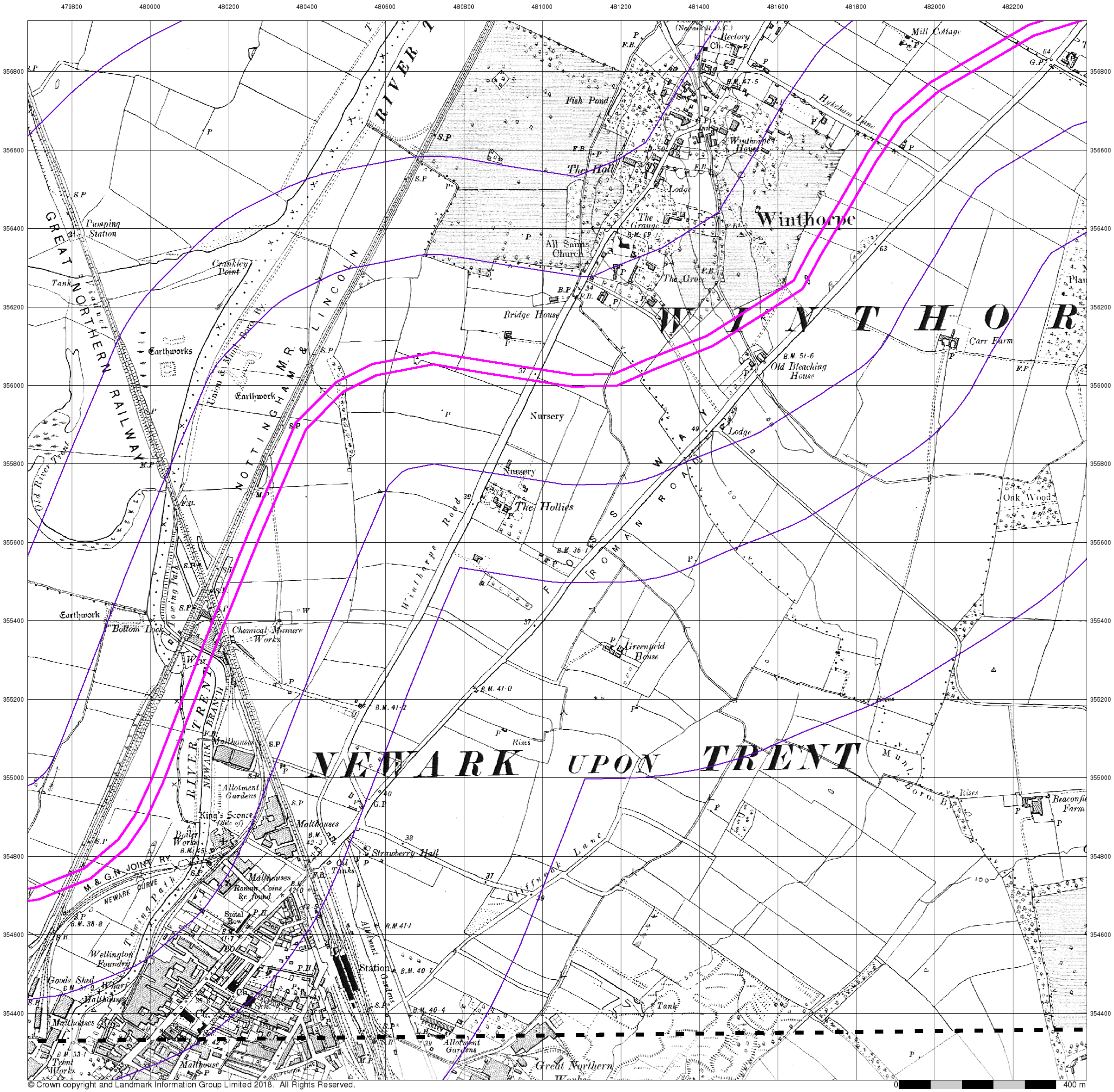

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Published 1921

Source map scale - 1:10,560

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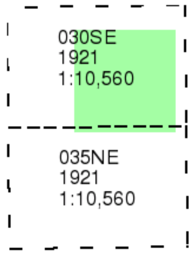
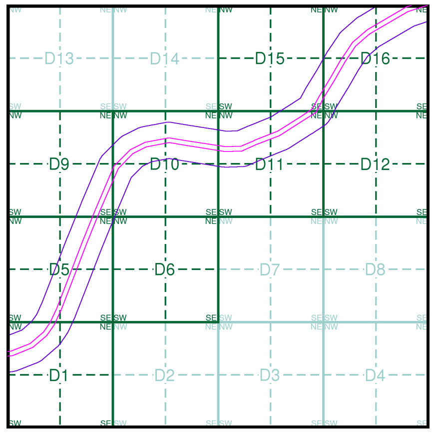


Historical Map - Slice D



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Order Details

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National Grid Reference: 480890, 355770
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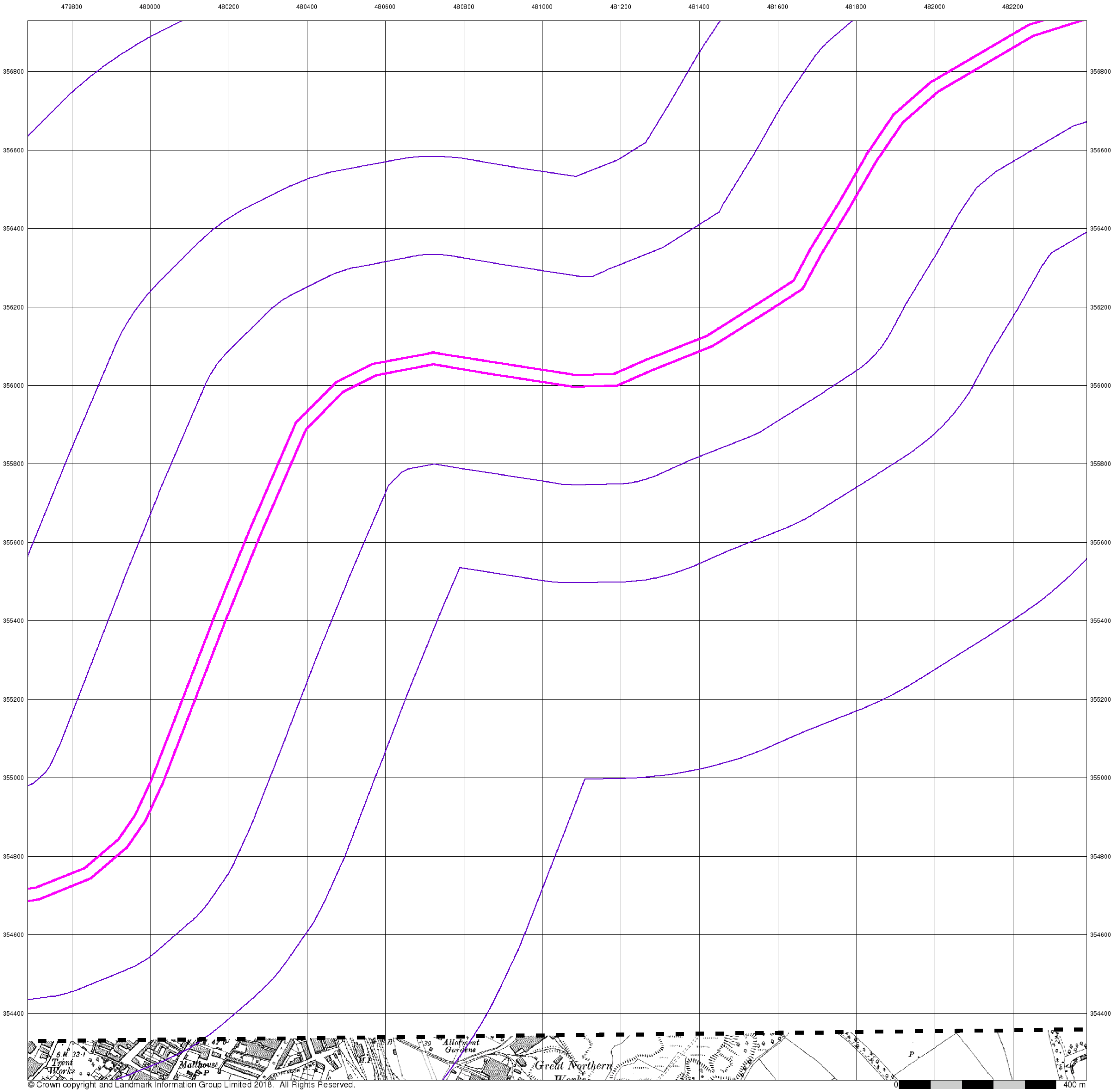

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Published 1921

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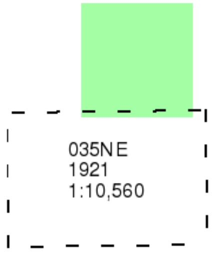
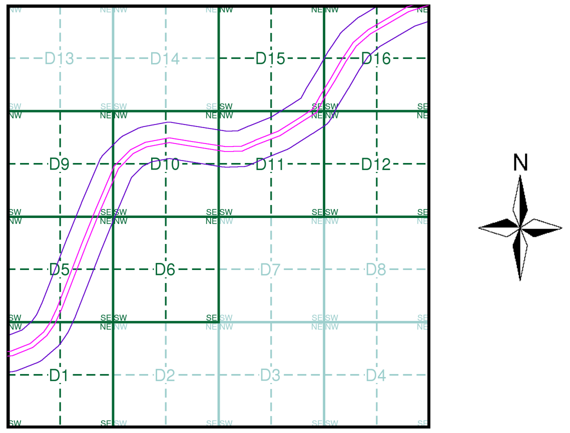


Historical Map - Slice D



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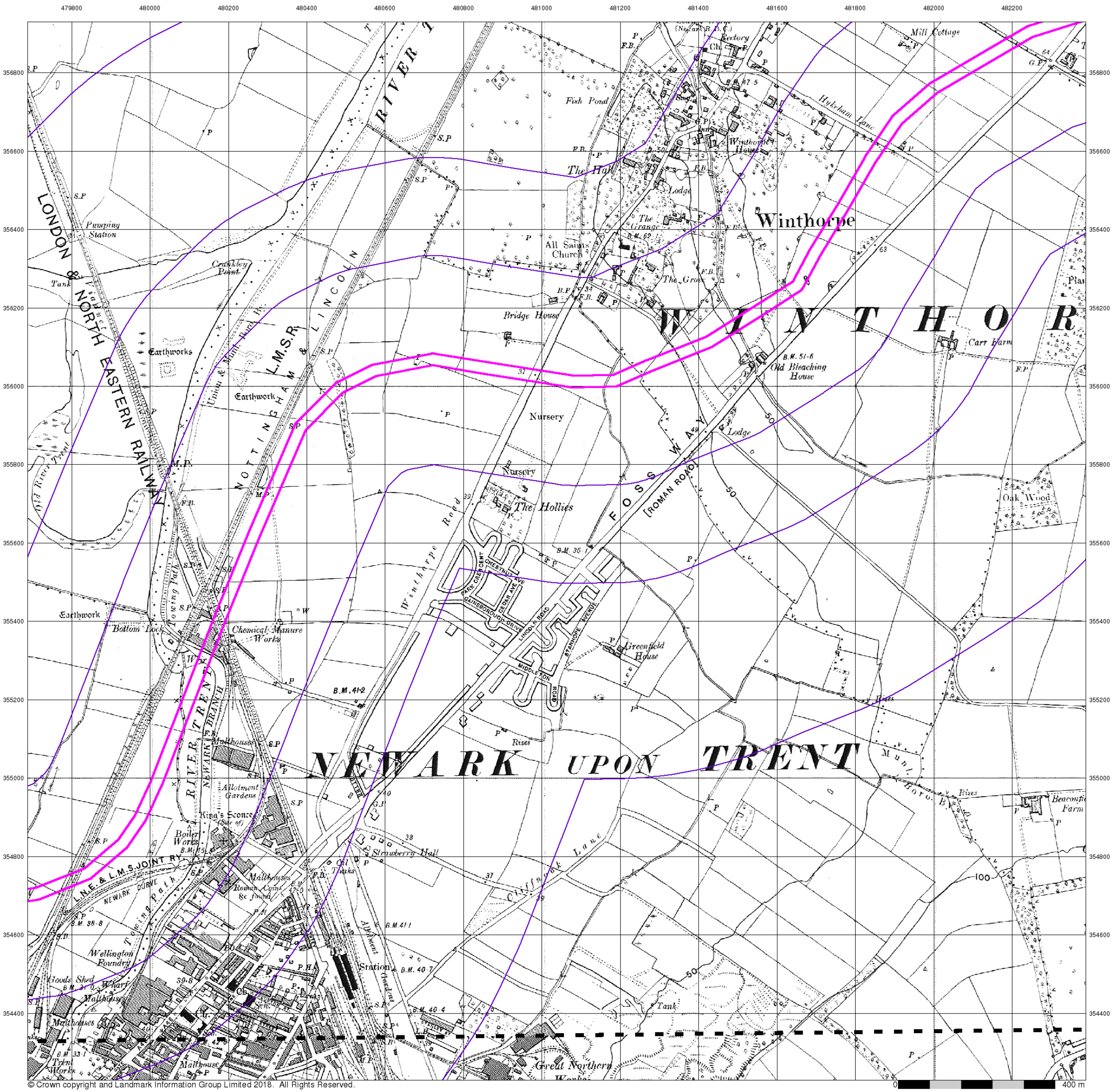

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Published 1938

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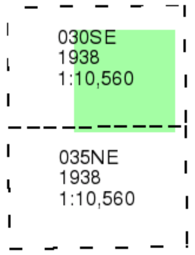
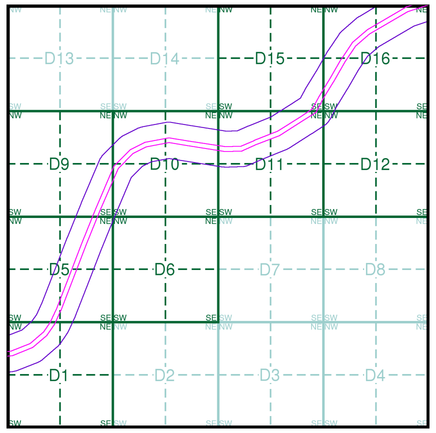


Historical Map - Slice D



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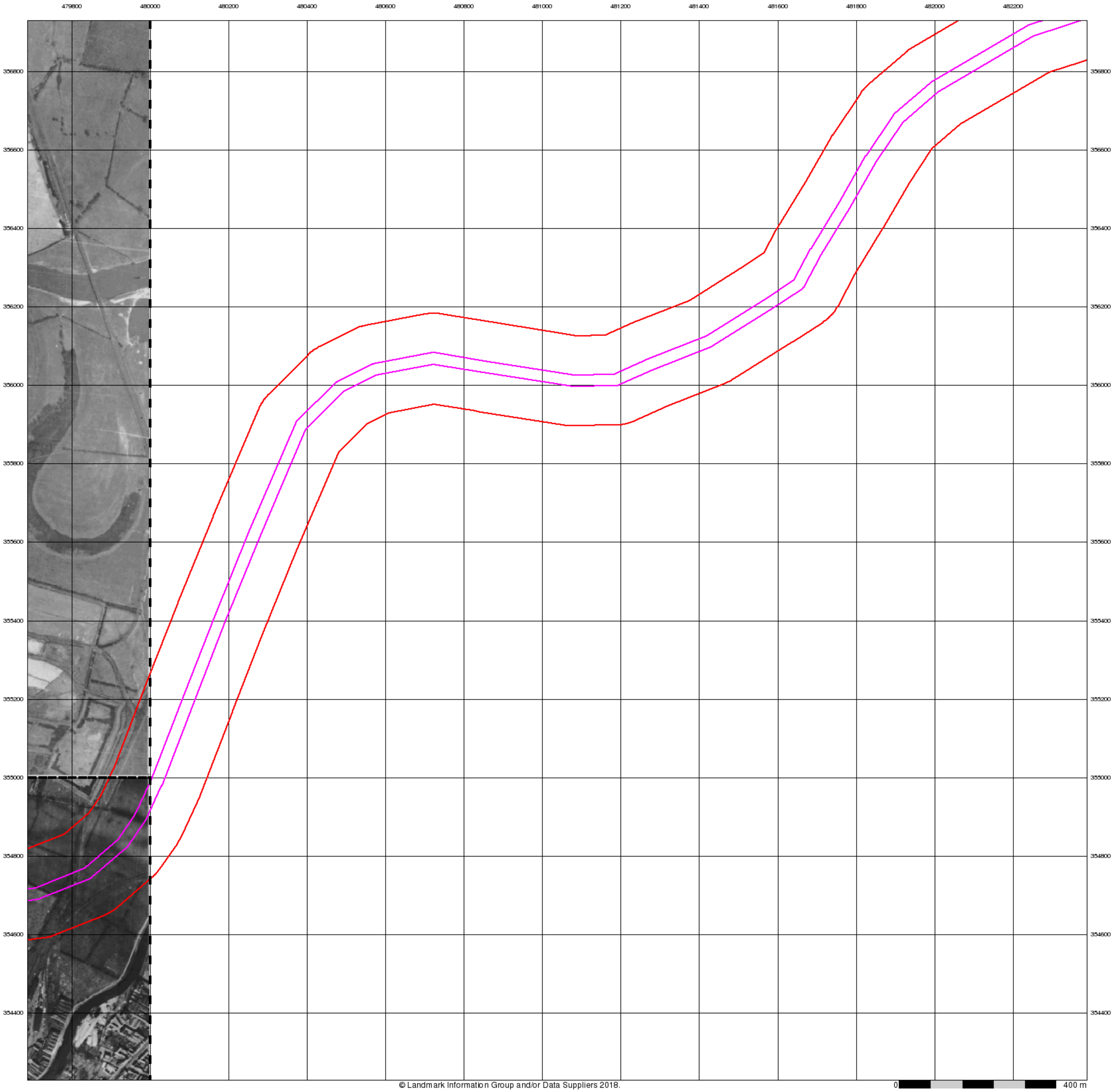

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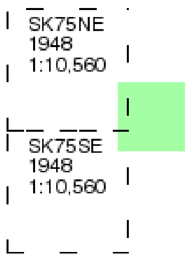
Historical Aerial Photography

Published 1948

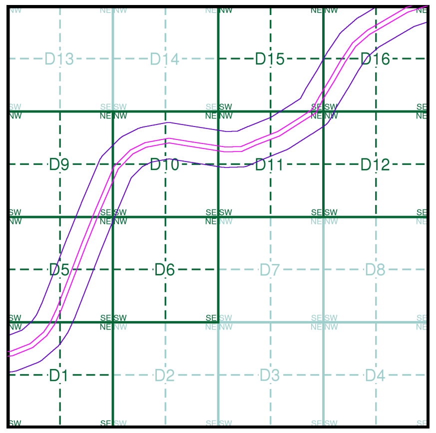
Source map scale - 1:10,560

The Historical Aerial Photos were produced by the Ordnance Survey at a scale of 1:1,250 and 1:10,560 from Air Force photography. They were produced between 1944 and 1951 as an interim measure, pending preparation of conventional mapping, due to post war resource shortages. New security measures in the 1950's meant that every photograph was re-checked for potentially unsafe information with security sites replaced by fake fields or clouds. The original editions were withdrawn and only later made available after a period of fifty years although due to the accuracy of the editing, without viewing both revisions it is not easy to spot the edits. Where available Landmark have included both revisions.

Map Name(s) and Date(s)



Historical Aerial Photography - Slice D



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Slice:	D
Site Area (Ha):	21.45
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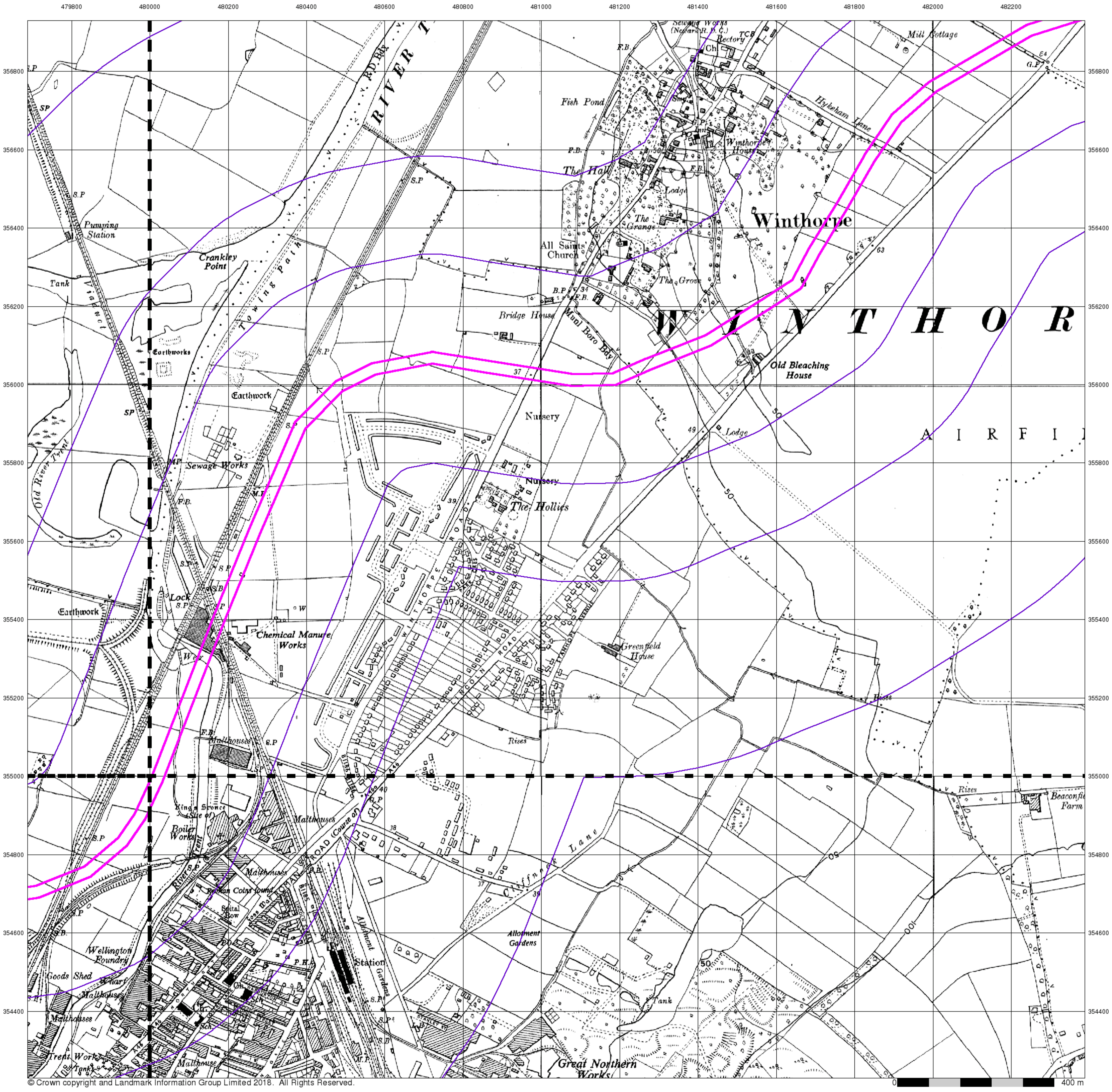

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Ordnance Survey Plan

Published 1955 - 1956

Source map scale - 1:10,000

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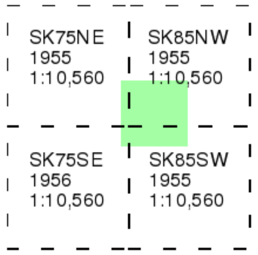
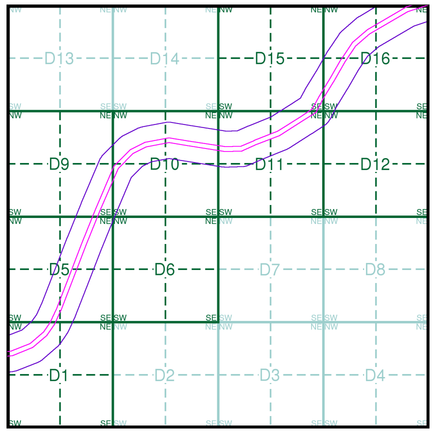


Historical Map - Slice D



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Ordnance Survey Plan

Published 1966 - 1969

Source map scale - 1:10,000

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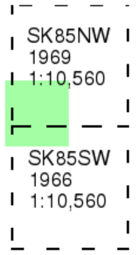
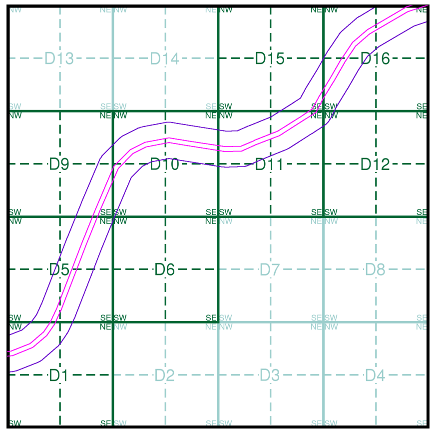


Historical Map - Slice D



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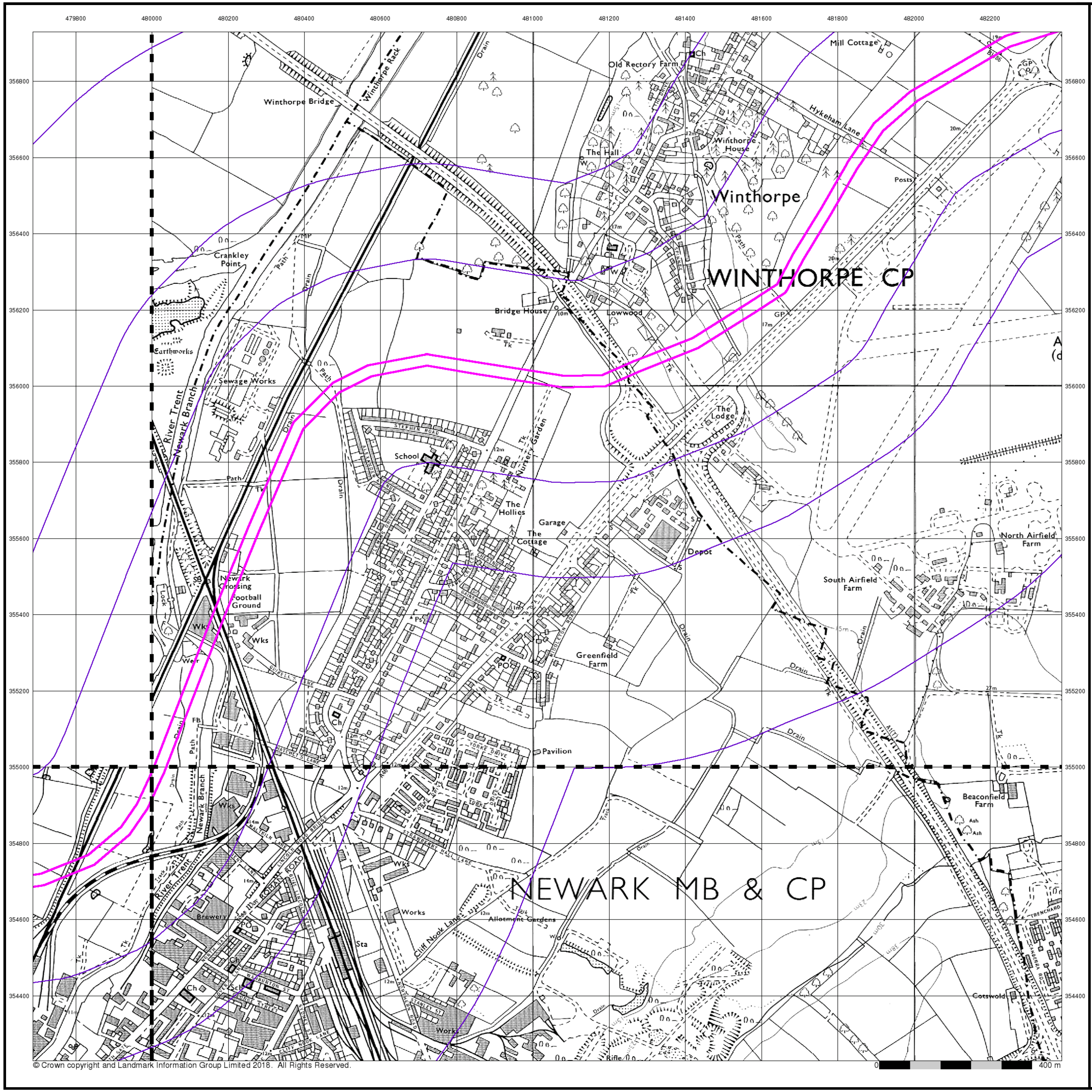

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Ordnance Survey Plan

Published 1971 - 1973

Source map scale - 1:10,000

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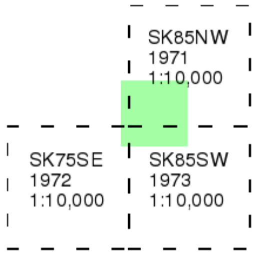
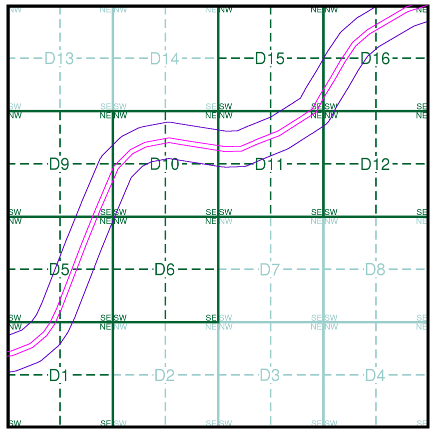


Historical Map - Slice D



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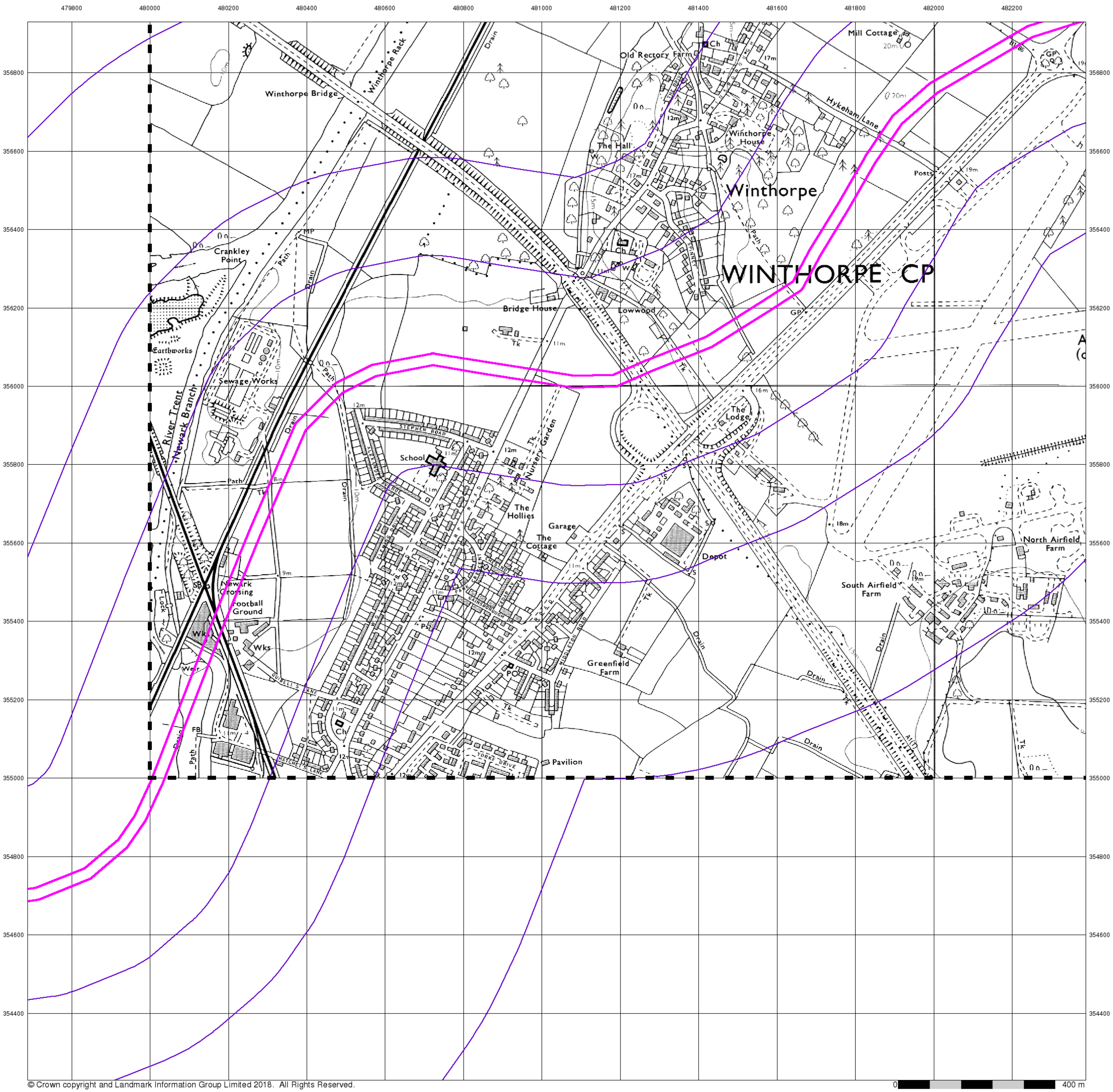

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Ordnance Survey Plan

Published 1971

Source map scale - 1:10,000

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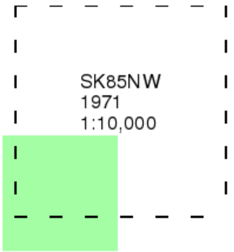
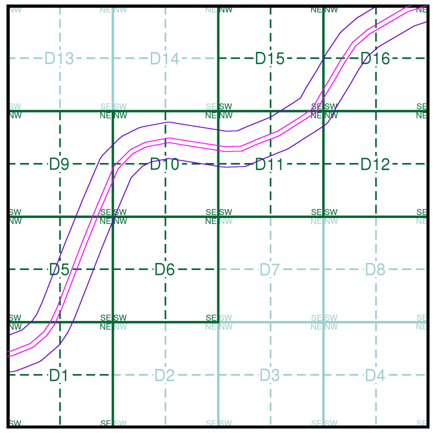


Historical Map - Slice D



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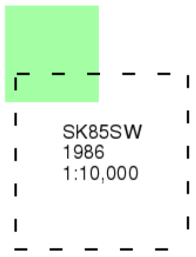
Ordnance Survey Plan

Published 1986

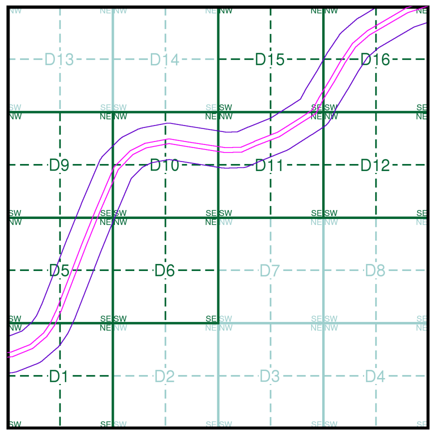
Source map scale - 1:10,000

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice D



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Order Number:	172582399_1_1
Customer Ref:	5162675 sub no 255
National Grid Reference:	480890, 355770
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Site Area (Ha):	21.45
Search Buffer (m):	1000

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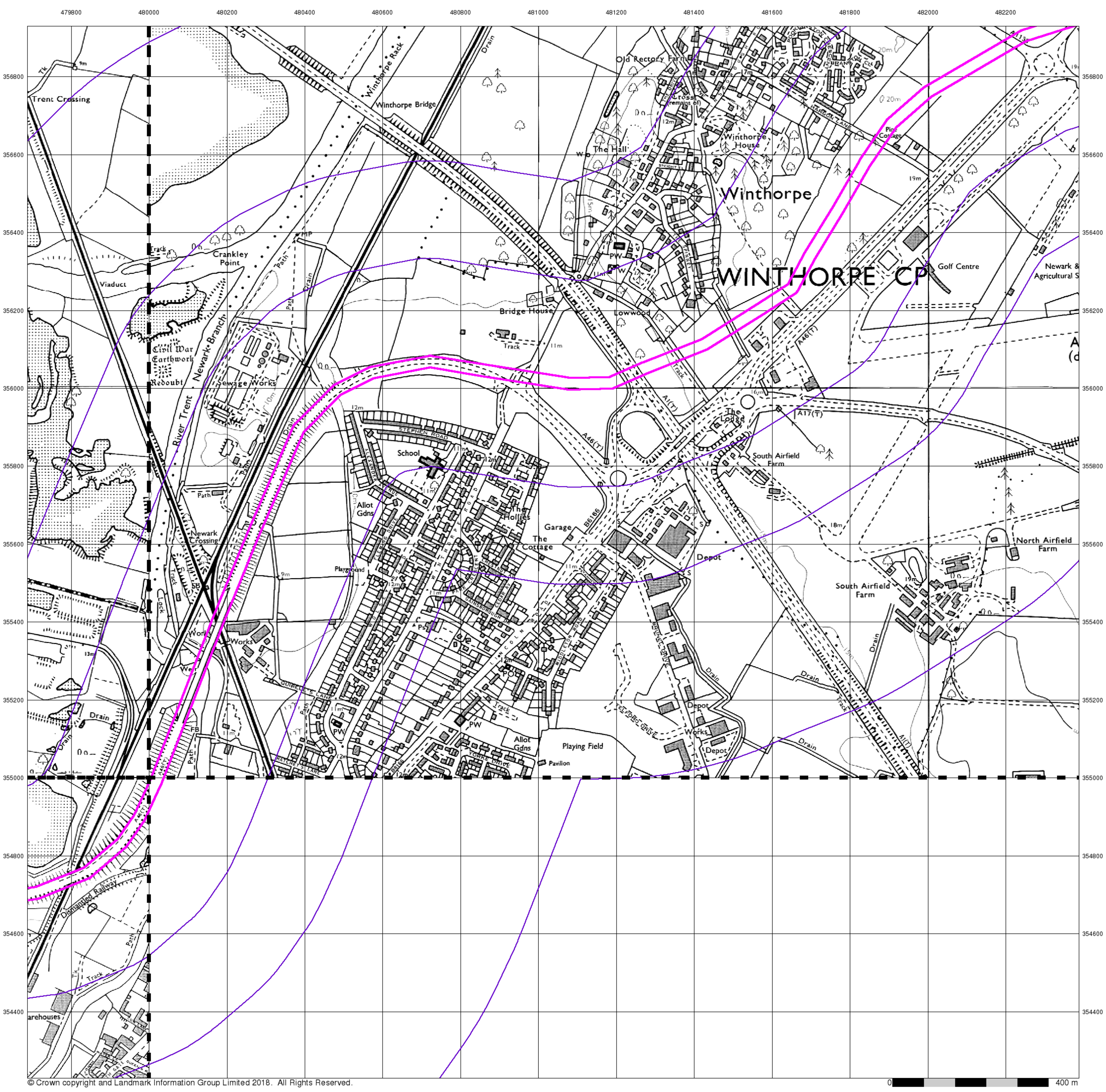

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Ordnance Survey Plan

Published 1992

Source map scale - 1:10,000

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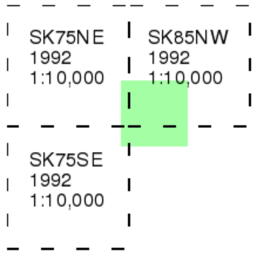

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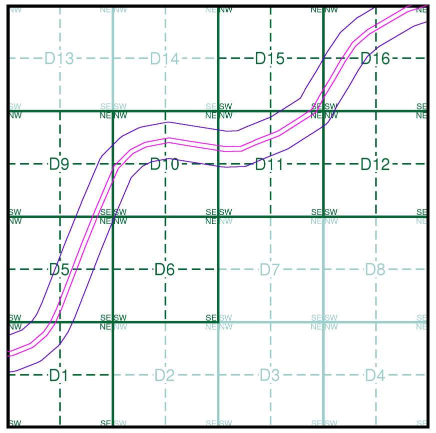

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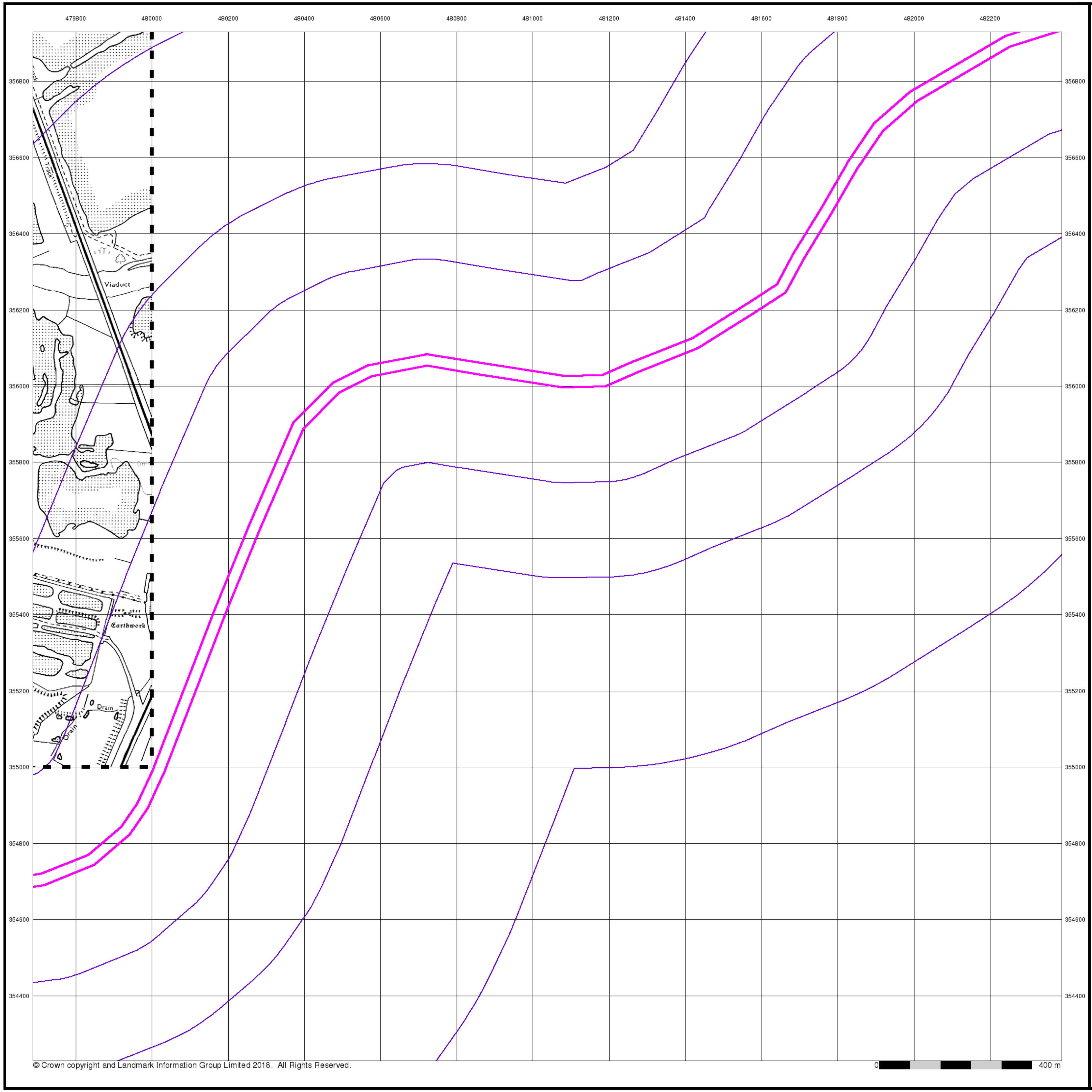

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Ordnance Survey Plan

Published 1992

Source map scale - 1:10,000

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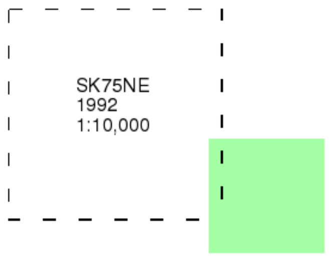

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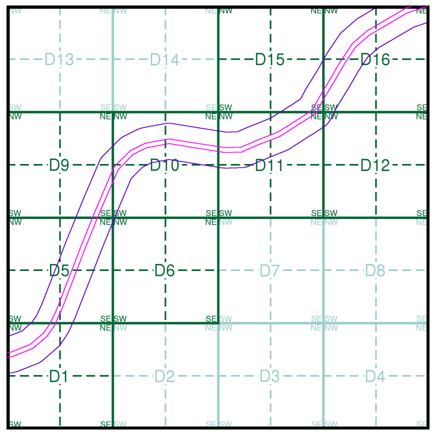

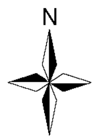

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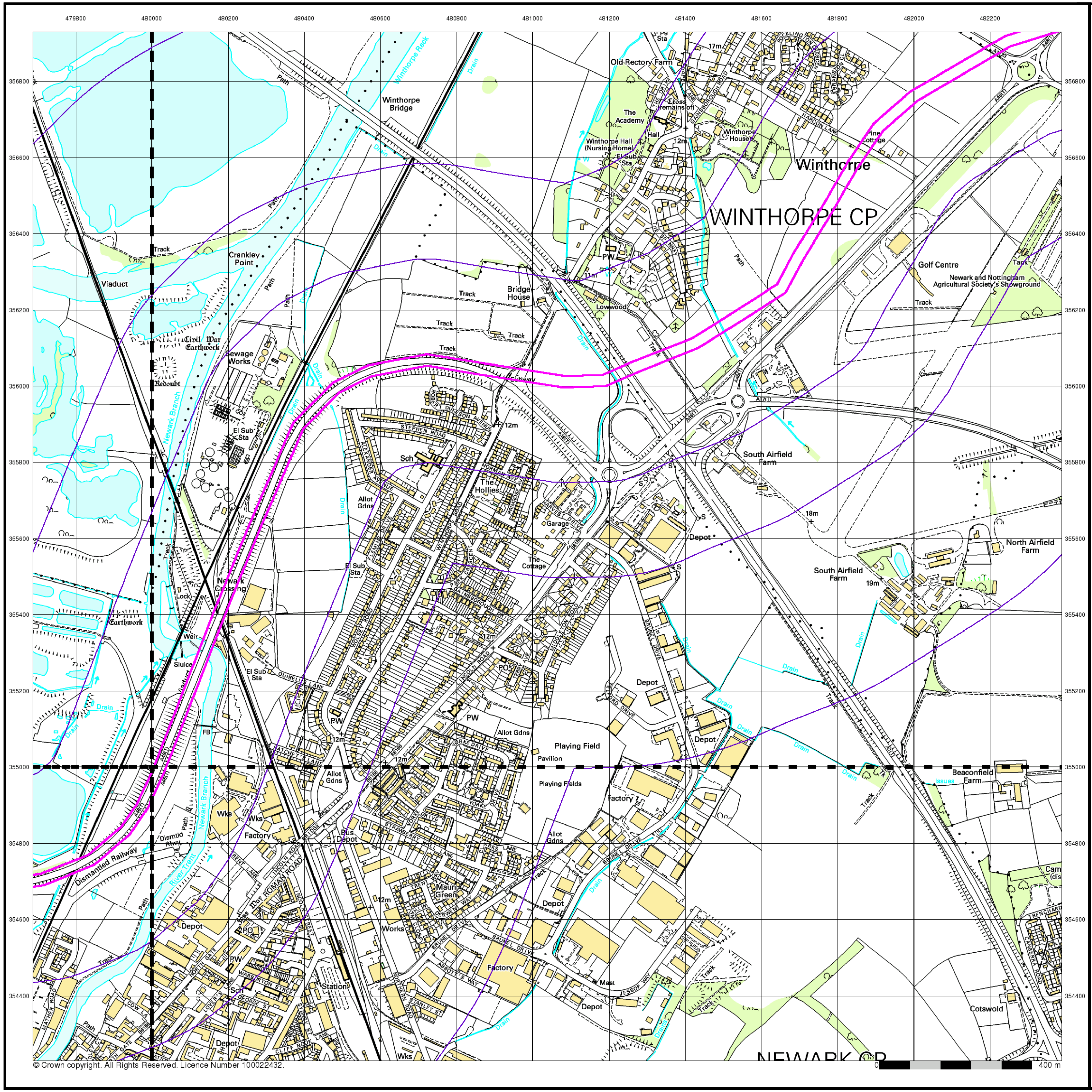

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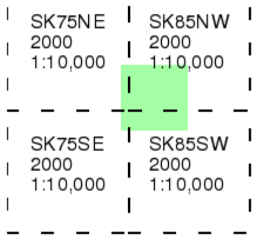
10k Raster Mapping

Published 2000

Source map scale - 1:10,000

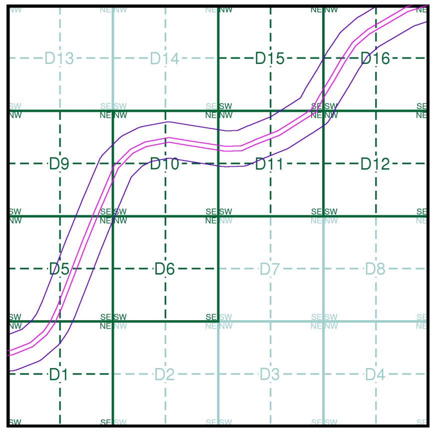
The historical maps shown were produced from the Ordnance Survey`s 1:10,000 colour raster mapping. These maps are derived from Landplan which replaced the old 1:10,000 maps originally published in 1970. The data is highly detailed showing buildings, fences and field boundaries as well as all roads, tracks and paths. Road names are also included together with the relevant road number and classification. Boundary information depiction includes county, unitary authority, district, civil parish and constituency.

Map Name(s) and Date(s)



SK75NE 2000 1:10,000	SK85NW 2000 1:10,000
SK75SE 2000 1:10,000	SK85SW 2000 1:10,000

Historical Map - Slice D



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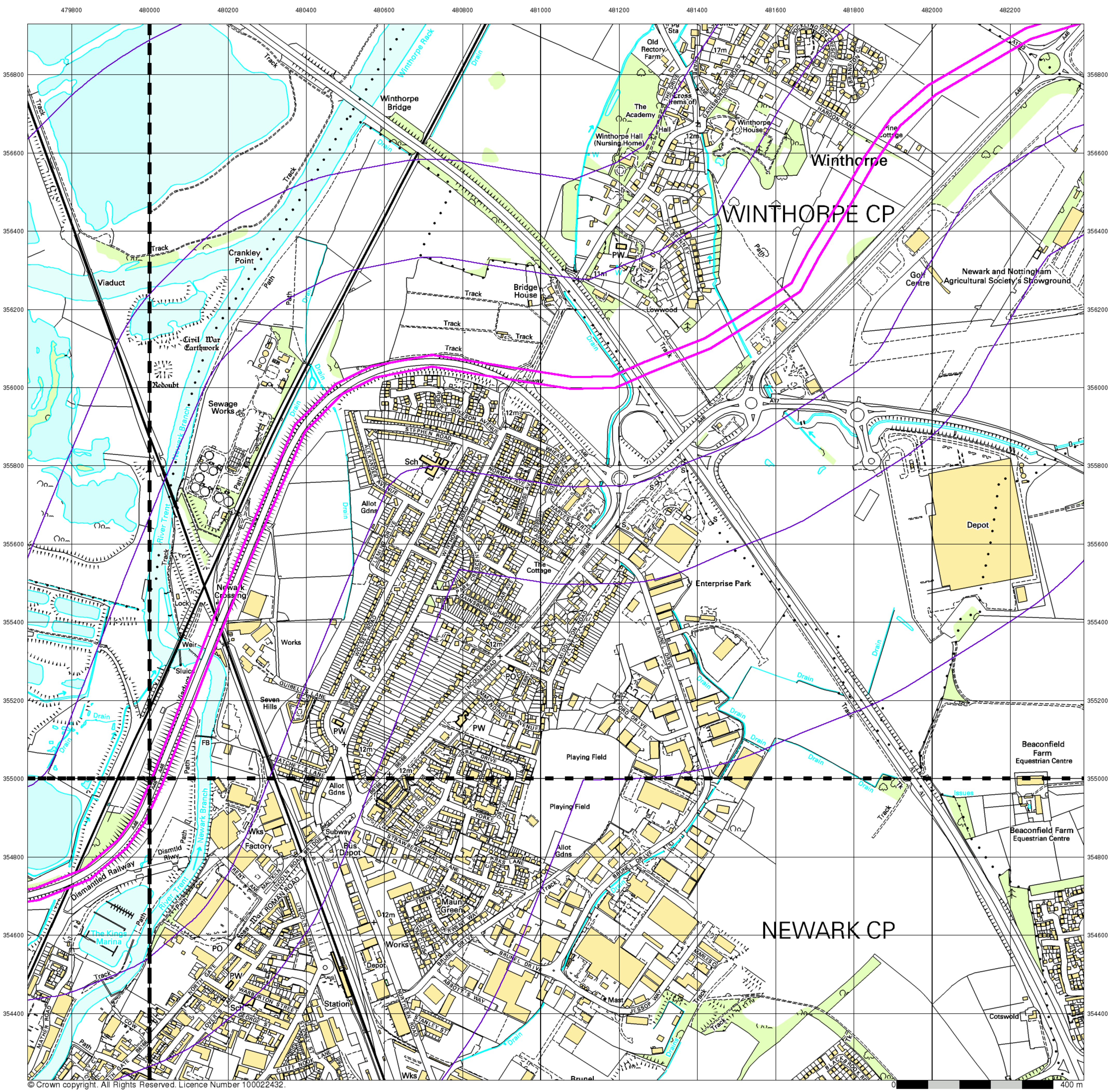


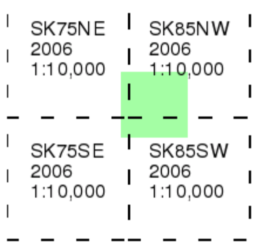
10k Raster Mapping

Published 2006

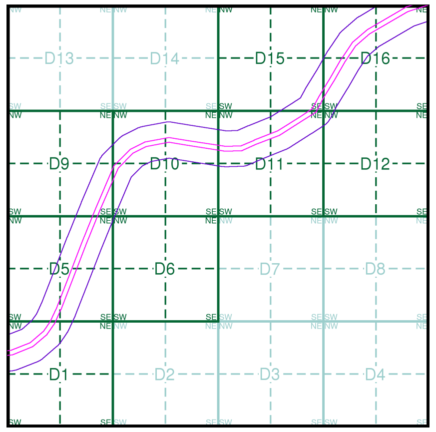
Source map scale - 1:10,000

The historical maps shown were produced from the Ordnance Survey`s 1:10,000 colour raster mapping. These maps are derived from Landplan which replaced the old 1:10,000 maps originally published in 1970. The data is highly detailed showing buildings, fences and field boundaries as well as all roads, tracks and paths. Road names are also included together with the relevant road number and classification. Boundary information depiction includes county, unitary authority, district, civil parish and constituency.

Map Name(s) and Date(s)



Historical Map - Slice D



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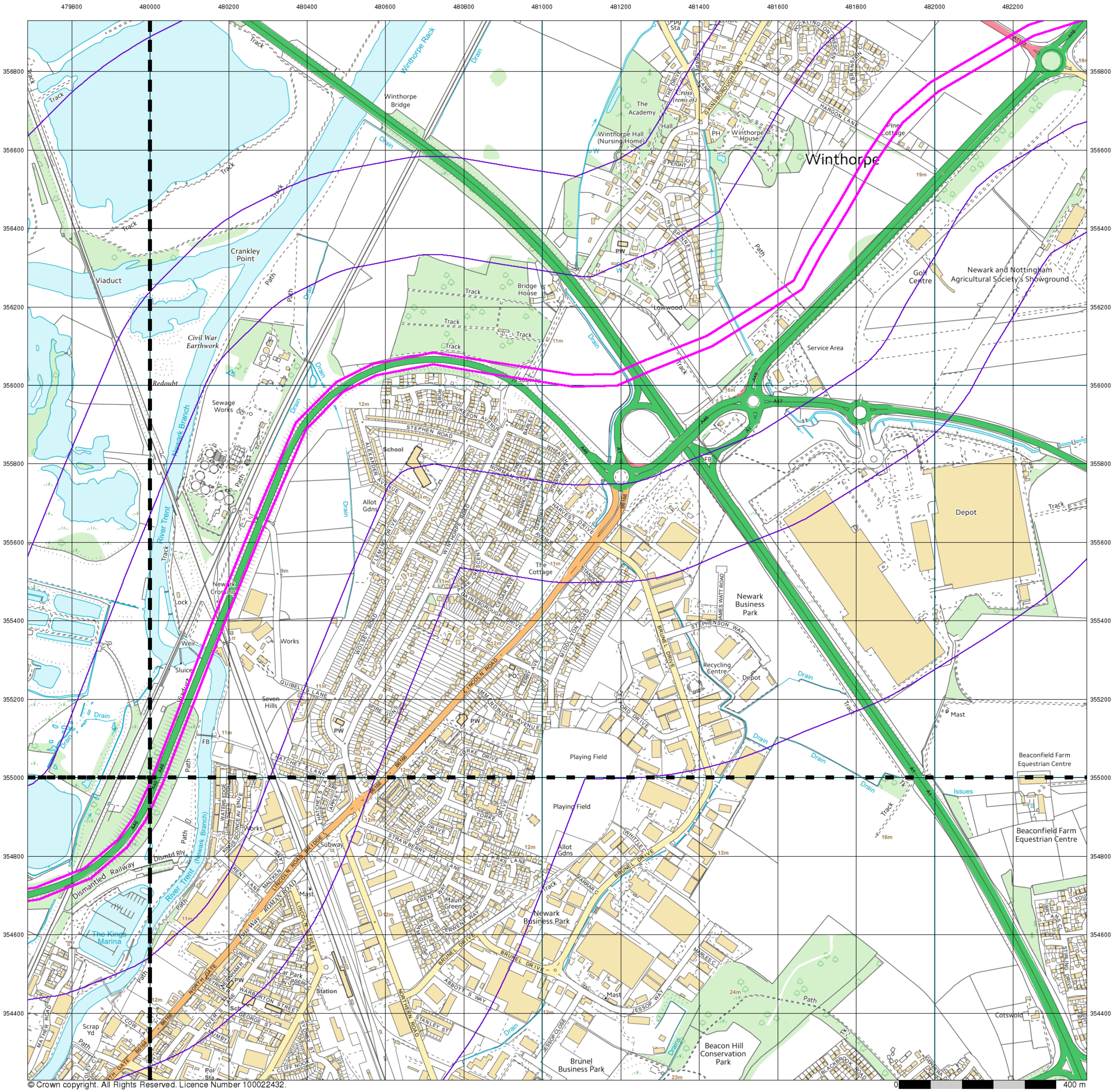

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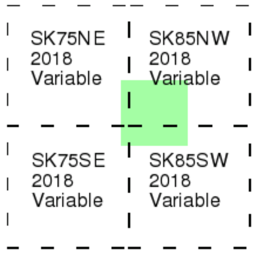
VectorMap Local

Published 2018

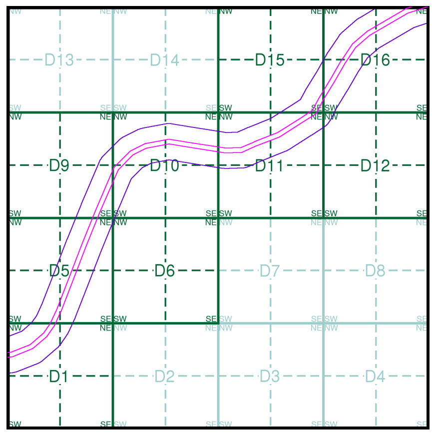
Source map scale - 1:10,000

VectorMap Local (Raster) is Ordnance Survey's highest detailed 'backdrop' mapping product. These maps are produced from OS's VectorMap Local, a simple vector dataset at a nominal scale of 1:10,000, covering the whole of Great Britain, that has been designed for creating graphical mapping. OS VectorMap Local is derived from large-scale information surveyed at 1:1250 scale (covering major towns and cities),1:2500 scale (smaller towns, villages and developed rural areas), and 1:10 000 scale (mountain, moorland and river estuary areas).

Map Name(s) and Date(s)



Historical Map - Slice D



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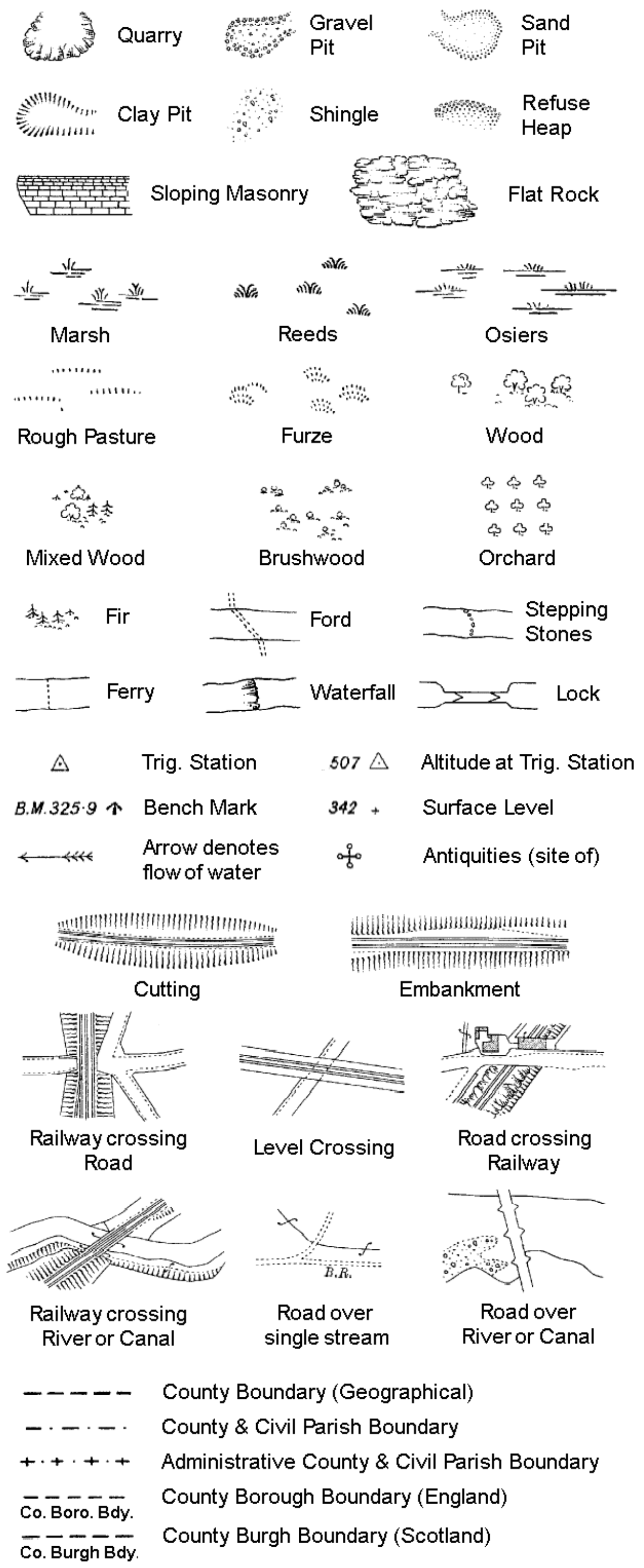
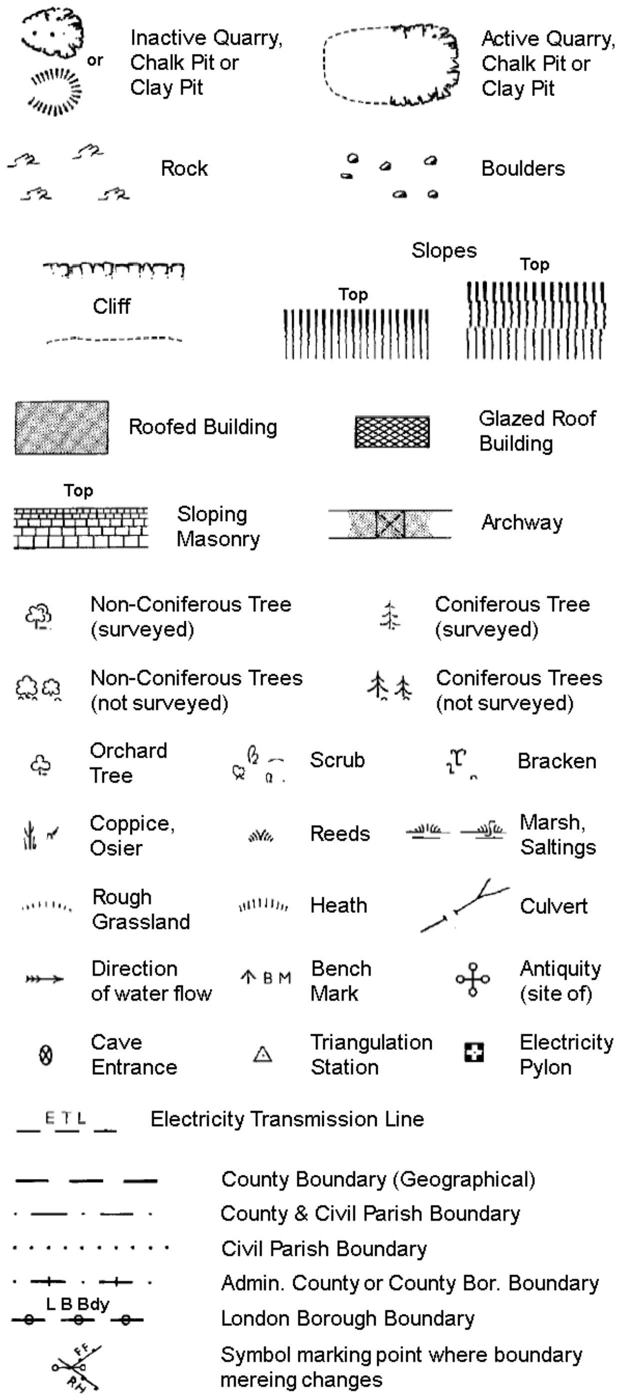
Historical Mapping Legends

Ordnance Survey County Series and Ordnance Survey Plan 1:2,500



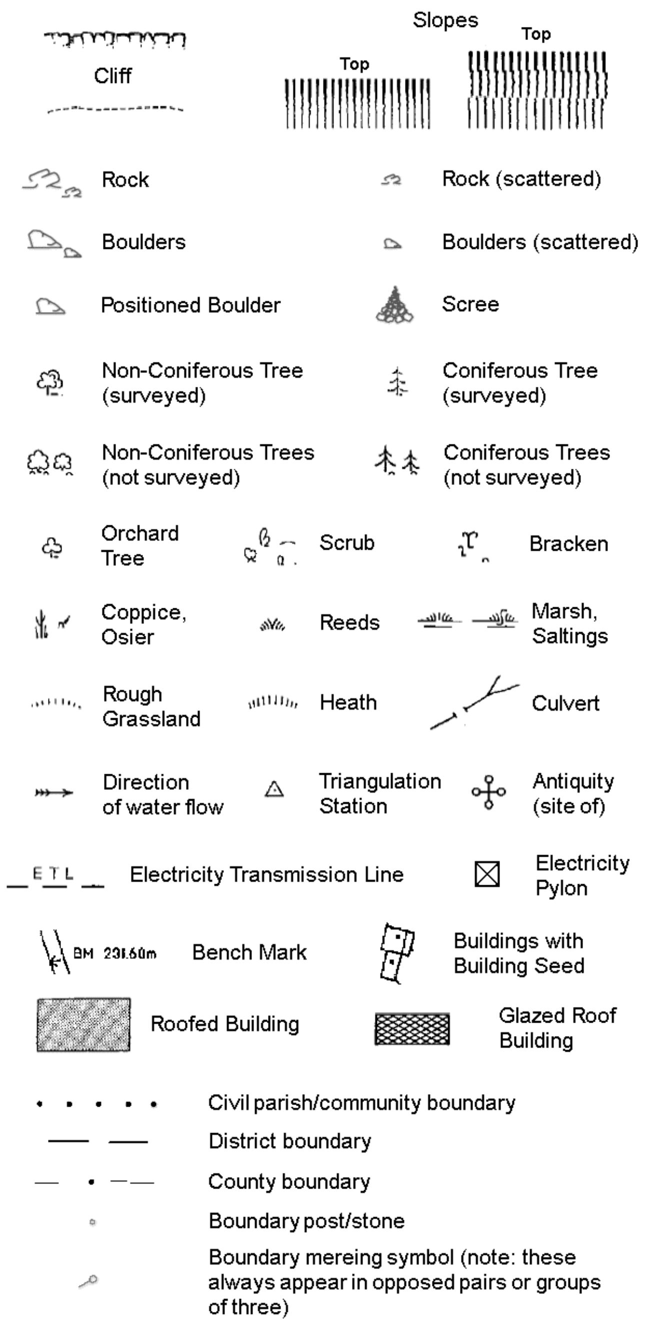
BP BS	Boundary Post or Stone	*P.C.B*	Police Call Box
B.R.	Bridle Road	*P*	Pump
E.P	Electricity Pylon	*S.P*	Signal Post
F.B.	Foot Bridge	*Sl.*	Sluice
F.P.	Foot Path	*Sp.*	Spring
G.P	Guide Post or Board	*T.C.B*	Telephone Call Box
M.S	Mile Stone	*Tr.*	Trough
M.P M.R	Mooring Post or Ring	*W*	Well

Ordnance Survey Plan, Additional SIMs and Supply of Unpublished Survey Information 1:2,500 and 1:1,250



BH	Beer House	P	Pillar, Pole or Post
BP, BS	Boundary Post or Stone	PO	Post Office
Cn, C	Capstan, Crane	PC	Public Convenience
Chy	Chimney	PH	Public House
D Fn	Drinking Fountain	Pp	Pump
El P	Electricity Pillar or Post	SB, S Br	Signal Box or Bridge
FAP	Fire Alarm Pillar	SP, SL	Signal Post or Light
FB	Foot Bridge	Spr	Spring
GP	Guide Post	Tk	Tank or Track
H	Hydrant or Hydraulic	TCB	Telephone Call Box
LC	Level Crossing	TCP	Telephone Call Post
MH	Manhole	Tr	Trough
MP	Mile Post or Mooring Post	Wr Pt, Wr T	Water Point, Water Tap
MS	Mile Stone	W	Well
NTL	Normal Tidal Limit	Wd Pp	Wind Pump

Large-Scale National Grid Data 1:2,500 and 1:1,250



Bks	Barracks	P	Pillar, Pole or Post
Bty	Battery	PO	Post Office
Cemy	Cemetery	PC	Public Convenience
Chy	Chimney	Pp	Pump
Cis	Cistern	Ppg Sta	Pumping Station
Dismtd Rly	Dismantled Railway	PW	Place of Worship
El Gen Sta	Electricity Generating Station	Sewage Ppg Sta	Sewage Pumping Station
El P	Electricity Pole, Pillar	SB, S Br	Signal Box or Bridge
El Sub Sta	Electricity Sub Station	SP, SL	Signal Post or Light
FB	Filter Bed	Spr	Spring
Fn / D Fn	Fountain / Drinking Ftn.	Tk	Tank or Track
Gas Gov	Gas Valve Compound	Tr	Trough
GVC	Gas Governer	Wd Pp	Wind Pump
GP	Guide Post	Wr Pt, Wr T	Water Point, Water Tap
MH	Manhole	Wks	Works (building or area)
MP, MS	Mile Post or Mile Stone	W	Well

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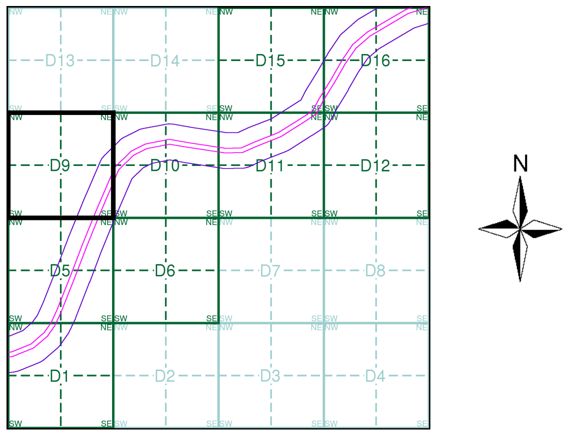
Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Nottinghamshire	1:2,500	1884 - 1886	2
Nottinghamshire	1:2,500	1900	3
Nottinghamshire	1:2,500	1919 - 1920	4
Ordnance Survey Plan	1:1,250	1965	5
Ordnance Survey Plan	1:2,500	1969 - 1970	6
Supply of Unpublished Survey Information	1:2,500	1974	7
Supply of Unpublished Survey Information	1:1,250	1976	8
Additional SIMs	1:2,500	1977 - 1991	9
Additional SIMs	1:1,250	1984	10
Additional SIMs	1:2,500	1990	11
Additional SIMs	1:1,250	1990	12
Large-Scale National Grid Data	1:2,500	1993 - 1994	13
Large-Scale National Grid Data	1:1,250	1993	14
Large-Scale National Grid Data	1:1,250	1996	15
Historical Aerial Photography	1:2,500	1999	16

Historical Map - Segment D9



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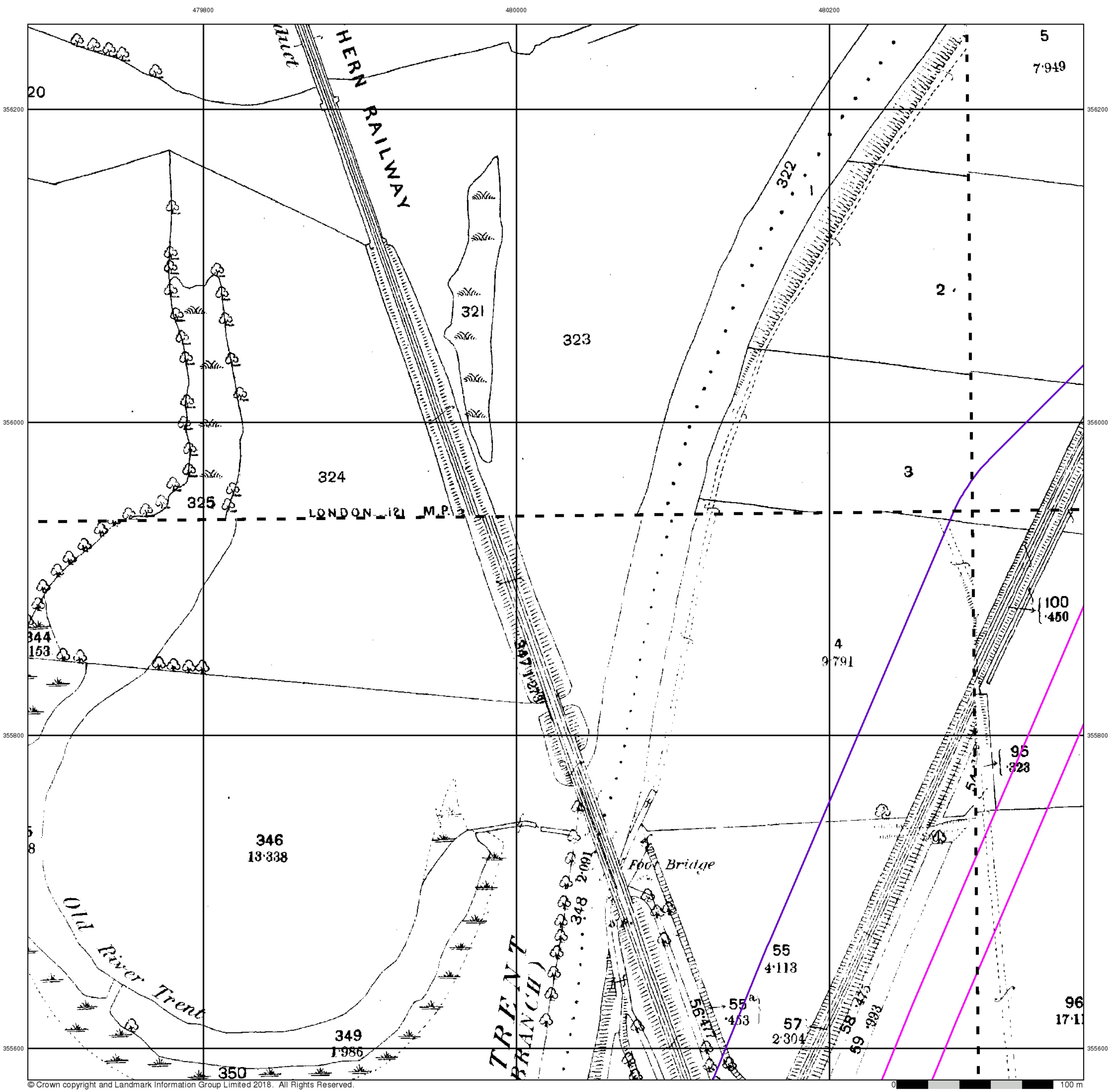

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Nottinghamshire

Published 1884 - 1886

Source map scale - 1:2,500

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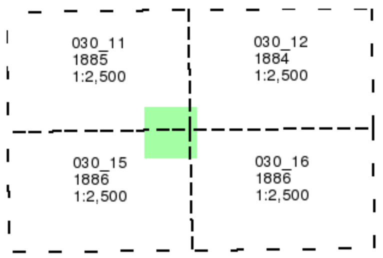
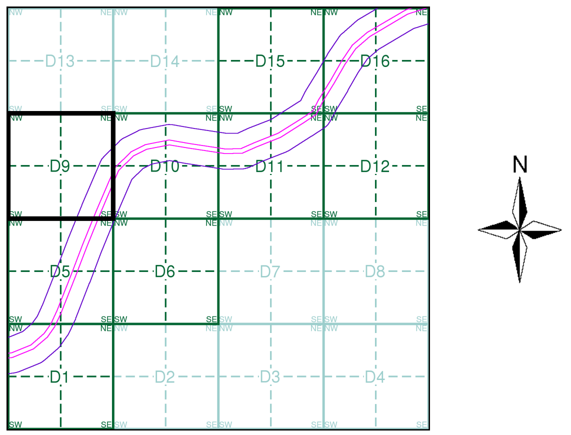
Map Name(s) and Date(s)



Historical Map - Segment D9



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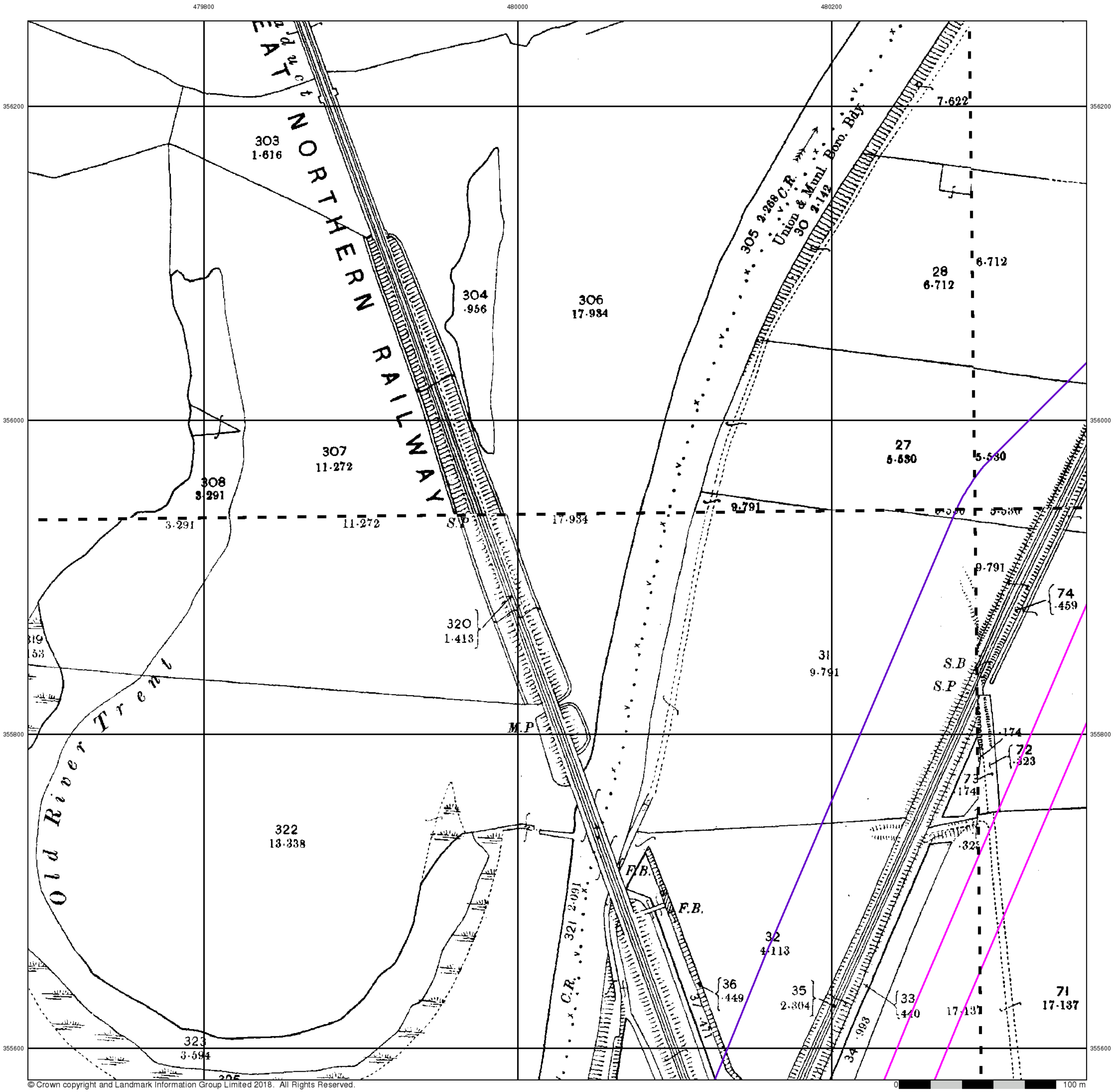

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Nottinghamshire

Published 1900

Source map scale - 1:2,500

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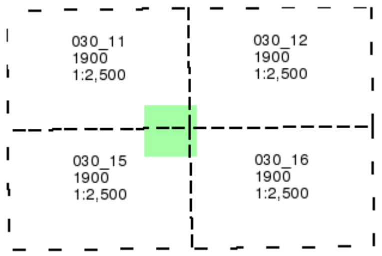

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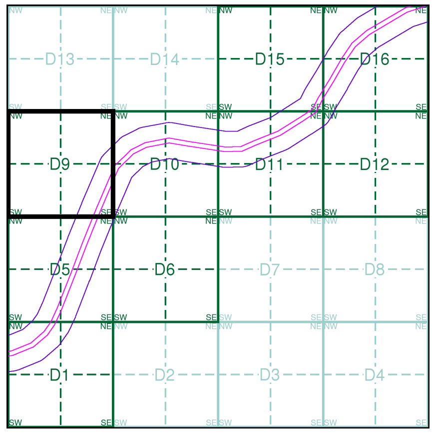

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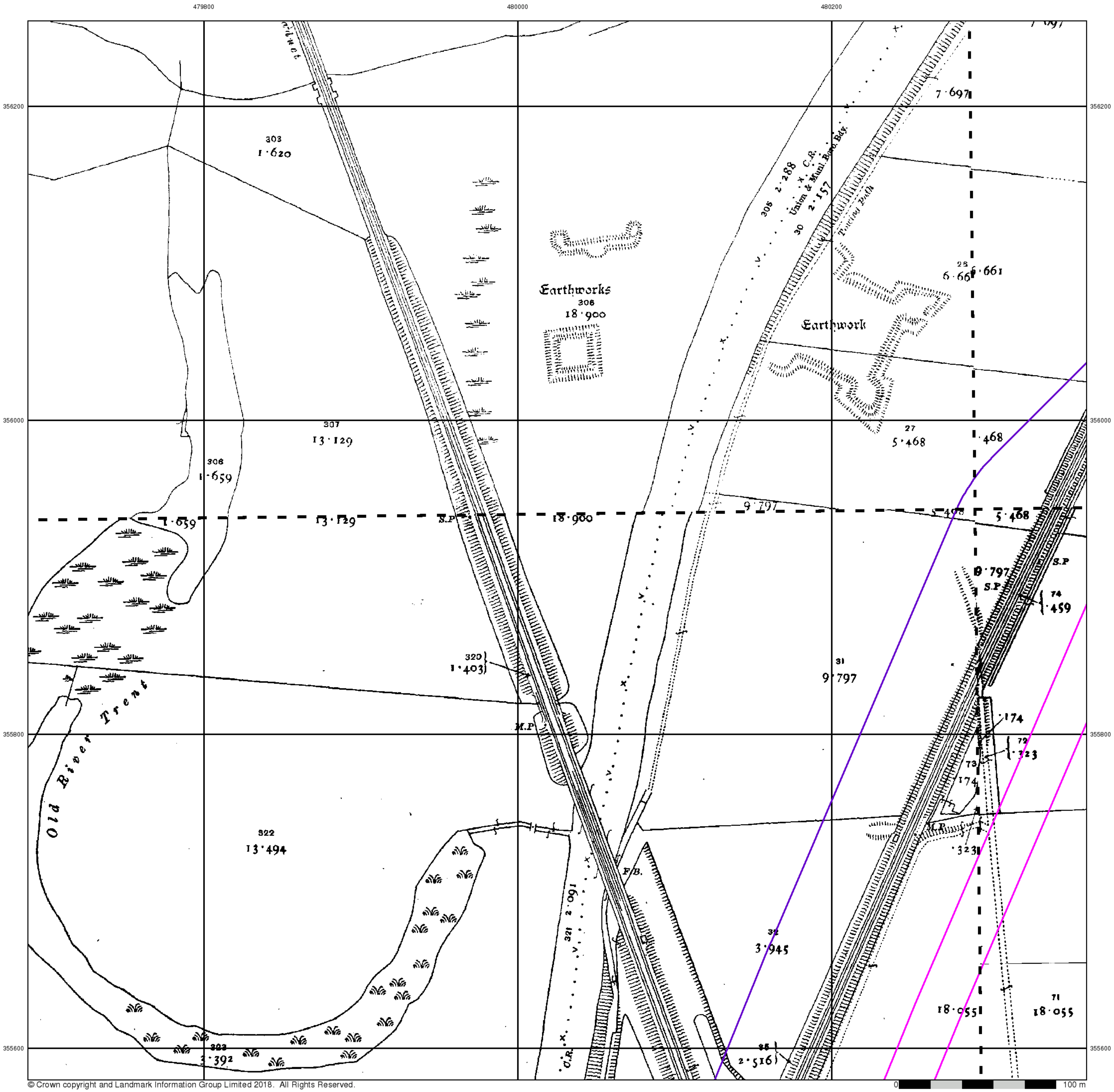

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Nottinghamshire

Published 1919 - 1920

Source map scale - 1:2,500

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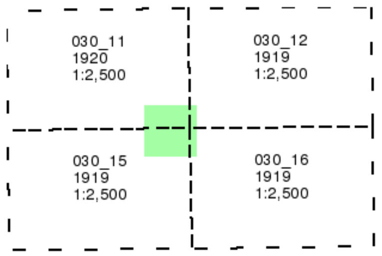
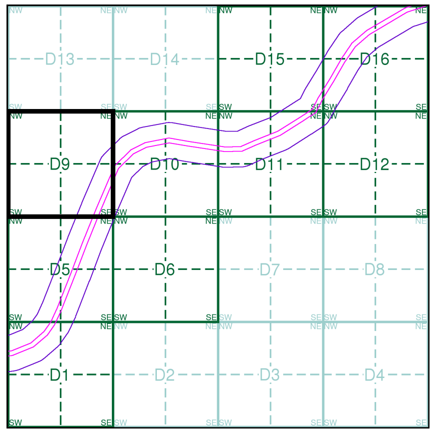


Historical Map - Segment D9



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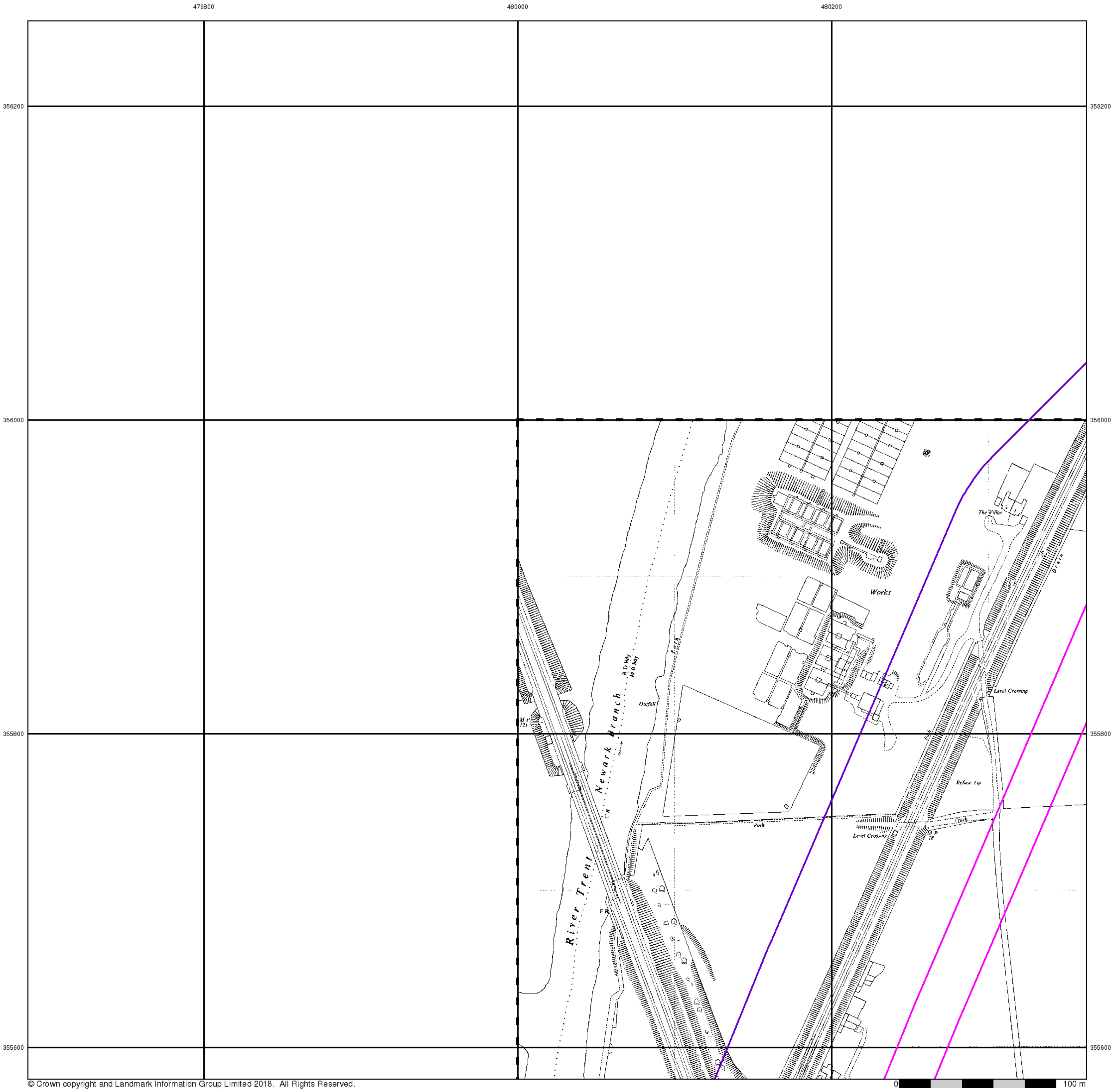

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Ordnance Survey Plan

Published 1965

Source map scale - 1:1,250

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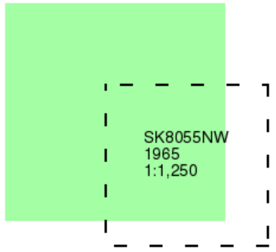

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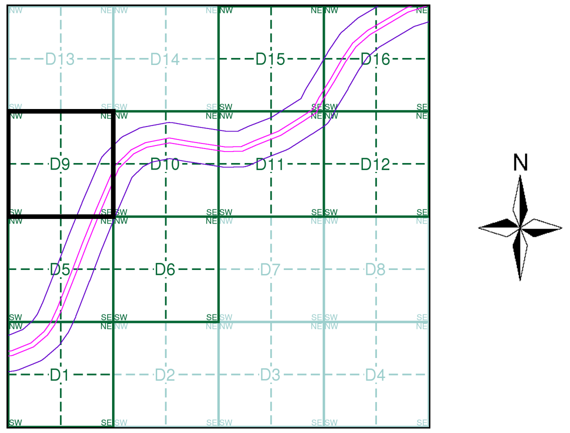

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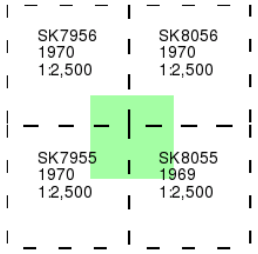
Ordnance Survey Plan

Published 1969 - 1970

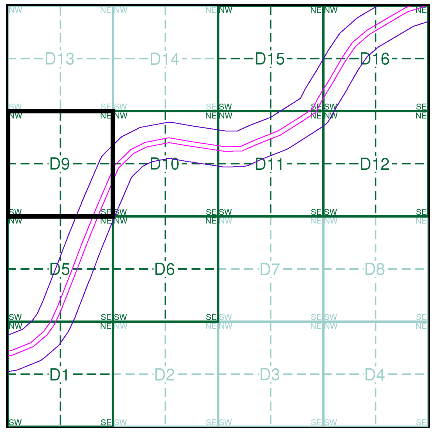
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment D9



Order Details

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Customer Ref:	5162675 sub no 255
National Grid Reference:	480890, 355770
Slice:	D
Site Area (Ha):	21.45
Search Buffer (m):	100

Site Details

A46, Newark, NG24 2PG

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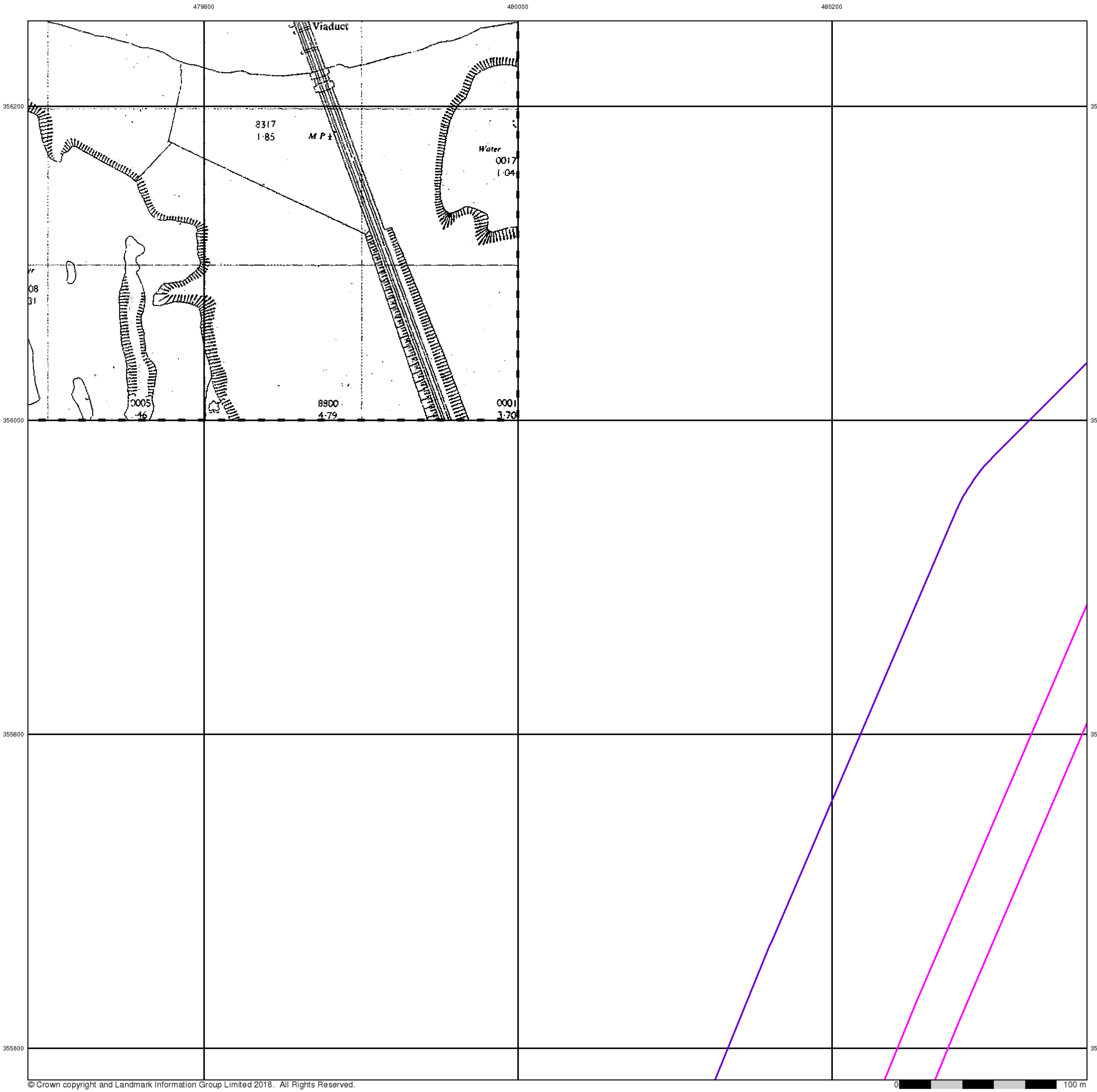

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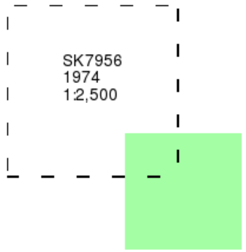
Supply of Unpublished Survey Information

Published 1974

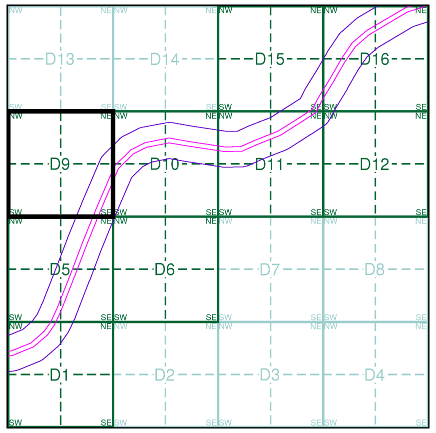
Source map scale - 1:2,500

SUSI maps (Supply of Unpublished Survey Information) were produced between 1972 and 1977, mainly for internal use at Ordnance Survey. These were more of a `work-in-progress' plan as they showed updates of individual areas on a map. These maps were unpublished, and they do not represent a single moment in time. They were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment D9



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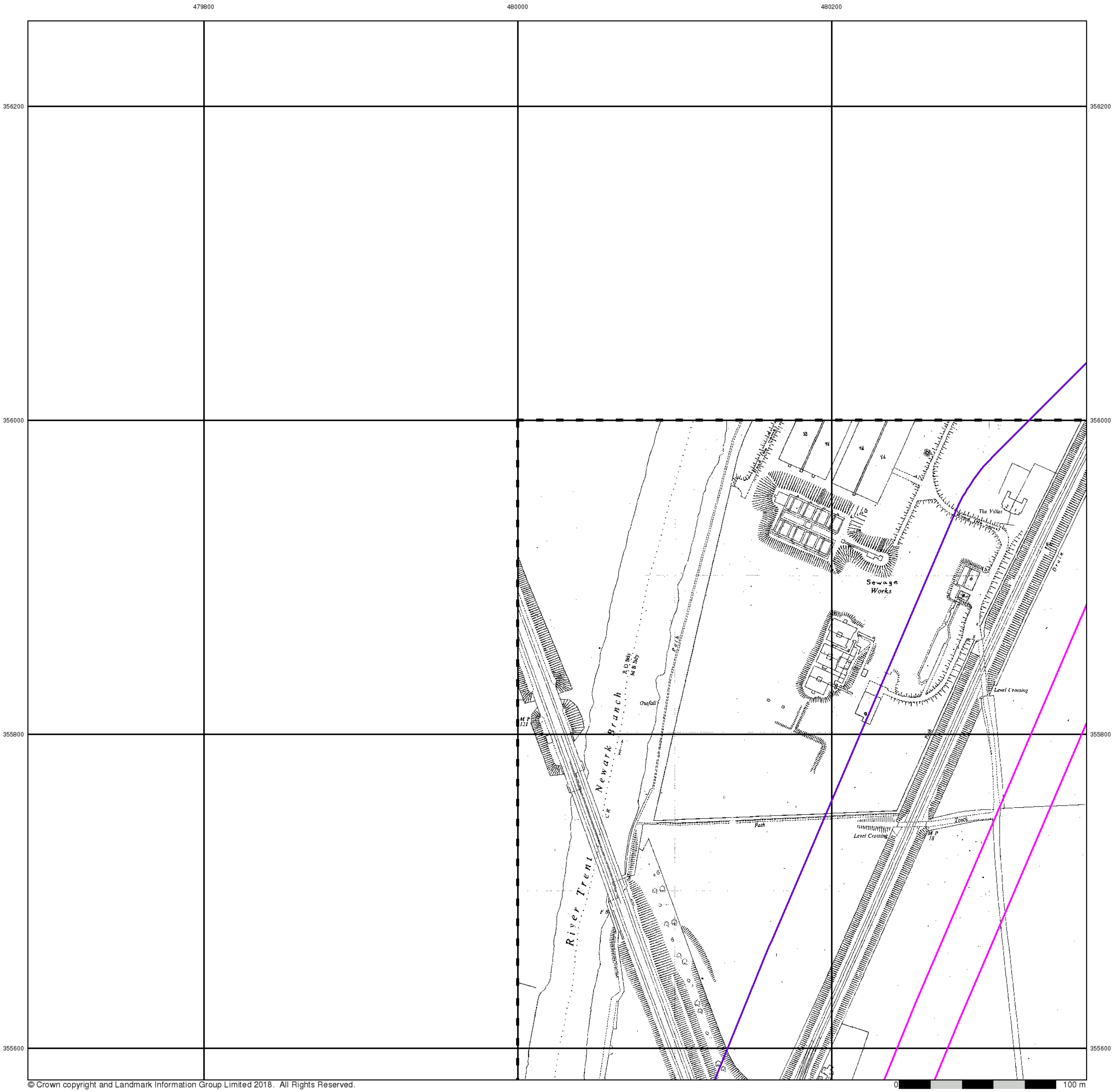

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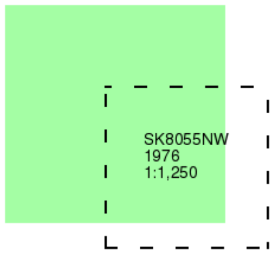
Supply of Unpublished Survey Information

Published 1976

Source map scale - 1:1,250

SUSI maps (Supply of Unpublished Survey Information) were produced between 1972 and 1977, mainly for internal use at Ordnance Survey. These were more of a `work-in-progress' plan as they showed updates of individual areas on a map. These maps were unpublished, and they do not represent a single moment in time. They were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



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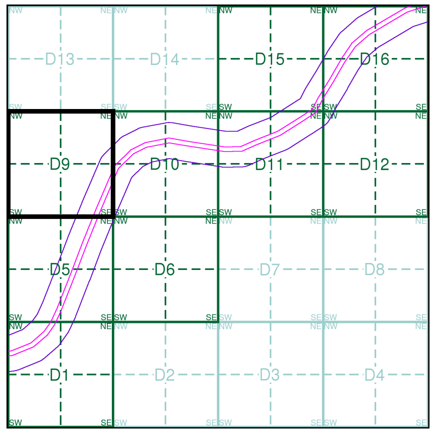

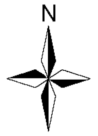

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National Grid Reference:	480890, 355770
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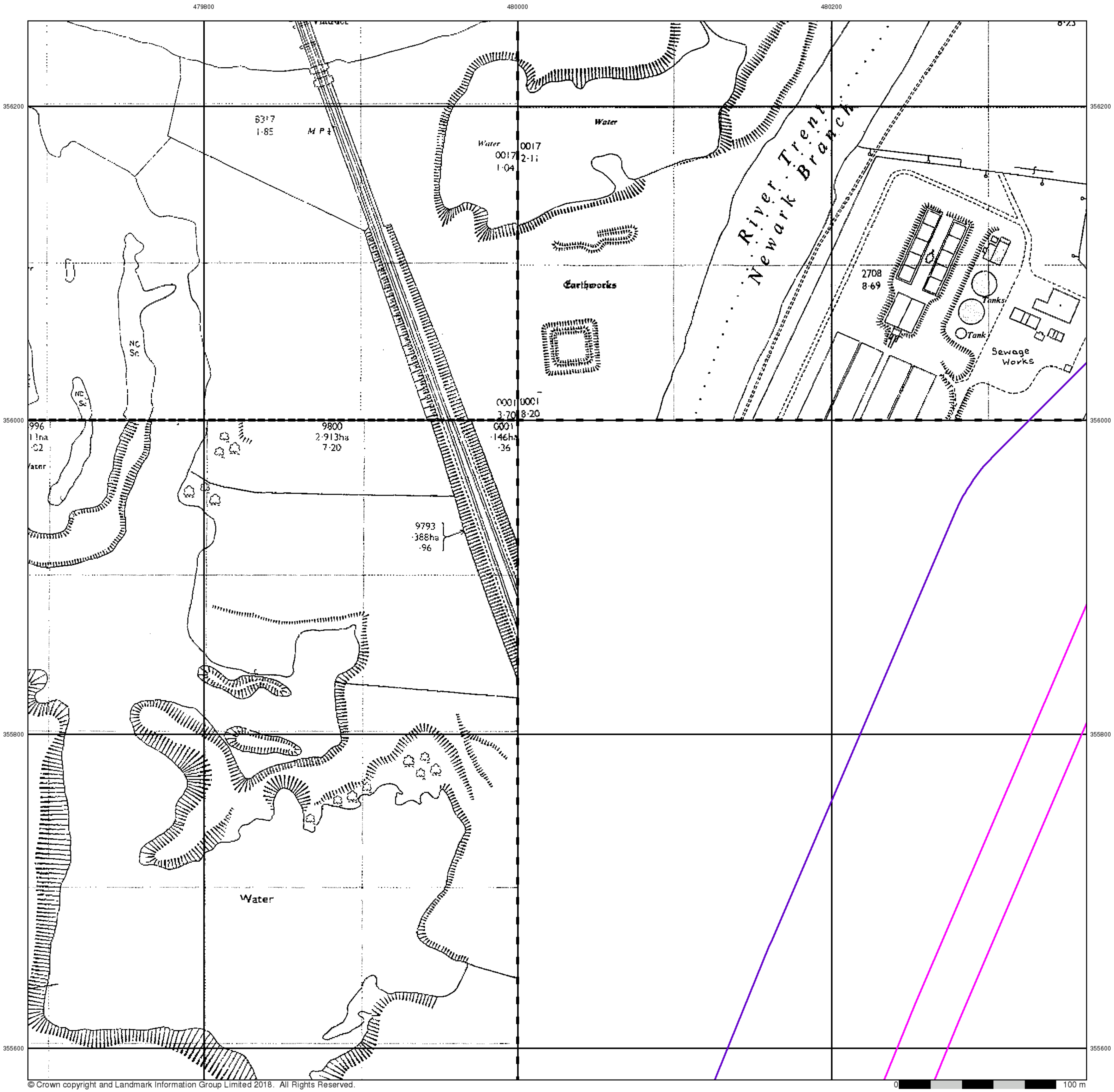

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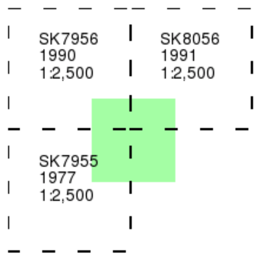
Additional SIMs

Published 1977 - 1991

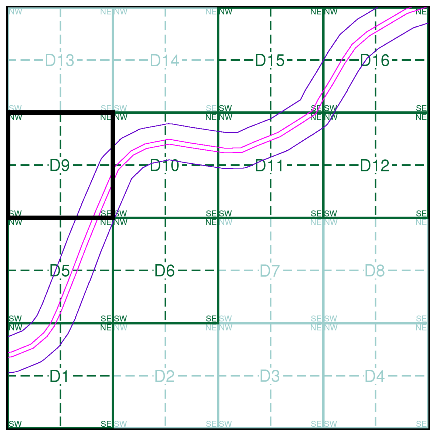
Source map scale - 1:2,500

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment D9



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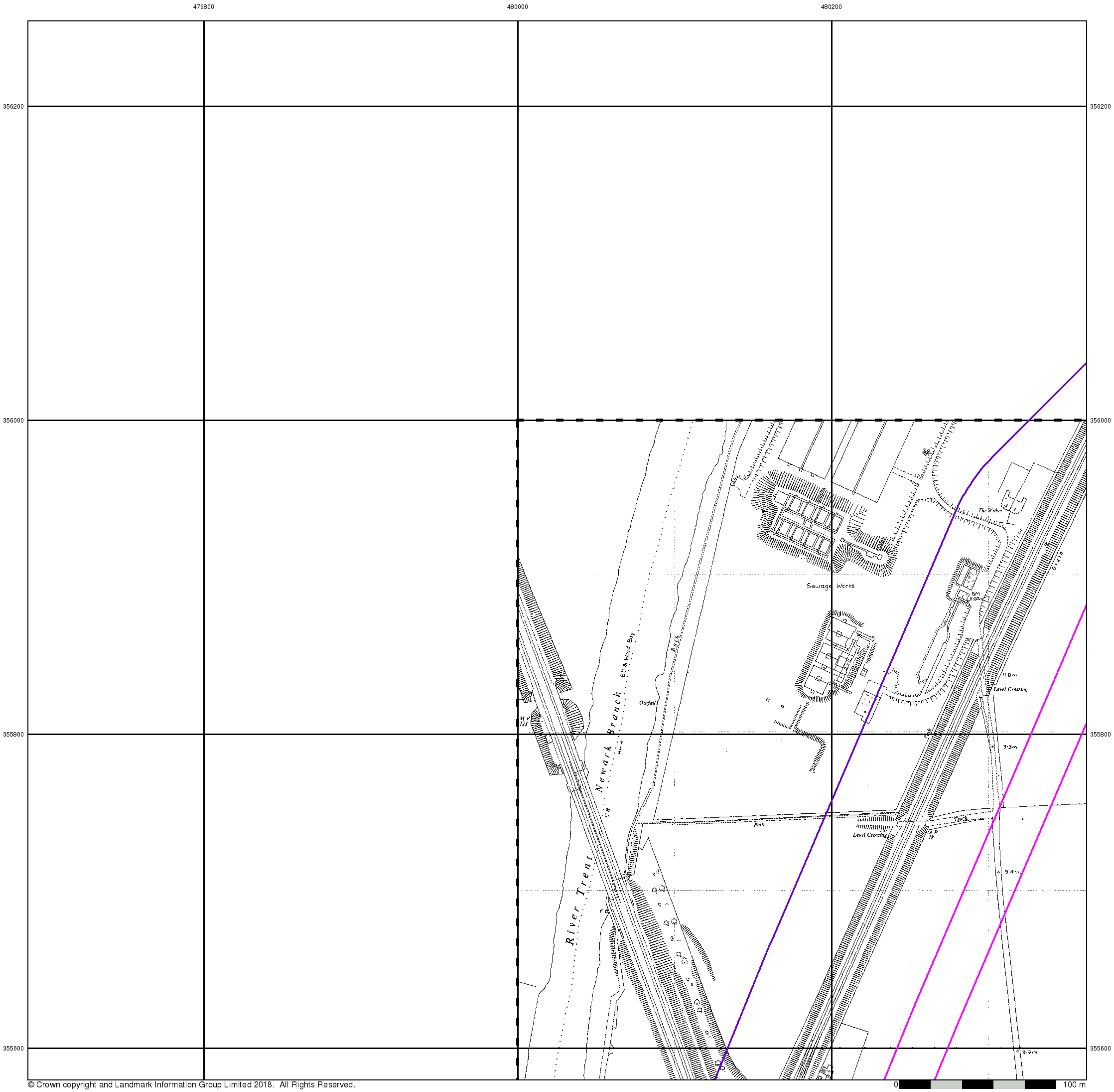

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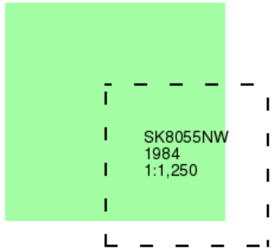
Additional SIMs

Published 1984

Source map scale - 1:1,250

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



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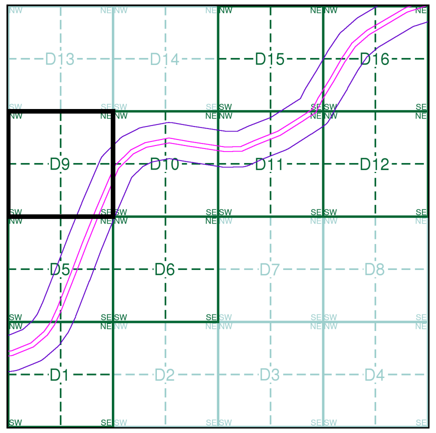

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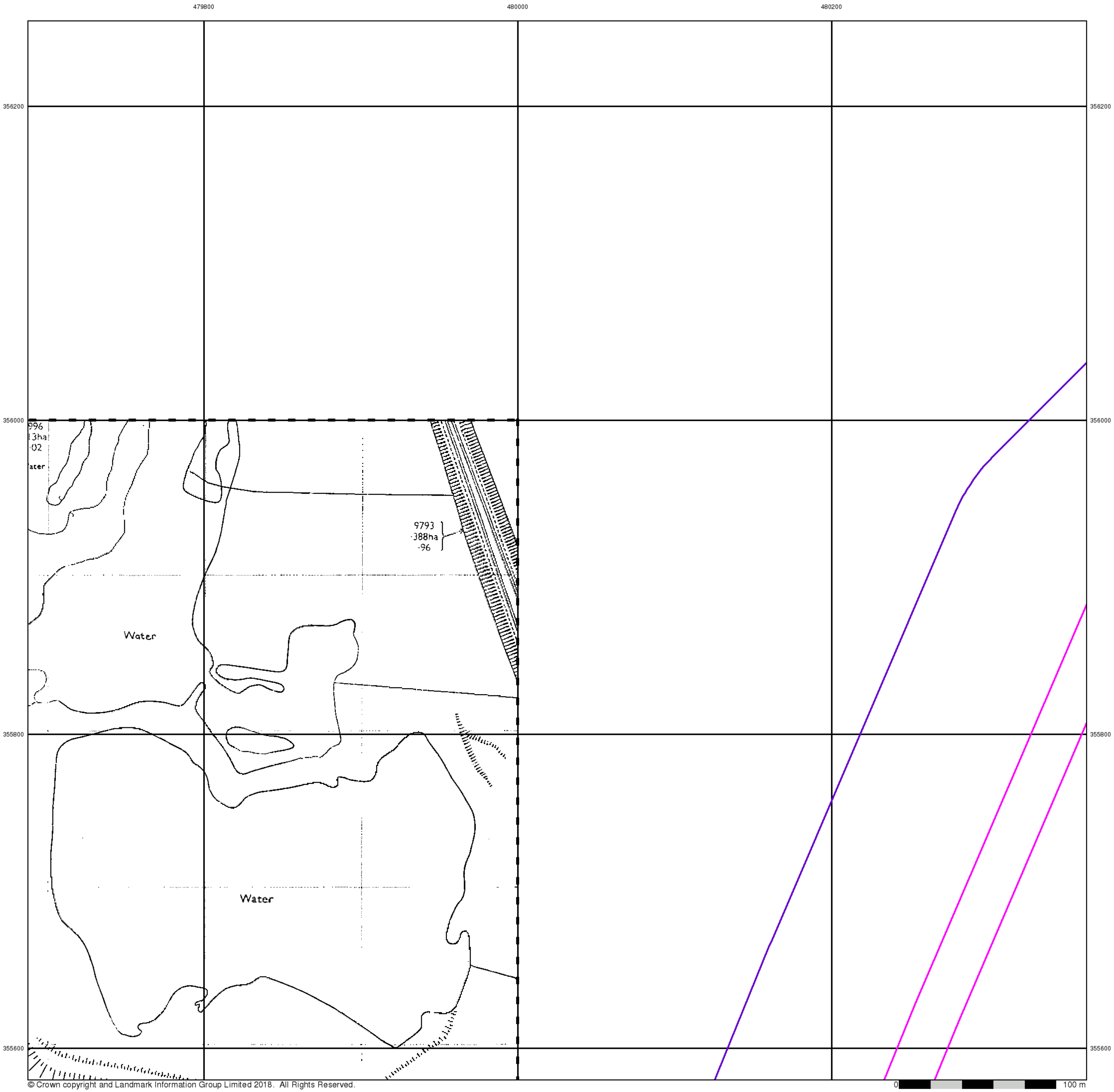

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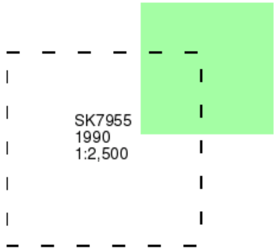
Additional SIMs

Published 1990

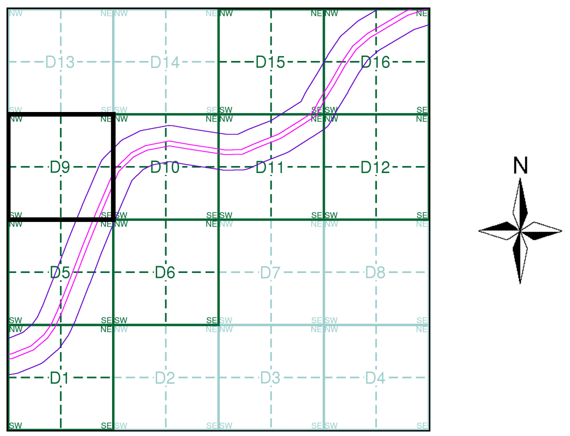
Source map scale - 1:2,500

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment D9



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National Grid Reference:	480890, 355770
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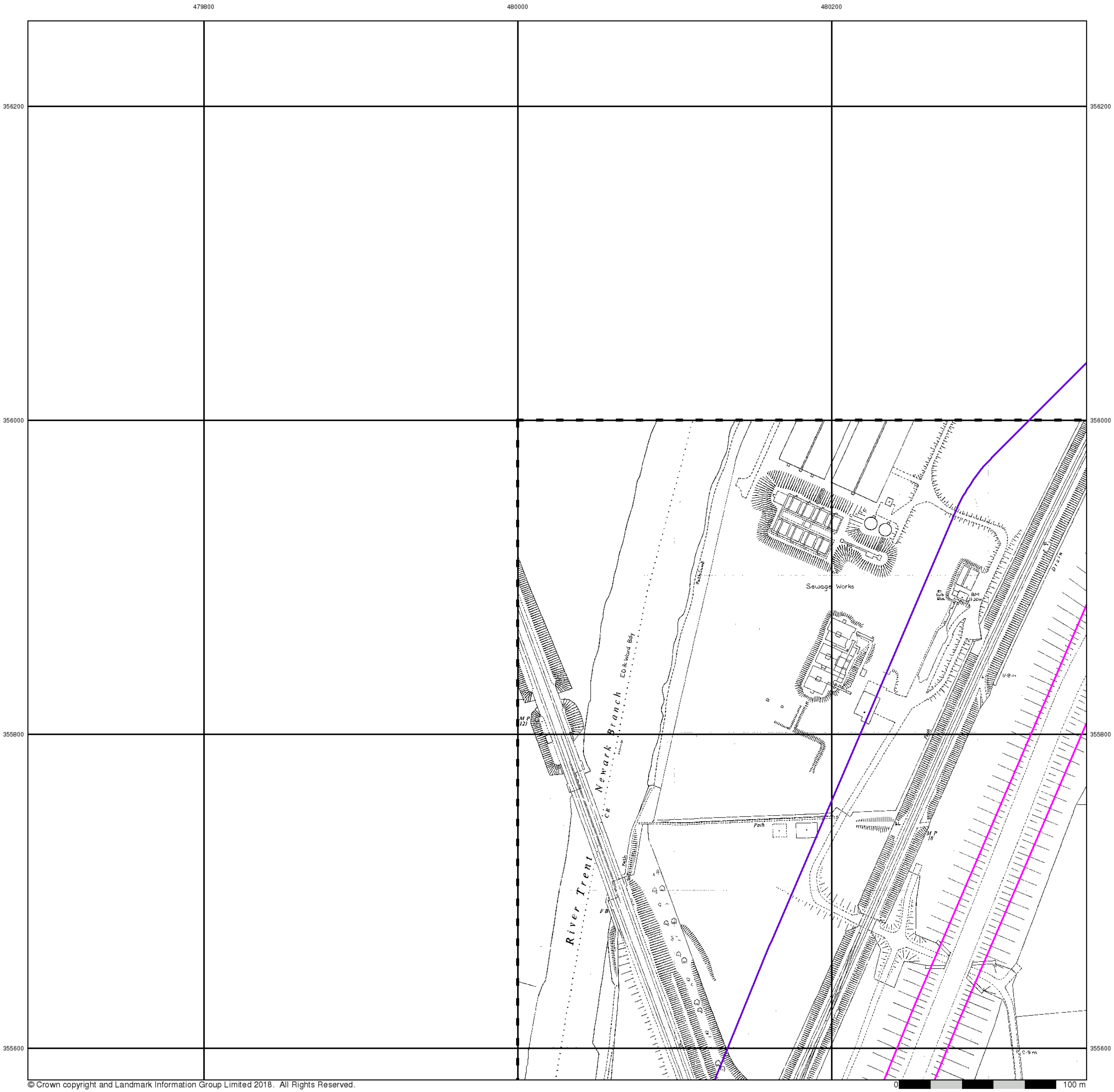

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Additional SIMs

Published 1990

Source map scale - 1:1,250

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

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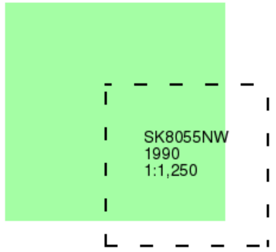
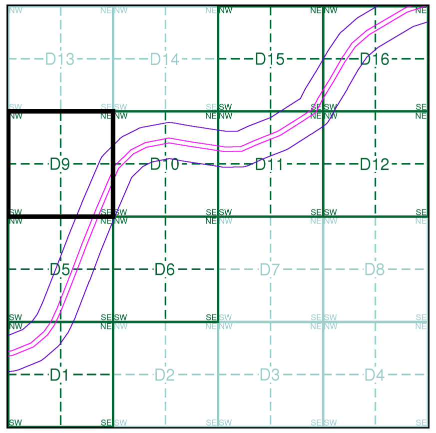


Historical Map - Segment D9



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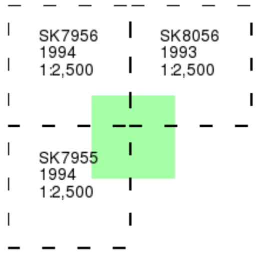
Large-Scale National Grid Data

Published 1993 - 1994

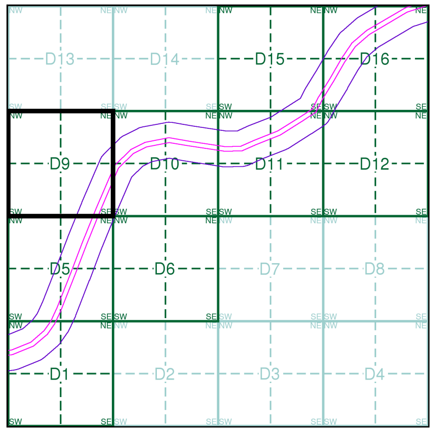
Source map scale - 1:2,500

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment D9



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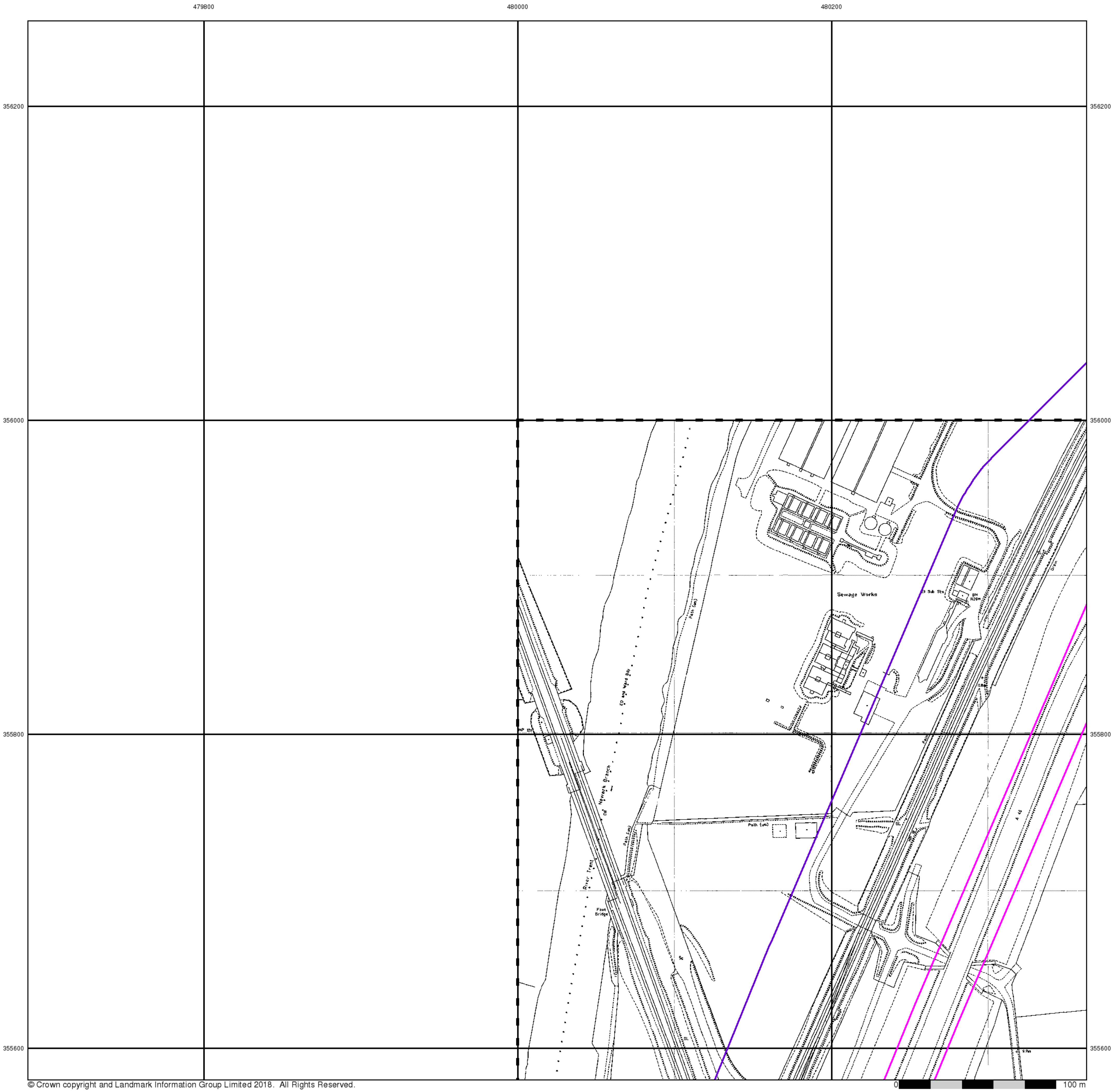

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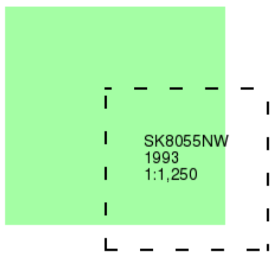
Large-Scale National Grid Data

Published 1993

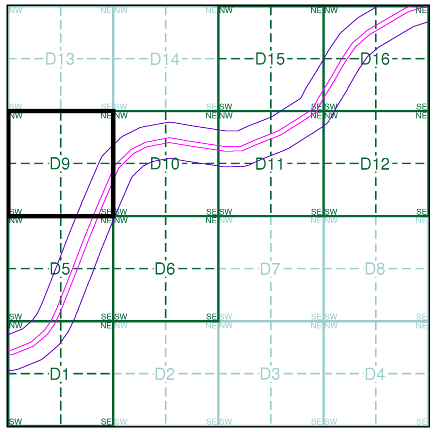
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment D9



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Site Details

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Large-Scale National Grid Data

Published 1996

Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

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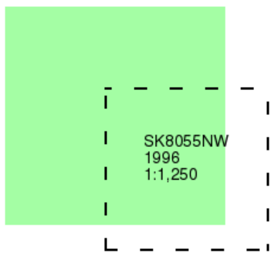
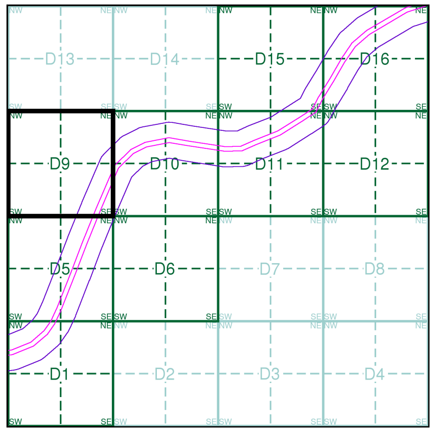


Historical Map - Segment D9



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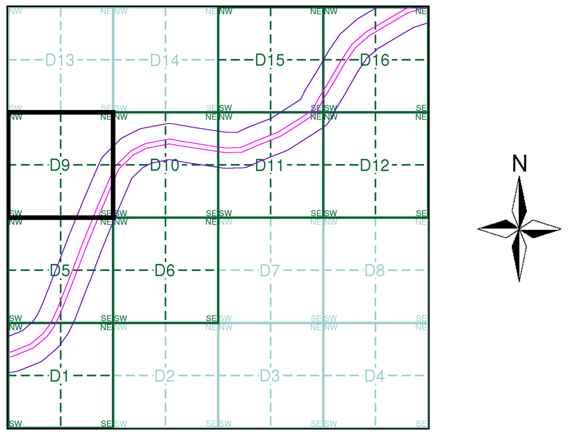
Historical Aerial Photography

Published 1999

This aerial photography was produced by Getmapping, these vertical aerial photographs provide a seamless, full colour survey of the whole of Great Britain

Historical Aerial Photography - Segment D9



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B. Groundwater monitoring data

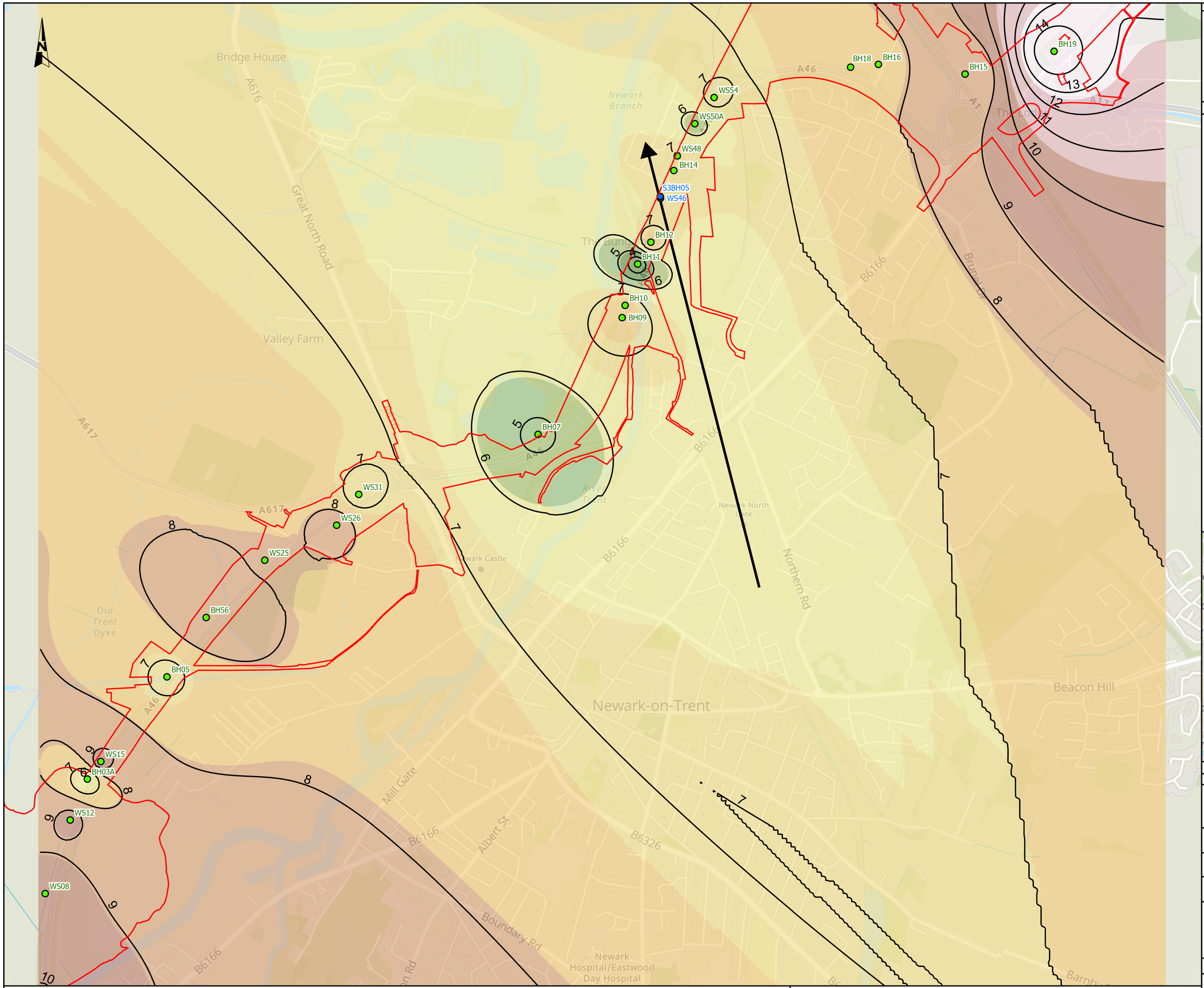
Table B.1 Tetra Tech groundwater monitoring data used to generate the groundwater contour map

Location ID	Ground surface elevation mAOD	Easting	Northing	Response zone mbgl	Response zone strata	Average surface water level SWL mbgl*	SWL mAOD
BH02	11.09	478083.7	352877.2	1.00 - 5.00	Granular Alluvium/ Mercia Mudstone	1.06	10.03
BH03A	7.10	478244.9	353614.1	1.00 - 5.00	Granular Alluvium	1.14	5.96
BH05	8.93	478519.1	353966.2	1.00 - 5.00	Made Ground/ granular Alluvium	2.16	6.77
BH07	6.17	479797.4	354801.4	1.00 - 5.00	Granular Alluvium	1.31	4.86
BH09	8.94	480086.9	355203.8	1.00 - 5.00	Granular Alluvium	1.32	7.62
BH10	9.10	480097.2	355246.0	1.00 - 5.00	Granular Alluvium/ Mercia Mudstone	1.76	7.34
BH11	6.85	480140.5	355388.4	1.00 - 6.00	Made Ground/ granular Alluvium	3.55	3.30
BH12	10.30	480185.7	355463.7	1.00 - 6.00	Granular Alluvium	2.68	7.62
BH14	9.55	480264.8	355710.6	1.00- 4.00	Granular Alluvium	2.63	6.92
BH15	9.76	481268.1	356042.7	1.00 - 4.00	Granular Alluvium/ Mercia Mudstone	1.77	8.00
BH16	10.88	480969.6	356076.1	2.00 - 6.00	Mercia Mudstone	3.02	7.86
BH18	10.01	480874.0	356066.4	2.00 - 7.00	Mercia Mudstone	2.42	7.59
BH19	15.19	481574.4	356121.2	1.00 - 5.00	Granular Alluvium/Mercia Mudstone	0.47	14.73
BH56	10.09	478654.0	354170.6	0.50 - 4.00	Granular Alluvium	1.44	8.65

WS08	10.59	478099.7	353219.7	1.00 - 5.00	Granular Alluvium	1.13	9.46
WS12	10.17	478185.6	353473.0	1.00 - 3.00	Granular Alluvium	0.93	9.24
WS15	10.78	478291.3	353674.6	1.00 - 3.00	Granular Alluvium	1.28	9.51
WS25	10.22	478855.7	354368.0	0.50 - 3.50	Granular Alluvium	2.24	7.99
WS26	10.15	479103.3	354488.6	1.00 - 3.50	Granular Alluvium	1.75	8.40
WS31	9.91	479179.4	354594.7	1.00 - 4.00	Granular Alluvium	3.21	6.70
WS48	9.08	480276.6	355760.9	1.00 - 2.00	Made Ground	2.06	7.02
WS50A	8.81	480337.1	355871.8	2.00 - 4.00	Granular Alluvium	3.21	5.60
WS54	8.46	480403.4	355962.0	3.00 - 5.00	Granular Alluvium	1.28	7.18
WS66	18.23	481947.1	356567.6	1.00 - 3.00	Granular Alluvium	2.66	15.57

*Average calculated from 6 rounds of monitoring data
Source – Tetra Tech “A46 Newark Nothern Bypass Factual GI Report” 2022

C. Groundwater contour map



NOTES

Source
Exploratory hole locations, GW level, TetraTech Factual Report, 2022. Flow direction, Contour line, Mott MacDonald, 2024.

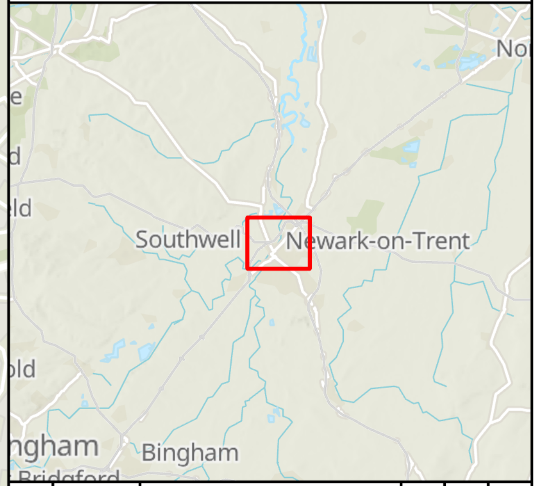
Service Layer Credits
Contains OS data © Crown Copyright and database right 2023
Contains data from OS Zoomstack

KEY TO SYMBOLS

- □ Order Limits
- ● Exploratory hole location
- ● Contamination hotspot location
- → Flow direction
- — Contour line (mAOD)

Groundwater level (mASL)

- ▨ 3.325 - 4.482
- ▨ 4.823 -5.891
- ▨ 5.892 - 6.654
- ▨ 6.665 - 7.199
- ▨ 7.2 - 7.962
- ▨ 7.963 - 9.031
- ▨ 9.032 - 10.529
- ▨ 10.53 - 12.628
- ▨ 12.629 - 15.569



C01	20/11/24	DCO EXAMINATION	JB	EF	HF
REV.	DATE	AMENDMENT DETAILS	ORIG	CHK'D	APP'D

CLIENT
national highways

PURPOSE OF ISSUE
DCO EXAMINATION

DEVELOPMENT CONSENT ORDER NUMBER
TR010065

PROJECT TITLE
A46 NEWARK BYPASS

DRAWING TITLE
Groundwater Contours

ORIGINAL SIZE A3
SCALE 1:12,500

DRAWING NUMBER
HE PIN | ORIGINATOR | VOLUME
HE551478 SKAG EGT
CONWI_CONW DR LE 00025
LOCATION | TYPE | ROLE | NUMBER

PROJECT REF NO.
HE551478

REVISION
C01

0 500 1,000 Metres

D. Key regulatory legislation, drivers, and contamination assessment criteria

D.1 Environmental Protection Act, Part IIA

The primary legislative regime under which historic contaminated land is managed in the UK is Part IIA of the Environmental Protection Act, 1990 (termed “Part IIA”). The framework for the assessment of potential land contamination adopted in this report is based on current guidance documents regarding the implementation of Part IIA of the EPA and the assessment of potentially contaminated land, with particular reference to:

- DEFRA (2012): “Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance;
- Land Contamination Risk Management (LCRM) (2021): How to assess and manage the risk from land contamination
- Contaminated Land Research Report SC050021/SR2 and SR3 describing the UK Contaminated Land Exposure Assessment Framework for assessing human health risks;
- British Standard (BS) 10175:2011+A1:2013 “Investigation of potentially contaminated sites: Code of practice”.
- British Standard (BS) 8485:2015 “Code of Practice for the Characterisation and remediation from ground gas in affected developments”.
- CIRIA C665 “Assessing Risks posed by hazardous ground gases to buildings”
- Environment Agency (2012) “Groundwater Protection Policy and Practice”, GP3.

Part IIA principally deals with sites where individual historic contamination linkages present a “Significant Possibility of Significant Harm” (SPOSH) or a Significant Possibility of Significant Pollution to Controlled Waters (SPOSPCOW) representing an unacceptable level of contamination risk for each linkage. The Part IIA clean-up is the minimum which can be done on a cost basis to make and keep the site in a “just safe” condition for an existing use. In determining SPOSPCOW, the requirements of the Groundwater Daughter Directive are taken into account under the Part IIA framework.

Elimination of liability under Part IIA is not always achievable largely because of the inherent risk basis of the statutory regime, changes in statutory guidance, the technical difficulty in establishing levels of contamination that are likely to represent SPOSH, and the variable distribution of contamination at many sites. Statutory guidance on Part IIA, recognises that sites require prioritisation by Local Authorities under the statutory Part IIA site inspection programme to ensure that only those sites likely to present the greatest risks are identified.

It should be recognised that considerable investigation and complex assessment is often required to establish whether sites are likely to meet the definition of contaminated land under Part IIA. As a result, it is advised that consensus is sought on any recommendations regarding the significance of contaminated land risks and remedial measures through consultation with the Regulator(s).

Water Resources Act 1991

In addition to liabilities under Part IIA of the Environmental Protection Act 1990, liabilities may also result from historic groundwater pollution under section 161 of the Water Resources Act. Section 161 allows the Environment Agency to recover the costs of cleaning up any poisonous, noxious, or polluting matter or any solid waste matter that persons have caused or knowingly permitted to be present in controlled waters.

Environmental Damage (Prevention and Remediation) Regulations 2009

The Environmental Damage (Prevention and Remediation) Regulations 2009 came into force on 1st March 2009 to implement EC Directive 2004/35 on environmental liability with regard to the prevention and remedying of environmental damage.

These Regulations do not apply retrospectively; environmental damage that took place before the Regulations came into force (1st March 2009), or damage that takes place (or is likely to take place) after that date but is caused by an incident, event or emission that occurred before that date are exempt from the requirements of the Regulations.

The Regulation is concerned with preventing environmental damage. It requires that all operators of activities that cause an imminent threat of environmental damage to take all reasonably practical steps to prevent the damage. Where damage has already been caused, the operator must take all reasonably practical steps to prevent further damage from occurring.

D.2 Contaminated Land Risk Methodology

Legislative Background

Contaminated land is defined in UK Legislation (Environmental Protection Act 1990, Part II, and Contaminated Land Regulations 2000) as:

‘any land which appears to the Local Authority in whose area is situated to be in such a condition, by reasons of substances in, on or under the land, that:

- Significant harm is being caused or there is significant possibility of significant harm being caused, or
- Pollution of controlled waters is being caused or is likely to be caused’.

Harm is defined such that it should meet the following criteria:

- 'Be harmful to a receptor listed in Table A of the statutory guidance (including human beings, certain ecological systems or living organisms, crops, livestock, and certain buildings);
- Be within the description of harm specified for each receptor in the same table'.

In order to determine whether there is a possibility for significant harm, the following should be taken into account:

- The nature and degree of harm;
- The susceptibility of the receptors;
- The time scale within which the harm may occur.

Current regulatory guidance requires that the findings from a site investigation are evaluated for contamination on a site-specific basis using a risk-based approach. Risk assessment involves identification and evaluation of the hazards presented by the concentrations of contaminants measured, followed by an estimation of the risks that are associated with these hazards. Such estimation can be qualitative or quantitative depending on the extent and nature of the investigation data available. Quantitative risk assessment requires detailed toxicological, chemical, geological, hydrological, and geotechnical data, and is not required unless the qualitative risk assessment demonstrates that a significant risk may exist but that there is enough uncertainty to make further detailed investigation and assessment desirable in order to reduce potential remediation costs. For the purposes of the investigations detailed herein, qualitative risk assessments have been undertaken.

The first step in assessing any risks, therefore, is to determine what hazards exist from the contaminants identified during the investigation. Hazard identification is widely undertaken by reference to published generic and site-specific guidelines. The following sections describe the available guidelines against which the chemical analytical data has been interpreted.

Risks to Human Health

This part of the risk assessment process uses a comparison of measured concentrations of contaminants in soil samples against conservative generic screening criteria. The generic screening criteria are selected based upon the industry-accepted hierarchy, as follows: Land Quality Management (LQM) Suitable for Use Values (S4UL's) 2014, Defra Category 4 Screening Levels (C4SL's) 2014 then other UK standards, followed by European standards, then US standards and then standards from the rest of the world. The most relevant of these criteria are now discussed.

Suitable for Use Levels (S4Uls)

In the UK, the most authoritative standards are those which were published by Land Quality Management Ltd (LQM) in 2014. LQM has revised their guidance values for soils to produce 'Suitable for Use' levels (S4Uls) for the additional land uses and exposure assumptions presented in Defra's recent C4SL guidance (Nathanail, McCaffrey, Gillett, Ogden, & Nathanail, 2015) – Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3420. All rights reserved. The S4Uls however, are all based on Health Criteria that represent minimal or tolerable levels of risks to health as described in the Environment Agency's SR2 guidance, ensuring that the resulting assessment criteria are 'suitable for use' under planning. Whilst representing a tolerable risk level they are generally less conservative than the previous Soil Guidance Values (SGVs) produced by CLEA. These revised values were released for use in 2014.

The S4ULs replace the previous LQM'Generic Assessment' Criteria which were published in 2009. S4ULs are available for residential, allotments. Commercial and public open space land uses and for a variety of soil organic contents.

Category 4 Screening Levels (C4SLs)

To support Defra's revised Statutory Guidance (SG) for Part 2A of the Environmental Protection Act 1990 (Part 2A) (Defra, 2012a) a methodology for deriving Category 4 Screening Levels (C4SLs) was presented by CL:AIRE in 2014. C4SLs have been derived using this methodology for six contaminants (arsenic, benzene, benzo(a)pyrene, cadmium, chromium VI, and lead) to date and act as guidance values to determine if sites fall into Category 4 of Part 2A. These were produced to support the planning process in determining which sites fall into 'Category 4' of Part IIA of the Environmental Protection Act. Category 4 refers to sites where there is no risk that land poses a significant possibility of significant harm (SPOSH), or the level of risk is low. Sites with contaminant concentrations below these levels would therefore be classified as low level of toxicological concern.

Other Criteria

In the absence of S4Uls and C4SLs, results have been assessed using:

- Contaminated Land Applications in Real Environments (CL:AIRE) Soil Generic Assessment Criteria (CL:AIRE, 2009).

CL:AIRE GAC

A range of GACs for 35 contaminants have been derived by a collection of scientific professionals under the oversight of Contaminated Land Applications in Real Environments (CL:AIRE, 2009). The methodology adopted in deriving the GACs was consistent with that used for producing the revised SGVs and used the CLEA model (v 1.06). These screening criteria will be used for any contaminants not covered by the current SGVs or LQM GACs.

The GAC have been derived for four generic land-uses; residential with consumption of homegrown produce, residential without consumption of homegrown produce, allotments, and commercial land-use. Each land-use scenario has had GAC produced for three SOM contents; 1%, 2.5% and 6%.

D.3 Risks to Controlled Waters

Risks to the aqueous environment (groundwater and surface water) are generally assessed in the UK by reference to the Environment Agency’s Remedial Targets Methodology Hydrogeological Risk Assessment for Land Contamination (EA, 2006). This allows remedial target concentrations for leachate extracts and groundwater to be derived for selected contaminants. The methodology is a tiered approach, with a remedial target being derived at the end of each tier, which would provide sufficient protection to controlled water resources.

There are four tiers of assessment, with each subsequent tier deriving a less conservative remedial target, due to examining further ways in which the contaminant may be reduced e.g. Dilution, natural attenuation, and degradation. For this site, it is considered appropriate to conduct a ‘Tier 1 Assessment’, using this guidance. This involves firstly selection of appropriate Assessment Criteria. For this site, the most sensitive receptor is considered to be groundwater in the underlying Principal Aquifer. The Tier 1 assessment requires a comparison of soil ‘pore water’ quality with the selected Assessment Criteria. ‘Pore water quality’ may be obtained by one of three methods:

- Laboratory analysis of pore water quality (or perched water quality).
- Laboratory analysis of soil leachate extracts (according to the Environment Agency R&D Note 301 – Leaching Tests for the Assessment of Contaminated Land).
- Theoretical calculation of the ‘pore-water’ concentration based on total soil concentrations, using soil-water partition coefficients.

The Environment Agency recommends that at least one of the above methods is used for analysis of data to allow for discrepancies, variations, and errors in results. For reasons of accuracy and practicality, laboratory analysis of the leachate quality and groundwater has been used to provide an indication of the risk to the environment.

E. Contamination risk methodology

The following Contaminated Land Risk Assessment methodology is based on the National House Building Council (NHBC), Environment Agency (EA) and Chartered Institute of Environmental Health (CIEH) document, *Guidance for the safe development of housing on land affected by contamination* (NHBC, 2008), in order to quantify potential risk via **risk estimation** and **risk evaluation**, which can be adopted at the Phase I stage. This will then determine an overall risk category which can be used to identify likely actions. This methodology uses qualitative descriptors and therefore is a qualitative approach.

The methodology requires the classification of:

- the magnitude of the **consequence** (severity) of a risk occurring, and
- the magnitude of the **probability** (likelihood) of a risk occurring.

The potential consequences of contamination risks occurring at this site are classified in accordance with **Table E-1: Classification of Consequence** below, which is adapted from the CIRIA guidance.

Table E-1: Classification of Consequence

Classification	Definition of Consequence
Severe	Highly elevated concentrations likely to result in “significant harm” to human health as defined by the EPA 1990, Part 2A, if exposure occurs. Equivalent to EA Category 1 pollution incident including persistent and/or extensive effects on water quality; leading to closure of a potable abstraction point; major impact on amenity value or major damage to agriculture or commerce. Major damage to aquatic or other ecosystems, which is likely to result in a substantial adverse change in its functioning or harm to a species of special interest that endangers the long-term maintenance of the population. Catastrophic damage to crops, buildings or property.
Medium	Elevated concentrations which could result in “significant harm” to human health as defined by the EPA 1990, Part 2A if exposure occurs. Equivalent to EA Category 2 pollution incident including significant effect on water quality; notification required to abstractors; reduction in amenity value or significant damage to agriculture or commerce. Significant damage to aquatic or other ecosystems, which may result in a substantial adverse change in its functioning or harm to a species of special interest that may endanger the long-term maintenance of the population. Significant damage to crops, buildings or property.
Mild	Exposure to human health unlikely to lead to “significant harm”.

	Equivalent to EA Category 3 pollution incident including minimal or short lived effect on water quality; marginal effect on amenity value, agriculture, or commerce. Minor or short lived damage to aquatic or other ecosystems, which is unlikely to result in a substantial adverse change in its functioning or harm to a species of special interest that would endanger the long-term maintenance of the population. Minor damage to crops, buildings or property
Minor	No measurable effect on humans. Equivalent to insubstantial pollution incident with no observed effect on water quality or ecosystems. Repairable effects of damage to buildings, structures, and services

The probability of contamination risks occurring at this site will be classified in accordance with **Table E-2: Classification of Probability** below which is also adapted from the CIRIA guidance. Note that for each category, it is assumed that a pollution linkage exists. Where a pollution linkage does not exist, the likelihood is zero, as is the risk.

Table E-2: Classification of Probability

Classification	Definition of Probability
High Likelihood	There is pollutant linkage, and an event would appear very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.
Likely	There is pollutant linkage, and all the elements are present and in the right place which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over the long-term.
Low Likelihood	There is pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a long period such an event would take place and is less likely in the shorter term.
Unlikely	There is pollutant linkage, but circumstances are such that it is improbable that an event would occur even in the very long-term.

For each possible pollution linkage (source-pathway-receptor) identified, the potential risk can be evaluated, based on the following principle:

Contamination risk = Probability of event occurring x Consequence of event occurring

This relationship can be represented graphically as a matrix **Table E-3 : Overall Contamination Risk Matrix** which is adapted from the CIRIA guidance

Table E-3 : Overall Contamination Risk Matrix

	Consequence			
Probability	**Severe**	**Medium**	**Mild**	**Minor**
High Likelihood	Very high risk	High risk	Moderate risk	Low risk
Likely	High risk	Moderate risk	Moderate/ low risk	Low risk
Low Likelihood	Moderate risk	Moderate/ low risk	Low risk	Very low risk
Unlikely	Moderate/ Low risk	Low risk	Very low risk	Very low risk

The definitions of the risk categories identified in the above matrix are given **Table E-4**, together with the investigatory and remedial actions that are likely to be necessary in each case. The risk categories apply to each pollutant linkage, not just to each hazard or receptor.

Table E-4 : Definition of Risk Categories and Likely Action Required

Risk Category	Definition and likely actions required
Very high	There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the site without remediation action OR there is evidence that severe harm to a designated receptor is already occurring. Realisation of that risk is likely to present a substantial liability to be site owner/or occupier. Investigation is required as a matter of urgency and remediation works likely to follow in the short-term.
High	Harm is likely to arise to a designated receptor from an identified hazard at the site without remediation action. Realisation of the risk is likely to present a substantial liability to the site owner/or occupier. Investigation is required as a matter of urgency to clarify the risk. Remediation works may be necessary in the short-term and are likely over the longer term.
Moderate	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, and if any harm were to occur it is more likely, that the harm would be relatively mild. Further investigative work is normally required to clarify the risk and to determine the potential liability to site owner/occupier. Some remediation works may be required in the longer term.
Low	It is possible that harm could arise to a designated receptor from identified hazard, but it is likely at worst, that this harm if realised would normally be mild. It is unlikely that the site owner/or occupier would face substantial liabilities from such a risk. Further investigative work (which is likely to be limited) to clarify the risk may be required. Any subsequent remediation works are likely to be relatively limited.

Very low	It is a low possibility that harm could arise to a designated receptor, but it is likely at worst, that this harm if realised would normally be mild or minor.

F. Model outputs

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**A46 Contamination Hotspot**			
Site Address:	**A46**			
Completed by:	**EF**			
Date:	**05-Nov-24**		**Version:**	**1.01**
Contaminant	**Arsenic**			
Target Concentration (C_T)	**0.05**	**mg/l**	**Origin of C_T:**	**Specify basis for target concentration**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Arsenic**	
Target concentration	C_T	**0.05**	**mg/l**

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_w	2.15E-01	fraction	Calculated using site specific data
Air filled soil porosity	θa	1.10E-01	fraction	Calculated using site specific data
Bulk density of soil zone material	ρ	2.00E+01	g/cm^3	Calculated using site specific data
Henry's Law constant	H	0.00E+00	dimensionless	*Elemental arsenic is not volatile*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	5.00E+02	l/kg	*Nathanail et al 2015: "The LQM / CIEH S4ULs for Human Health Risk Assessment ", Copyright Land Quality management Limited reproduced with perm*
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	
Organic carbon partition coefficient	Koc		l/kg	
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**2.50E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.05	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 2 - Soil

Contaminant		Arsenic		from Level 1
Target concentration	C_T	**0.05**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	6.30E-04	m/d	**Rainfall Met Office Data and PET EA data 2024**	
Area of contaminant source	A	3.60E+01	m^2	**MAGIC maps area measurement tool**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	6.00E+00	m	**MAGIC maps measurement tool**	
Saturated aquifer thickness	da	2.95E+00	m	**m the gw monitoring around netherlock used. Althou**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	5.64E-05	m/d	**Calculated using site specific data**	
Hydraulic gradient of water table	i	2.71E-03	fraction	**Calculated using site specific data**	
Width of contaminant source perpendicular to groundwater flow	w	6.00E+00	m	**MAGIC maps measurement tool**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	**Calculated using site specific data**	
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	2.95E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.00E+00**		
Level 2 Remedial Target		**5.00E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		2.50E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		**Arsenic**		from Level 1
Target Concentration	**C_T**	**0.05**	mg/l	from Level 1
Dilution Factor	**DF**	**1.00E+00**		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration	**Soil leachate concentration as mg/l**			
Enter soil leachate concentration		**0.0669**	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+100	days	*Aresnic does not degrade*
Calculated decay rate	λ	6.93E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	6.00E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	2.95E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.99E+00	g/cm^3	*Calculated using site specific data*
Effective porosity of aquifer	n	3.00E-01	fraction	*McWorter, D.B. and Sunada, D.K., 1977. Gro*
Hydraulic gradient	i	2.27E+01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.64E-05	m/d	from Level 2
Distance to compliance point	x	1.65E+02	m	*River Trent*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	16.500	m	*see options*
Transverse dispersivity	az	1.650	m	*see options*
Vertical dispersivity	ay	0.165	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	4.27E-03	m/d
Retardation factor	Rf	3.32E+03	fraction
Decay rate used	λ	2.09E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	2.27E+01	fraction
Rate of contaminant flow due to retardation	u	1.29E-06	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.18E-02	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**3.15E+01**	**fraction**
Soil leachate concentration	Co	6.69E-02	

Remedial Targets

Level 3 Remedial Target		**1.57E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		7.87E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**165**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**3.18E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	5.00E+02	l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction

Soil water partition coefficient	Kd	5.00E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

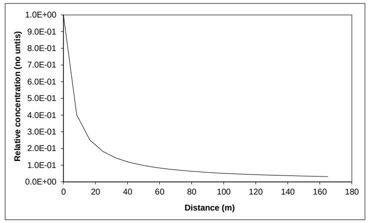
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	1.65E+01	5.68E+00	m
Transverse dispersivity	**az**	0.00E+00	1.65E+00	5.68E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.65E-01	5.68E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	########
Version:	1.01

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Relative concentration (No units)**	**Concentration mg/l**
0	**1.0E+00**	**6.69E-02**
8.3	**4.03E-01**	**2.69E-02**
16.5	**2.51E-01**	**1.68E-02**
24.8	**1.82E-01**	**1.21E-02**
33.0	**1.42E-01**	**9.51E-03**
41.3	**1.17E-01**	**7.82E-03**
49.5	**9.92E-02**	**6.64E-03**
57.8	**8.62E-02**	**5.76E-03**
66.0	**7.61E-02**	**5.09E-03**
74.3	**6.82E-02**	**4.56E-03**
82.5	**6.18E-02**	**4.13E-03**
90.8	**5.64E-02**	**3.78E-03**
99.0	**5.20E-02**	**3.48E-03**
107.3	**4.81E-02**	**3.22E-03**
115.5	**4.48E-02**	**3.00E-03**
123.8	**4.20E-02**	**2.81E-03**
132.0	**3.94E-02**	**2.64E-03**
140.3	**3.72E-02**	**2.49E-03**
148.5	**3.52E-02**	**2.35E-03**
156.8	**3.34E-02**	**2.23E-03**
165.0	**3.18E-02**	**2.13E-03**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**A46 Contamination Hotspot**			
Site Address:	**A46**			
Completed by:	**EF**			
Date:	**05-Nov-24**		**Version:**	**1.01**
Contaminant	**Aromatics >C10<C12**			
Target Concentration (C_T)	**0.01**	**mg/l**	**Origin of C_T:**	**Specify basis for target concentration**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Aromatics >C10<C12**	
Target concentration	C_T	**0.01**	**mg/l**

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.15E-01	fraction	Tetra Tech Factual Report
Air filled soil porosity	θa	1.10E-01	fraction	Tetra Tech Factual Report
Bulk density of soil zone material	ρ	2.00E+01	g/cm^3	A46 GIR - with ref to BS 8002:2015
Henry's Law constant	H	1.40E-01	dimensionless	*Environment Agency, 2008, Soil Guideline Values*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	5.15E-03	fraction	TetraTech GI
Organic carbon partition coefficient	Koc	2.51E+03	l/kg	*Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWG), 1999. Human Health Risk-Based Evaluation of Petroleum Release Sites: Imple*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.29E+01**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.29E-01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.01	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Aromatics >C10<C12**		from Level 1
Target concentration	**C_T**	**0.01**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	6.30E-04	m/d	**Rainfall Met Office Data and PET EA data 2024**	
Area of contaminant source	A	3.60E+01	m^2	**MAGIC maps area measurement tool**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	6.00E+00	m	**MAGIC maps measurement tool**	
Saturated aquifer thickness	da	2.95E+00	m	**m the gw monitoring around netherlock used. Althoug**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	5.64E-05	m/d	**Site GI info**	
Hydraulic gradient of water table	i	2.71E-03	fraction	**Site GI info**	
Width of contaminant source perpendicular to groundwater flow	w	6.00E+00	m	**MAGIC maps measurement tool**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	**Site GI info**	
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	2.95E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.00E+00**		
Level 2 Remedial Target		**1.00E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		1.30E-01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatics >C10<C12		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	1.00E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration	**Soil concentration as mg/kg**			
Enter soil concentration		**46900**	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.01E+02	days	*Howard et al. 1991. Environmental Degredatio*
Calculated decay rate	λ	3.45E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	6.00E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	2.95E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.99E+00	g/cm^3	*Site info summarised in GIR*
Effective porosity of aquifer	n	3.00E-01	fraction	*McWorter, D.B. and Sunada, D.K., 1977. Grou*
Hydraulic gradient	i	2.27E+01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.64E-05	m/d	from Level 2
Distance to compliance point	x	1.65E+02	m	*start with 50m, shortest to trent, distance to north*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.29E+01	l/kg	*see options*
Longitudinal dispersivity	ax	16.500	m	*see options*
Transverse dispersivity	az	1.650	m	*see options*
Vertical dispersivity	ay	0.165	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	4.27E-03	m/d
Retardation factor	Rf	8.68E+01	fraction
Decay rate used	λ	3.97E-05	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	2.27E+01	fraction
Rate of contaminant flow due to retardation	u	4.92E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.69E-16	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**2.13E+15**	**fraction**
Calculated soil leachate concentration	Co	3.62E+03	mg/l

Remedial Targets

Level 3 Remedial Target		**2.13E+13**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.76E+14	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**165**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**4.69E-16**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	5.15E-03	fraction
Organic carbon partition coefficient	Koc	2.51E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.29E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

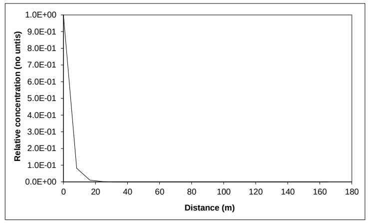
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	1.65E+01	5.68E+00	m
Transverse dispersivity	**az**	0.00E+00	1.65E+00	5.68E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.65E-01	5.68E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: A46 Contamination Hotspot
Completed by: EF
Date: #######
Version: 1.01

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.62E+03
8.3	8.19E-02	2.97E+02
16.5	1.04E-02	3.76E+01
24.8	1.53E-03	5.54E+00
33.0	2.44E-04	8.82E-01
41.3	4.07E-05	1.48E-01
49.5	7.03E-06	2.55E-02
57.8	1.24E-06	4.50E-03
66.0	2.23E-07	8.09E-04
74.3	4.07E-08	1.47E-04
82.5	7.50E-09	2.72E-05
90.8	1.39E-09	5.05E-06
99.0	2.61E-10	9.46E-07
107.3	4.92E-11	1.78E-07
115.5	9.33E-12	3.38E-08
123.8	1.78E-12	6.43E-09
132.0	3.40E-13	1.23E-09
140.3	6.52E-14	2.36E-10
148.5	1.25E-14	4.54E-11
156.8	2.42E-15	8.77E-12
165.0	4.69E-16	1.70E-12

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**A46 Contamination Hotspot**			
Site Address:	**A46**			
Completed by:	**EF**			
Date:	**05-Nov-24**		**Version:**	**1.01**
Contaminant	**Benzo(a)pyrene**			
Target Concentration (C_T)	**0.00000017**	**mg/l**	**Origin of C_T:**	**Specify basis for target concentration**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Benzo(a)pyrene**		
Target concentration	C_T	**0.00000017**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.15E-01	fraction	Calculated using site specific data
Air filled soil porosity	θa	1.10E-01	fraction	Calculated using site specific data
Bulk density of soil zone material	ρ	2.00E+01	g/cm^3	Calculated using site specific data
Henry's Law constant	H	1.76E-06	dimensionless	*Environment Agency, 2008, Soil Guideline Values*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	5.15E-03	fraction	Calculated using site specific data
Organic carbon partition coefficient	Koc	1.29E+05	l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**6.64E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.13E-04**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.00000017	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Benzo(a)pyrene**		from Level 1
Target concentration	**C_T**	**0.00000017**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	6.30E-04	m/d	**Rainfall Met Office Data and EA PET Data 2024**	
Area of contaminant source	A	3.60E+01	m^2	**MAGIC maps area measurement tool**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	6.00E+00	m	**MAGIC maps measurement tool**	
Saturated aquifer thickness	da	2.95E+00	m	**m the gw monitoring around netherlock used. Althoug**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	5.64E-05	m/d	**Calculated using site specific data**	
Hydraulic gradient of water table	i	2.71E-03	fraction	**Calculated using site specific data**	
Width of contaminant source perpendicular to groundwater flow	w	6.00E+00	m	**MAGIC maps measurement tool**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	**Calculated using site specific data**	
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	2.95E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.00E+00**		
Level 2 Remedial Target		**1.70E-07**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		1.13E-04	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Benzo(a)pyrene		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.00E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		**Soil concentration as mg/kg**		
Enter soil concentration		**78**	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.06E+03	days	*Howard et al. 1991. Environmental Degredatio*
Calculated decay rate	λ	6.54E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	6.00E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	2.95E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.99E+00	g/cm^3	*Calculated using site specific data*
Effective porosity of aquifer	n	3.00E-01	fraction	*McWorter, D.B. and Sunada, D.K., 1977. Grou*
Hydraulic gradient	i	2.27E+01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.64E-05	m/d	from Level 2
Distance to compliance point	x	1.65E+02	m	*River Trent*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	6.64E+02	l/kg	*see options*
Longitudinal dispersivity	ax	16.500	m	*see options*
Transverse dispersivity	az	1.650	m	*see options*
Vertical dispersivity	ay	0.165	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	4.27E-03	m/d
Retardation factor	Rf	4.40E+03	fraction
Decay rate used	λ	1.49E-07	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	2.27E+01	fraction
Rate of contaminant flow due to retardation	u	9.70E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.73E-07	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**3.67E+06**	**fraction**
Calculated soil leachate concentration	Co	1.18E-01	mg/l

Remedial Targets

Level 3 Remedial Target	**6.24E-01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	4.14E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**165**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration C_{ED}/C_0	**2.73E-07**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	5.15E-03	fraction
Organic carbon partition coefficient	Koc	1.29E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	6.64E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

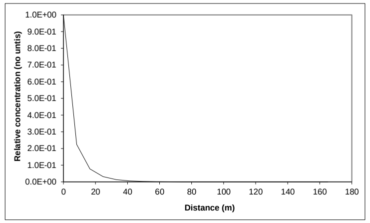
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	1.65E+01	5.68E+00	m
Transverse dispersivity	**az**	0.00E+00	1.65E+00	5.68E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.65E-01	5.68E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	#######
Version:	1.01

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.18E-01
8.3	2.25E-01	2.64E-02
16.5	7.80E-02	9.17E-03
24.8	3.15E-02	3.71E-03
33.0	1.38E-02	1.62E-03
41.3	6.33E-03	7.44E-04
49.5	3.00E-03	3.52E-04
57.8	1.45E-03	1.71E-04
66.0	7.16E-04	8.42E-05
74.3	3.58E-04	4.21E-05
82.5	1.81E-04	2.13E-05
90.8	9.23E-05	1.08E-05
99.0	4.74E-05	5.57E-06
107.3	2.45E-05	2.88E-06
115.5	1.27E-05	1.50E-06
123.8	6.65E-06	7.82E-07
132.0	3.49E-06	4.10E-07
140.3	1.84E-06	2.16E-07
148.5	9.70E-07	1.14E-07
156.8	5.13E-07	6.04E-08
165.0	2.73E-07	3.20E-08

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**A46 Contamination Hotspot**			
Site Address:	**A46**			
Completed by:	**EF**			
Date:	**05-Nov-24**		**Version:**	**1.01**
Contaminant	**Benzo(b)fluoranthene**			
Target Concentration (C_T)	**0.00000017**	**mg/l**	**Origin of C_T:**	**Specify basis for target concentration**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Benzo(b)fluoranthene**	
Target concentration	C_T	**0.00000017**	**mg/l**

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_w	2.15E-01	fraction	Tetra Tech Factual Report
Air filled soil porosity	θa	1.10E-01	fraction	Tetra Tech Factual Report
Bulk density of soil zone material	ρ	2.00E+01	g/cm^3	A46 GIR - with ref to BS 8002:2015
Henry's Law constant	H	2.05E-06	dimensionless	*Environment Agency, 2008, Soil Guideline Values*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	5.15E-03	fraction	TetraTech GI
Organic carbon partition coefficient	Koc	1.05E+05	l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.39E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**9.17E-05**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.00000017	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Benzo(b)fluoranthene**		from Level 1
Target concentration	**C_T**	**0.00000017**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	6.30E-04	m/d	**Met Office Rainfall Data and EA PET data**	
Area of contaminant source	A	3.60E+01	m^2	**MAGIC maps area measurement tool**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	6.00E+00	m	**MAGIC maps measurement tool**	
Saturated aquifer thickness	da	2.95E+00	m	**oring around netherlock used with average depth of a**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	5.64E-05	m/d	**Site GI info**	
Hydraulic gradient of water table	i	2.71E-03	fraction	**Site GI info**	
Width of contaminant source perpendicular to groundwater flow	w	6.00E+00	m	**MAGIC maps measurement tool**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	**Site GI info**	
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	2.95E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.00E+00**		
Level 2 Remedial Target		**1.70E-07**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		9.17E-05	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Benzo(b)fluoranthene		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.00E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		**Soil concentration as mg/kg**		
Enter soil concentration		**94**	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.22E+03	days	*Howard et al. 1991. Environmental Degredatio*
Calculated decay rate	λ	5.68E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	6.00E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	2.95E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.99E+00	g/cm^3	*Site info summarised in GIR*
Effective porosity of aquifer	n	3.00E-01	fraction	*McWorter, D.B. and Sunada, D.K., 1977. Grou*
Hydraulic gradient	i	2.27E+01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.64E-05	m/d	from Level 2
Distance to compliance point	x	1.65E+02	m	*start with 50m, shortest to trent, distance to north*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.39E+02	l/kg	*see options*
Longitudinal dispersivity	ax	16.500	m	*see options*
Transverse dispersivity	az	1.650	m	*see options*
Vertical dispersivity	ay	0.165	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	4.27E-03	m/d
Retardation factor	Rf	3.58E+03	fraction
Decay rate used	λ	1.59E-07	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	2.27E+01	fraction
Rate of contaminant flow due to retardation	u	1.19E-06	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	7.64E-07	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**1.31E+06**	**fraction**
Calculated soil leachate concentration	Co	1.74E-01	mg/l

Remedial Targets

Level 3 Remedial Target		**2.22E-01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.20E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**165**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**7.64E-07**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	5.15E-03	fraction
Organic carbon partition coefficient	Koc	1.05E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.39E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

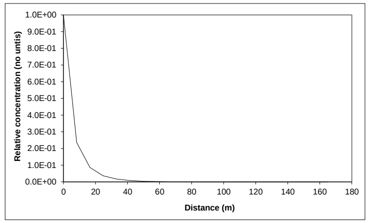
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	1.65E+01	5.68E+00	m
Transverse dispersivity	**az**	0.00E+00	1.65E+00	5.68E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.65E-01	5.68E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	#######
Version:	1.01

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.74E-01
8.3	2.37E-01	4.12E-02
16.5	8.65E-02	1.51E-02
24.8	3.68E-02	6.42E-03
33.0	1.70E-02	2.95E-03
41.3	8.19E-03	1.43E-03
49.5	4.08E-03	7.11E-04
57.8	2.08E-03	3.63E-04
66.0	1.08E-03	1.88E-04
74.3	5.69E-04	9.92E-05
82.5	3.03E-04	5.28E-05
90.8	1.63E-04	2.83E-05
99.0	8.80E-05	1.53E-05
107.3	4.79E-05	8.35E-06
115.5	2.62E-05	4.57E-06
123.8	1.44E-05	2.51E-06
132.0	7.96E-06	1.39E-06
140.3	4.41E-06	7.69E-07
148.5	2.45E-06	4.27E-07
156.8	1.37E-06	2.38E-07
165.0	7.64E-07	1.33E-07

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**A46 Contamination Hotspot**			
Site Address:	**A46**			
Completed by:	**EF**			
Date:	**05-Nov-24**		**Version:**	**1.01**
Contaminant	**Dibenz(a,h)anthracene**			
Target Concentration (C_T)	**0.00000017**	**mg/l**	**Origin of C_T:**	**Specify basis for target concentration**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Dibenz(a,h)anthracene**		
Target concentration	C_T	**0.00000017**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.15E-01	fraction	Tetra Tech Factual Report
Air filled soil porosity	θa	1.10E-01	fraction	Tetra Tech Factual Report
Bulk density of soil zone material	ρ	2.00E+01	g/cm^3	A46 GIR - with ref to BS 8002:2015
Henry's Law constant	H	5.76E-06	dimensionless	*Environment Agency, 2008, Soil Guideline Values*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	5.15E-03	fraction	TetraTech GI
Organic carbon partition coefficient	Koc	1.91E+06	l/kg	*RAIS Database (Risk Assessment Information System, http://rais.ornl.gov/tools/)*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**9.85E+03**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.67E-03**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.00000017	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 2 - Soil

Contaminant		**Dibenz(a,h)anthracene**		from Level 1
Target concentration	C_T	**0.00000017**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	6.30E-04	m/d	**Rainfall Met Office Data and PET EA data 2024**	
Area of contaminant source	A	3.60E+01	m^2	**MAGIC maps area measurement tool**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	6.00E+00	m	**MAGIC maps measurement tool**	
Saturated aquifer thickness	da	2.95E+00	m	**m the gw monitoring around netherlock used. Althoug**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	5.64E-05	m/d	**Site GI info**	
Hydraulic gradient of water table	i	2.71E-03	fraction	**Site GI info**	
Width of contaminant source perpendicular to groundwater flow	w	6.00E+00	m	**MAGIC maps measurement tool**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	**Site GI info**	
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	2.95E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.00E+00**		
Level 2 Remedial Target		**1.70E-07**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		1.67E-03	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Dibenz(a,h)anthracene		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.00E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration	**Soil concentration as mg/kg**			
Enter soil concentration		**14**	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.59E+02	days	*Howard et al. 1991. Environmental Degredatio*
Calculated decay rate	λ	2.68E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	6.00E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	2.95E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.99E+00	g/cm^3	*Site info summarised in GIR*
Effective porosity of aquifer	n	3.00E-01	fraction	*McWorter, D.B. and Sunada, D.K., 1977. Grou*
Hydraulic gradient	i	2.27E+01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.64E-05	m/d	from Level 2
Distance to compliance point	x	1.65E+02	m	*River Trent as compliance point*
Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.85E+03	l/kg	*see options*
Longitudinal dispersivity	ax	16.500	m	*see options*
Transverse dispersivity	az	1.650	m	*see options*
Vertical dispersivity	ay	0.165	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	4.27E-03	m/d
Retardation factor	Rf	6.53E+04	fraction
Decay rate used	λ	4.10E-08	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	2.27E+01	fraction
Rate of contaminant flow due to retardation	u	6.54E-08	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.49E-14	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**2.87E+13**	**fraction**
Calculated soil leachate concentration	Co	1.42E-03	mg/l

Remedial Targets

Level 3 Remedial Target		**4.88E+06**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		4.80E+10	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**165**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.49E-14**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	[redacted]	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	5.15E-03	fraction
Organic carbon partition coefficient	Koc	1.91E+06	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$	[redacted]	l/kg
pH value	pH	[redacted]	
Acid dissociation constant	pKa	[redacted]	
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Soil water partition coefficient	Kd	9.85E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

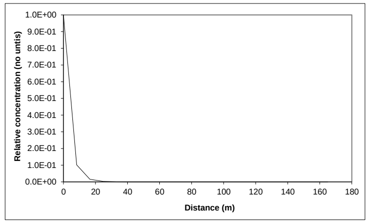
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	1.65E+01	5.68E+00	m
Transverse dispersivity	**az**	0.00E+00	1.65E+00	5.68E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.65E-01	5.68E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	########
Version:	1.01

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.42E-03
8.3	1.02E-01	1.44E-04
16.5	1.60E-02	2.27E-05
24.8	2.92E-03	4.15E-06
33.0	5.77E-04	8.20E-07
41.3	1.20E-04	1.70E-07
49.5	2.56E-05	3.64E-08
57.8	5.62E-06	7.98E-09
66.0	1.25E-06	1.78E-09
74.3	2.83E-07	4.02E-10
82.5	6.47E-08	9.20E-11
90.8	1.49E-08	2.12E-11
99.0	3.47E-09	4.93E-12
107.3	8.11E-10	1.15E-12
115.5	1.91E-10	2.71E-13
123.8	4.50E-11	6.40E-14
132.0	1.07E-11	1.52E-14
140.3	2.54E-12	3.61E-15
148.5	6.07E-13	8.62E-16
156.8	1.45E-13	2.06E-16
165.0	3.49E-14	4.96E-17

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**A46 Contamination Hotspot**			
Site Address:	**A46**			
Completed by:	**EF**			
Date:	**05-Nov-24**		**Version:**	**1.01**
Contaminant	**Napthalene**			
Target Concentration (C_T)	**0.002**	**mg/l**	**Origin of C_T:**	**Specify basis for target concentration**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Napthalene**	
Target concentration	C_T	**0.002**	**mg/l**

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_w	2.15E-01	fraction	Tetra Tech Factual Report
Air filled soil porosity	θa	1.10E-01	fraction	Tetra Tech Factual Report
Bulk density of soil zone material	ρ	2.00E+01	g/cm^3	A46 GIR - with ref to BS 8002:2015
Henry's Law constant	H	6.62E-03	dimensionless	*Environment Agency, 2008, Soil Guideline Values*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	5.15E-03	fraction	TetraTech GI
Organic carbon partition coefficient	Koc	6.46E+02	l/kg	*Environment Agency, 2008, Soil Guideline Values*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**3.33E+00**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**6.68E-03**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.002	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Napthalene**		from Level 1
Target concentration	**C_T**	**0.002**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	6.30E-04	m/d	**Rainfall Met Office Data and EA PET Data 2024**	
Area of contaminant source	A	3.60E+01	m^2	**MAGIC maps area measurement tool**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	6.00E+00	m	**MAGIC maps measurement tool**	
Saturated aquifer thickness	da	2.95E+00	m	**m the gw monitoring around netherlock used. Althoug**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	5.64E-05	m/d	**Site GI info**	
Hydraulic gradient of water table	i	2.71E-03	fraction	**Site GI info**	
Width of contaminant source perpendicular to groundwater flow	w	6.00E+00	m	**MAGIC maps measurement tool**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	**Site GI info**	
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	2.95E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.00E+00**		
Level 2 Remedial Target		**2.00E-03**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		6.68E-03	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	05-Nov-24
Version:	1.01

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		**Napthalene**		from Level 1
Target Concentration	C_T	**0.002**	mg/l	from Level 1
Dilution Factor	**DF**	**1.00E+00**		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration	**Soil concentration as mg/kg**			
Enter soil concentration		**19000**	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.59E+02	days	*Howard et al. 1991. Environmental Degradatio*
Calculated decay rate	λ	2.68E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	6.00E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	2.95E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.99E+00	g/cm^3	*Site info summarised in GIR*
Effective porosity of aquifer	n	3.00E-01	fraction	*McWorter, D.B. and Sunada, D.K., 1977. Grou*
Hydraulic gradient	i	2.27E+01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.64E-05	m/d	from Level 2
Distance to compliance point	x	1.65E+02	m	*Distance to River Trent*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.33E+00	l/kg	*see options*
Longitudinal dispersivity	ax	16.500	m	*see options*
Transverse dispersivity	az	1.650	m	*see options*
Vertical dispersivity	ay	0.165	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	4.27E-03	m/d
Retardation factor	Rf	2.31E+01	fraction
Decay rate used	λ	1.16E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	2.27E+01	fraction
Rate of contaminant flow due to retardation	u	1.85E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.49E-14	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**2.87E+13**	**fraction**
Calculated soil leachate concentration	Co	5.69E+03	mg/l

Remedial Targets

Level 3 Remedial Target		**5.74E+10**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.91E+11	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**165**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.49E-14**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	5.15E-03	fraction
Organic carbon partition coefficient	Koc	6.46E+02	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	3.33E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	1.65E+01	5.68E+00	m
Transverse dispersivity	**az**	0.00E+00	1.65E+00	5.68E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.65E-01	5.68E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
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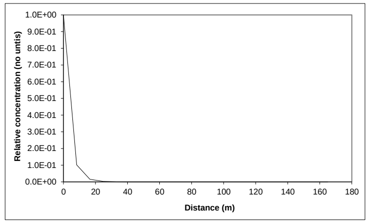

Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

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Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	A46 Contamination Hotspot
Completed by:	EF
Date:	#######
Version:	1.01

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.69E+03
8.3	1.02E-01	5.78E+02
16.5	1.60E-02	9.08E+01
24.8	2.92E-03	1.66E+01
33.0	5.77E-04	3.28E+00
41.3	1.20E-04	6.81E-01
49.5	2.56E-05	1.46E-01
57.8	5.62E-06	3.20E-02
66.0	1.25E-06	7.13E-03
74.3	2.83E-07	1.61E-03
82.5	6.47E-08	3.68E-04
90.8	1.49E-08	8.49E-05
99.0	3.47E-09	1.97E-05
107.3	8.11E-10	4.61E-06
115.5	1.91E-10	1.08E-06
123.8	4.50E-11	2.56E-07
132.0	1.07E-11	6.07E-08
140.3	2.54E-12	1.45E-08
148.5	6.07E-13	3.45E-09
156.8	1.45E-13	8.27E-10
165.0	3.49E-14	1.98E-10