

Next Navigation East:

Part 14: Design Elements V: Tunnels

Contents:

14	Design Elements V: Tunnels	
14.1	Introduction	1
14.2	Norwood Tunnel: History & Design	2
14.3	Current Condition	2
14.4	Options for Replacing and Reusing the Norwood Tunnel	3
14.5	Creating a New Surface Route	4
14.6	Works to stabilise the Western Portal of the Norwood Tunnel	4
14.7	New channel and locks west of the M1 ridge	6
14.8	Modification of the M1 Motorway underpass	6
14.9	New channel, water storage ponds and locks to the east of the M1 ridge	7
14.10	New cutting and locks to descend to tunnel level	8
14.11	Re-use of the eastern tunnel fragment and the Eastern Portal of the Norwood Tunnel	8
14.12	Access, interpretation and display improvements	9
14.13	Reconstruction Principles & Materials	10

14 Design Elements V: Tunnels

14.1 Introduction

- 14.1.1 The Norwood Tunnel and the M1 motorway which now lies above it are commonly perceived to be the main obstacles to the full restoration of the Chesterfield Canal.
- 14.1.2 The Tunnel was plagued throughout its life by structural problems; in 1907 the eastern end of the tunnel collapsed after heavy rain and the owners of the canal declined to carry out further repairs. In 1908 the Tunnel was abandoned and the Chesterfield Canal was divided into two.
- 14.1.3 The M1 Motorway is one of the most heavily used roads in the UK and any solution to gaining a passage under it cannot involve new construction which interrupts traffic flow.
- 14.1.4 Recent engineering studies have demonstrated a cost effective and feasible solution for both problems. This chapter summarises how the Norwood Tunnel can be replaced and the link remade.

14.2 Norwood Tunnel: History & Design

- 14.2.1 The Norwood Tunnel was designed by James Brindley. It was, in many respects, the “twin” of Harecastle Tunnel in Staffordshire (Richardson 2002) of a similar length and with an equally stark functional design.
- 14.2.2 There is some suggestion that Brindley originally intended to carry the canal over most of the Coal Measures ridge on the surface with a short summit tunnel of around 630 yards. This would have given a summit pound of circa 2 ½ miles.
- 14.2.3 By the time construction actually commenced in 1771, the route had been revised to create a longer, four mile summit pound, with a tunnel of 2880 yards. It seems possible that the longer tunnel was foisted on Brindley partly by the wishes of the local landowner, the Duke of Leeds, and partly by a reconsideration of the water supply needs of the summit pound. Whatever the driving factor the Norwood Tunnel, while very long, is one of the shallowest canal tunnels, with the great majority being less than 10 metres (c.30ft) from former water level to the ground surface.
- 14.2.4 James Brindley died in 1772 and the tunnel was brought to completion by John Varley and Hugh Henshall in 1775. The full history of the tunnel and its construction is discussed at length in Part Eight. In summary:
- 14.2.5 Construction commenced in 1771 with the laying out of a surface transect and the excavation of a series of vertical shafts to the depth of the tunnel. From the base of each shaft headings were driven east and west to intersect with the headings from adjacent shafts to form the main bore of the tunnel. Some construction shaft mounds and the earth rings which mark the site of horse gins (winding wheels) can be seen above the eastern end of the tunnel between Hard Lane and the Eastern Portal.

- 14.2.6 These construction shafts were used to lower bricks, most of which were made locally, to the tunnel works. A visitor to the canal in 1774 was told these shafts were to be bricked up and infilled. Many do appear to have been infilled but at least one was left open. This was a large shaft near the centre of the tunnel. When woodland was planted adjacent to it – this became known as “Open Shaft Plantation” and was marked as such on the 1870 edition Ordnance Survey maps.
- 14.2.7 The tunnel was finished in 1775 some 3 years and six months after commencement. The formal opening took place on 9th May when 300 people led by High Henshall and accompanied by a band were legged through the tunnel from western to eastern portal in little over an hour.
- 14.2.8 The first sign of problems came in September 1777 when a nineteen yard section of roof was damaged due to the removal of coal in the overlying ground leading to the unloading and weakening of the tunnel arch (it effectively “burst” upward as lateral pressures exceeded downwards compression forces on the arch).
- 14.2.9 Coal mining related problems continued and from the 1860’s onwards the development of deep collieries at West Kiveton and Kiveton led to progressive undermining the tunnel and its subsidence relative to the rest of the summit pound. As a result the roof of the tunnel sank and it became progressively more difficult to navigate.
- 14.2.10 Over a twenty year period from 1871 onwards the MS&LR undertook the slow process of raising the roof of the tunnel and creating a new tunnel arch. The process was interrupted in 1875 when a major collapse took place in the area immediately south of Wales around “Open Shaft Plantation”. This was subsequently opened out into a short cutting with two new tunnel portals being formed at each end of the breach. The opportunity was taken to widen the canal channel at the breach and it appears possible for two boats to pass. The length appears to have been used to lower construction materials to the tunnel re-lining works below.
- 14.2.11 In October 1907 after heavy rain a length of the tunnel immediately east of Hard lane collapsed. In 1908 the canal’s owners, the Great Central Railway, decided not to proceed with repairs.
- 14.2.12 As built the tunnel was lined three rings of with locally made hard red brick, The portals each had retaining wing walls of local stone. The portals had an extremely functional appearance and lacked any ornamentation or decoration.
- 14.2.13 Subsequent reconstruction work raised the roof of the tunnel and may have changed the shape of the portal entrance. The original entrance arch (by comparison with Harecastle) was probably nearly semicircular, following reconstruction the portal had a slightly elliptical arch which sits rather oddly in the plain wing wall.

14.3 Current Condition of the Tunnel

- 14.3.1 A survey of the history and recorded condition of the tunnel was undertaken by Structural Perspectives Ltd., in 2004 (Fitzgerald 2004). The historical conclusions are reported in Part Eight. The overall conclusion was that the original tunnel has

been severely damaged by mining works and the progressive infilling of working shafts and underground voids during the 1960's, 1970's and 1980's.

14.3.2 An annotated long section of the tunnel is shown in figure xx. This shows the location and chronology of damage as recorded by British Coal.

14.3.3 In summary, the tunnel is either collapsed or infilled by deliberate grouting from immediately inside the western portal to around the site of the Kiveton Waters Ponds. The area under the M1 Motorway was injection grouted with pulverised fly ash and concrete during road construction. The vertical shafts to the east of the motorway were infilled by the National Coal Board and the open shaft plantation cutting was infilled with colliery waste with the expansion of the Kiveton Colliery south tip. It now lies under the reclaimed Kiveton Community Woodlands Park.

14.3.4 In the area adjacent to the Kiveton Waters Ponds the tunnel was removed by the driving of a drift mine adit in the 1950's; large parts of the original tunnel were excavated away and those areas with exposed voids were infilled with concrete. From the eastern edge of the drift mine adit to c. 50 m east of Hard Lane the tunnel is collapsed. Beyond that point the tunnel is intact and standing. Possibly because it is within the protected zone near the railway which was not mined.

14.4 Options for Replacing the Norwood Tunnel

14.4.1 To determine how the Norwood Tunnel could be replaced and a passage achieved under the M1 Motorway which now runs above and across the tunnel site a study was commissioned from Arup in 2007 (Arup 2008). A copy of the Arup report is provided in Volume Two: Supporting Evidence.

14.4.2 Arup examined four alternatives:

- Reconstruct and re-open the original Norwood Tunnel
- Re-use a parallel railway tunnel
- Build an entirely new tunnel
- Build a new surface route and re-use some parts of the original tunnel

14.4.3 The Arup study demonstrated that the western portion of the Norwood Tunnel cannot reasonably be restored – some sections have collapsed, others were infilled by the National Coal Board and one length was injection grouted when the M1 was built. It also confirmed that the portion of the tunnel east of Hard Lane was intact, not infilled and could reasonably be restored to use.

14.4.4 The study concluded that the full reopening of the original tunnel was not feasible and that re-excavation along the original line posed too many problems to be cost effective. Further, reconstructing an extremely long narrow bore tunnel would not be amenable to use by powered boats and would not serve the needs of a tourism orientated waterway. It did promote re-use of the eastern tunnel fragment as part of a combined route.

14.4.5 The railway tunnel was on a gradient and modification of the bore would compromise the structure with significant cost implications. Similarly, the building of an entirely new tunnel was also dismissed on the grounds of cost, unquantifiable

underground risks in an area with a history of coal mining. Further, a new long tunnel would suffer from similar ventilation and poor amenity benefit as the original tunnel and, like the original, any new tunnel would be a bottle neck in operation.

14.4.6 Arup concluded that the most cost effective and sustainable option for replacing the tunnel was the construction of a new surface route incorporating the short length of surviving tunnel at the eastern end. A part surface route is possible because the tunnel lies at a very shallow depth (barely 4m or 12ft below ground surface) and there is an existing farm underpass suitable for conversion to canal channel. Arup noted that a similar conversion had been successfully carried out on the Rochdale Canal during restoration in the 1990's.

14.4.7 Arup made recommendations for further work. The proposals here reflect the development of the Arup proposals in the light of that work.

14.5 Creating a New Surface Route

14.5.1 The proposed replacement for the Norwood Tunnel has the following elements:

- Works to stabilise the Western Portal of the Norwood Tunnel
- New channel and locks west of the M1 ridge
- Modification of the M1 Motorway underpass
- New channel, water storage ponds and locks to the east of the M1 ridge
- New cutting and locks to descend to tunnel level
- Re-use of the eastern tunnel fragment and the Eastern Portal of the Norwood Tunnel
- Access, Interpretation and display improvements

14.5.2 The works proposed are described below.

14.6 Works to stabilise the Western Portal of the Norwood Tunnel

Current Condition

14.6.1 The western portal takes the form of a simple arched opening in a vertical stone wing wall. The wall is composed of coal measure sandstone blocks laid in roughly half-overlapped mortared courses. The block heights are consistent at around 0.25 to 0.3 m and the resulting horizontal courses appear straight regular; the block lengths are less regular and vary from 0.45 to 0.25 m, leading to an irregular vertical overlap with the blocks below. The wall is completely plain and lacks any form of ornamentation or decoration.

14.6.2 The tunnel arch consists of three rings of hard red brick sitting on a footing of sandstone blocks keyed into the wall courses. Five courses of keyed sandstone blocks are visible above water level before commencement of the brick arch which extends through eight stone courses and is capped by a single course of stone.



Figure 14.1 Norwood Tunnel Western Portal

The west portal of Norwood Tunnel photographed by Hugh Potter in 1972. ((C) Hugh Potter)

- 14.6.3 It is uncertain if this interesting composite arch is original or results from the partial replacement of an original stone arch during the raising of the tunnel roof in the 1870's (above). It is noticeable that the projected centre and radius of the partial arch formed by the keyed stone blocks is different from the arch centre and radius of the brick arch leading to the portal having a slightly elliptical appearance. This may support the notion that the current arrangement is not original and results from the reconstruction.
- 14.6.4 At present the tunnel arch is infilled with a lighter soft red brick with a single rectangular opening in the middle of the blocking wall. This opening is closed with a series of vertical bars. Through the bars it is possible to see that the tunnel roof has collapsed into the passage space within approximately 5 to 10 metres of the opening.
- 14.6.5 The tunnel level summit pond is still in water and this runs up to foot of the blocking wall. The curtain wall is visible and in reasonable condition with no obvious indications of immanent collapse. Much of area round the wall is overgrown especially in the summer. For example, the site of the Tunnel Keepers cottage and the stables to the left and above the tunnel entrance can only be seen in the winter when the vegetation is low.
- 14.6.6 The opening in the tunnel blocking has enabled the short length of tunnel before the collapse to be used as a bat roost and bats are active over the surviving water spaces. The channel leading to the portal is in water. Water-vole, although not reported in this location, are present in the upper pond immediately below this level and it is likely that are also resident here.

Proposed Treatment

- 14.6.7 The site will be sensitively cleared of excess vegetation and a programme of woodland management initiated to control tree growth which could damage the historic fabric.
- 14.6.8 Once cleared the wall and portal will be inspected and any necessary repairs undertaken to ensure the stability of the structure. This will include ground anchoring if required together with replacement of rotted / displaced stone and pointing.
- 14.6.9 The remaining foundation features of the Toll Cottage and Stables block will be consolidated and stabilised (not rebuilt). On-site interpretation will be used to explain the significance of the remains and their relationship to the tunnel.

14.7 New channel and locks west of the M1 ridge

- 14.7.1 The new surface route will commence where a new length of canal channel leaves the original line on the off-bank around 75 m west of the standing West Portal of the Norwood Tunnel. The new line will be carried in shallow cutting to the south of the tunnel entrance wing wall.
- 14.7.2 The towpath will be carried up and around the top of the original Norwood Tunnel mouth past the site once occupied by the Tunnel Keepers cottage and the towing horse stables. The towpath will then rejoin the north bank of the waterway.
- 14.7.3 After 50 m the cutting will deepen and enter the first of the new “Norwood Extension Locks”. A bridge over the lock tail will maintain connectivity between the towpath and the public right of way extending south through the Nor Wood to Killamarsh.
- 14.7.4 The Norwood extension locks are sited off the line of the original tunnel to avoid new construction on potentially compromised ground where long term stability cannot be assured.
- 14.7.5 The Norwood Extension Locks consist of two three-rise locks (the Locks are described in detail in Part 15). The first is the Norwood High Treble Locks (No.’s 19a, 19b and 19c). At the top of this multiple lock the canal enters a short pound where the canal track turns slightly before entering the second three rise group – the Norwood Top Treble Locks (No.’s 19d, 19e and 19f). At the top of the second group the canal reaches the new summit pound and turns north-east and arrives at the west entrance to the farm underpass below the M1 Motorway.

14.8 Modification of the M1 Motorway underpass

- 14.8.1 There are two options for how the M1 Motorway or Poplar Farm underpass can be modified to accommodate the canal. The simplest involves foundation underpinning, excavation of the farm track surface and insertion of a new canal channel. The towpath would run beside the water channel.
- 14.8.2 The second option would involve deep piling beneath the underpass, excavation and the insertion of a reinforced concrete box culvert. The upper surface of the culvert box would lie at the current surface/trackway level within the underpass and would be designed to accommodate the weight of farm vehicles. The culvert box

- would extend beyond the ends of the existing underpass to accommodate the farm tracks on the surface.
- 14.8.3 The box culvert would only be large enough for a single boat and the towpath would be brought up to the surface level above the canal and then pass through the underpass. Leaving the underpass it would then drop back down to canal level.
- 14.8.4 This option would require longer cuttings on both east and west flanks of the ridge with consequent spoil disposal issues but it would reduce the number of locks by four (2 up and 2 down), remove the need for a footbridge at the underpass, extend the summit pound and increase water storage. It would also allow the underpass to be retained for farm traffic.
- 14.8.5 The second option obviously requires more complex civil engineering but the increased costs can be balanced by a reduction in lock construction costs and, by decreasing the number of locks, yield a long term saving in maintenance costs.
- 14.8.6 It should be noted that the two options do not affect the horizontal alignment of the canal and the track required is the same.

14.9 New channel, water storage ponds and locks to the east of the M1 ridge

- 14.9.1 On the eastern side of the motorway the canal would run for a short distance in a shallow cutting before running on or around the current ground surface. In option one, a foot and cycleway bridge over the canal maintains rights of way connectivity.
- 14.9.2 The new summit pound will be relatively short irrespective of which option is adopted. To increase water storage two new side ponds will be created on the off bank. These will also form new off-line wetland nature reserves. The ponds will link, via separate feeders, to the main canal channel to the east and west of a single flood-gate / lock gate. This will be counterbalanced to swing closed after use and will divide the waters in the western and eastern halves of the section. This is intended to ensure separation of the waters of the Rother and Idle catchments in line with the catchment management strategy of the Environment Agency.
- 14.9.3 Beyond the ponds, at the eastern end of this short summit pound, the canal will run onto a short length of low embankment before descending a two-rise staircase lock. At the tail of the lock a minor bridge will carry Coalpit Lane over the canal. The route then follows the approximate line of existing field edge drains and adopts the extant hedge line as the off-bank boundary.
- 14.9.4 At the western edge of the former Kiveton Colliery Tip (now reclaimed and landscaped as amenity woodlands and country park) the canal descends via a further two locks in a staircase configuration (the Wales Double Locks).
- 14.9.5 East of the Wales Locks and Wales Bridge the canal is at the Kiveton Waters pond level. It then skirts the north-west boundary of the former colliery tip utilising the line of an existing trackway and drain before entering the former colliery site itself.
- 14.9.6 The route within the Kiveton Colliery site has already been defined by the construction of a canal channel and deep cutting. This prepared and protected route was built when the landscaping of the former colliery site was undertaken by

English Partnerships. At the same time three large ponds, Kiveton Waters, were constructed. These ponds were cut to a navigable depth profile with the intention that they can be converted into a marina once the canal is restored. In the interim they are let as fishing ponds.

14.10 New cutting and locks to descend to tunnel level

- 14.10.1 The link to the re-usable fragment of the Norwood Tunnel will be made by excavating a cutting to the west of Hard Lane. Within the cutting a three-rise staircase lock will lower the canal to the tunnel pound level.
- 14.10.2 The location and land for the cutting was identified by British Waterways in the site masterplan for the development of the Kiveton Colliery site. This land now form part of their holding along with the reserved canal corridor.
- 14.10.3 Further information on the Hard Lane Locks is given in Part 15.

14.11 Re-use of the eastern tunnel fragment and the Eastern Portal of the Norwood Tunnel

- 14.11.1 Once at tunnel level a concrete box culvert will take the canal beneath Hard Lane and make a junction with the intact section of the tunnel.
- 14.11.2 The eastern tunnel fragment was opened and inspected by British Waterways during their restoration of the section from Shireoaks to Kiveton Park in 2001-2003. British Waterways report that the first c. 420 m of the tunnel is in excellent condition with no obvious signs of structural distress or damage. The tunnel is collapsed a point roughly 420 m inside (i.e. west of) the eastern portal. This corresponds with a point circa 20 m east of Hard Lane.
- 14.11.3 The intention is to use this first 400 section of the tunnel and bring the canal through this short fragment and out of the existing east portal of the Norwood Tunnel into the cutting west of Kiveton Park Station. This is the current head of navigation from West Stockwith on the British Waterways section.
- 14.11.4 The eastern portal is the twin of the western one and is no more adorned. It consists of a straight limestone retaining wall in coursed rectangular blocks. The main arch of the tunnel is roughly central to the wall and is formed of three rings of hard red brick. The entrance itself is infilled with a red brick wall. This has no openings.
- 14.11.5 The land corridor required for the new canal, marina and works within the former colliery site, together with the remaining tunnel fragment, are all owned by British Waterways.



Figure 14.2 Norwood Tunnel Eastern Portal

The east portal of Norwood Tunnel photographed by Hugh Potter in 1972. ((C) Hugh Potter)

Current Condition of the Eastern Portal

- 14.11.6 The Eastern Portal forms the current limit of navigation on the restored canal from West Stockwith to Kiveton Park. The retaining wall is in good condition as was re-pointed by British Waterways as part of the restoration programme. During that programme the blocking wall was partially take down and the tunnel entered and surveyed. At the end of the survey the wall was re-erected.
- 14.11.7 The blocking wall at the eastern end of the tunnel has no openings and the tunnel did not provide a roost for bats at the time of the last inspection. In consequence this is not envisaged to be an issue at this end.
- 14.11.8 The Canal is fully navigable as far as the blocking wall – no works outside the removal of the wall and the dredging of recent accumulations in front of the wall are required.

14.12 Access, interpretation and display improvements

Access

- 14.12.1 Access improvements will be undertaken as described in Part 12.

Interpretation & Display

- 14.12.2 As described in detail in Part Eight, the Norwood Tunnel is an important part of the nations industrial heritage. While it had many competitors in terms of length, its delivery in around three and a half years is considerably faster than the comparable

Harecastle Tunnel (eight years) and represents an early triumph of engineering method.

- 14.12.3 The site offers the opportunity to explore the story of how the tunnel was built, the lives of those who built it and made it work. On the ground there is archaeological evidence for construction which can be interpreted and this should be exploited. Good quality reconstruction drawings are an appropriate media.
- 14.12.4 Further discussion of interpretation is given in Parts 21 and 22.

14.13 Reconstruction Principles & Materials

- 14.13.1 The replacement of the Norwood Tunnel involve both re-used and new construction. The guiding principles in Part 9 will be followed.
- 14.13.2 New build will incorporate, wherever possible, generic features based on original structures and utilising a palette of materials based upon local brick and stone together with wrought iron and timber where appropriate. The overriding factor in the choice of appropriate style and materials will be the architecture and character of the surrounding development.
- 14.13.3 In common with all structures on the reinstated canal, bridges will be designed to offer access for all. To that end all bridge reconstruction will employ the BT/Fieldfare standards for accessibility.
- 14.13.4 Specified dimensions for all new structures (including the passage of the canal and the towpath under any new bridge) are given in the Table D4 at the end of this Volume. These specifications are based, where relevant, on the appropriate BT/Fieldfare Access for All standards.
- 14.13.5 Details for each individual element will be refined upon submission of the final planning application for each project length as it comes forward.