History and Significance of the Great Western Main Line

Prepared for Network Rail

April 2012

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Contents

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1.0 Introduction

This document has been produced in connection with the project to electrify the Great Western Main Line from London to Bristol, plus the subsidiary lines from Didcot to Oxford, from Reading to Newbury and via the Severn Tunnel to Cardiff. Its aim is to provide an assessment of the historic buildings and structures along these lines. The assessment falls under two headings: first a summary history of the lines (including their constituent elements such as stations, bridges and tunnels) and secondly an assessment of significance.

In compiling this report over 650 buildings and structures have been assessed, details of which are given in the accompanying *GWML Route Structures Gazetteer*. This exercise has been accompanied by a wide-ranging review of the literature on the Great Western Railway and its engineering: for the sources consulted see the Appendix. In addition, with the immensely helpful assistance of the Network Rail National Records Centre at York, the original drawings (design and contract drawings, and alteration drawings) for c.80 of the principal buildings and structures have been consulted. Details of these drawings are given in the *Gazetteer*.

The methodology used in this assessment exercise has been based on the references to significance in the *National Planning Policy Framework* (2012) and *Planning Policy Wales (*2011), as amplified in two non-statutory English Heritage documents - *Conservation Principles, Policies and Guidance* (2008) and the *Listing Selection Guide: Transport Buildings* (2011) - and Cadw's *Conservation Principles* (2011). The methodology is discussed further in Chapter 3 of this report and in the Introduction to the *GWML Route Structures Gazetteer*.

The main subject of this report is the Great Western Main Line (GWML), completed from London to Bristol 1835-41. This is known to railwaymen by the abbreviation MLN1 (Fig. 1 over the page). Individual structures along the route are identified by their distance from Paddington Station in London: thus Gatehampton Viaduct is MLN1 4402 (44 miles, 2 chains from Paddington). This is known as the structure number. In this report the prefix MLN1 is normally omitted.

The other lines in the electrification project each have their own designations:

BHL - Berks & Hants Line: Reading – Newbury

BKE - Berks & Hants Line: Reading – Basingstoke

DCL - Didcot & Chester Line: Didcot – Oxford

DWC - Didcot West Chord

SWB - South Wales & Bristol Direct Line: Wootton Bassett – Patchway

BSW - Bristol & South Wales Union Line: Bristol – New Passage Pier

SWM2 - South Wales Main Line: Severn Tunnel – Cardiff

Structures on these lines are referred to by their ELR prefix and structure number.

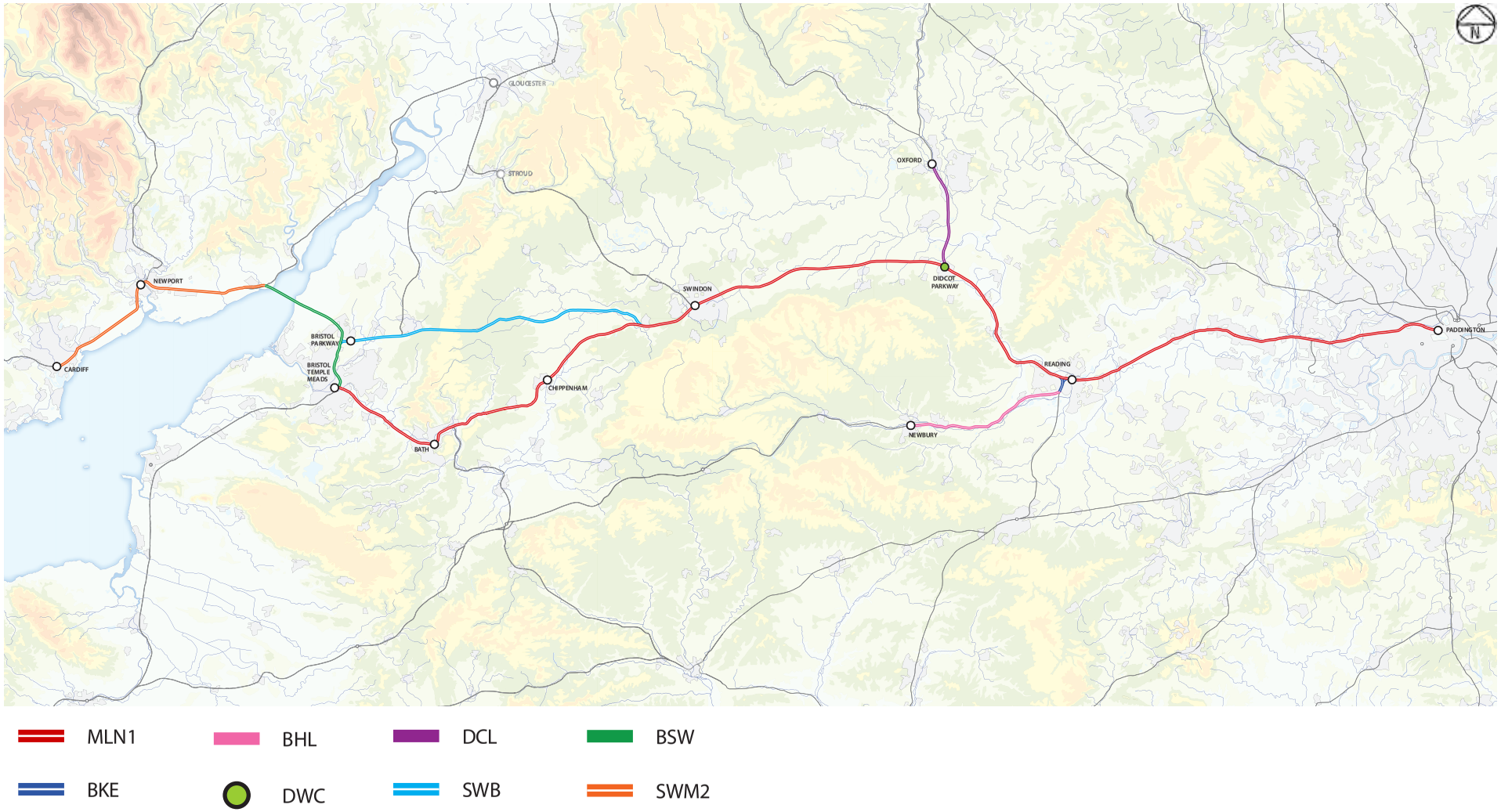


Fig. 1 : The lines to be electrified

2.0
History of the Main Line and subsidiary lines

2.1 Introduction

This chapter summarises the history of the Great Western Main Line and the lines to Newbury, Oxford and South Wales. It starts by outlining the development of these lines seen in the context of the railway revolution of the 1830s and 1840s. It then describes how the lines have been altered and extended since that pioneering era. A separate section (2.6) discusses the railway's component elements, including its civil engineering, bridges and stations. Finally section 2.7 gives brief biographies of the principal engineers and other designers involved in the development of the lines.

At the eastern end of the Main Line the overhead electrification project starts at Maidenhead. However for the sake of completeness, and to assist the review of significance in Chapter 3, reference is made here to the whole line including the London terminus at Paddington and other structures such as Maidenhead Bridge.

There is a large literature on the Great Western Railway and its principal engineer Isambard Kingdom Brunel. References to some of the key works are given throughout this report and in the sources listed in Appendix 1. Much of the existing literature is repetitious, nostalgic and unfocused, and despite the amount that has been written there are major aspects of the story, particularly concerning how the lines were designed and built, which have not been fully explored. Because of the context in which it has been prepared this report focuses primarily on what has survived, and the structures along it. For that reason some topics which normally feature prominently in the history of the GWR, such as the controversy over the broad gauge, are only lightly touched on here.

2.2 The pioneering phase of railway building

Railways were not a new phenomenon in the early nineteenth century, but prior to the 1820s they were limited to small scale local lines operated by horse power or stationary engines. Most of these lines were for carrying coal from mines to ports for shipment. The breakthrough was the development of the steam locomotive, which promised a much wider range of commercial possibilities. The Stockton and Darlington Railway, opened in 1825, was a hybrid operation – part locomotives, part horses – but is generally regarded as having inaugurated the railway age. Even more important was the Liverpool & Manchester Railway of 1830 because of its length and its total reliance on steam power. It also heralded the future in the provision it made for passenger traffic, which yielded about half its revenue.

The success of the Liverpool & Manchester led to the first peak in railway investment in the mid-1830s, symbolised by the incorporation of five railway companies:

- The Grand Junction Railway (Birmingham to the Liverpool & Manchester) 1833: completed 1837
- London & Birmingham Railway, 1833: completed 1838
- London & Southampton Railway, 1834: completed 1840
- Great Western Railway, London to Bristol, 1835: completed 1841
- London & Greenwich Railway, 1835: completed 1838

Thus the initiative to build the GWR was clearly part of the pioneering phase. [1] Like other lines it was a local promotion, largely stemming from Bristol business interests, and it relied on local sources of investment. After the mid-1830s boom there was a lull in railway promotion: only 250 miles were sanctioned by Parliament in 1838-43. Then followed the railway mania of 1844-48 when about 12,000 miles were authorised.[2] Some of these schemes had no hope of being financed or built, but by 1852 7,500 miles of railway were in use: in England the only substantial towns that did not have a line by that date were Hereford, Yeovil and Weymouth.

The impact of the railway was profound, in stimulating economic growth through the ease of transporting raw materials and goods, in encouraging labour mobility, and in bringing people and places closer together. Railway investment was of outstanding importance to the economy in the mid-nineteenth century. Although its significance then lessened it left a permanent transformation of the nation's society and economy.

2.3 The Construction of the Great Western Main Line

The Great Western Main Line which is the principal subject of this report was built at the initiative of Bristol businessmen and industrialists who recognised that a railway link to London and the rest of the country would help invigorate their city's economy. The committee set up to promote the line appointed Brunel as engineer for the line in 1833. He was then aged 27 and was well known in Bristol for his design of the Clifton suspension bridge, adopted in 1831, and his work on the docks and the floating harbour. Brunel carried out the first surveys of the route in about nine weeks immediately after he had been appointed.

The surveys established the route from Bristol to London via Bath, Chippenham and Reading, though the location of the London Terminus was later to change from Euston to Paddington. The way the surveys were made was a foretaste of how the line was to be designed and built, for Brunel rode over every mile and dealt personally

[1] H.J. Dyos and D.H. Aldcroft, British Transport: *An Economic Survey from the Seventeeth century to the Twentieth* (Leicester, 1969), pp.117-119

[2] Ibid. pp 127-9

with the many landowners affected. It is clear that in addition to the selection of the route he had strong opinions about how the line would fit in the landscape, from an aesthetic as well as an engineering point of view. In addition, as an engineer who liked to think problems through from first principles, he decided that the line should be built to a broad (7ft ¼ inch) gauge. The Board of the GWR confirmed this decision in 1839. [3] Ultimately this proved to be a mistake which placed the Great Western at a great disadvantage, but it had the effect of creating a line on a nobler scale than the other main lines. That is a legacy which can still be clearly be seen today, especially in the design of overbridges and tunnels.

The first Bill to authorise the line was put before Parliament in 1834 but failed because it was not for the whole route but only the two extremities, London-Reading and Bath-Bristol. A second Bill succeeded in 1835, allowing work to start the same year. Of the original shares, 23% were subscribed from Bristol and the 27% from London, and the railway was administered by separate committees at the two ends of the line, not united until 1843. [4]

The construction of the line was organised as a series of contracts, numbered for sections of the line from London, Reading, Steventon, Chippenham and Bath. Except for the extraordinary degree of control that he exercised, the way that Brunel ran the project was not substantially different to other railway projects, or indeed canal projects before them.

- Resident engineers worked under Brunel supervising the project. These included G.E. Frere for Bristol-Shrivenham assisted by, for instance, Michael Lane and R.P.Brereton, and J.W.Hammond for the line from London-Shrivenham. Although some of these men signed contracts they appear to have had almost no independent design role (see para 2.7 below).

- Contractors. Well-known, substantial firms were employed, for instance Grissell & Peto at Wharncliffe Viaduct, but so were small-scale local firms. Some of the smaller firms, such as William Ranger of Bristol, under-performed or failed. Box Tunnel, the most demanding project on the line, was divided between George Burge of Herne Bay and two local contractors, Lewis and Brewer. [5]

The line was built in stages from the two ends, from London to Wootton Bassett by December 1840 and from Bristol to Bath by August the same year. The final section, including Box and Middlehill Tunnels, was completed in June 1841, enabling trains to run from London to Bristol for the first time.

The detailed sequence of construction is shown in maps within Section 2.6 (pp. 10-24). This sequence is summarised on the next page (relevant maps in italics):

[3] E.T. MacDermot, *History of the Great Western Railway Vol I* (Revised edn., 1964), pp.46-47

[4] André Gren, *The Foundation of Brunel's Great Western Railway* (Kettering, 2003), p.103; MacDermot, op.cit., p.78

[5] Colin G.Maggs, *The GWR Bristol to Bath Line* (Stroud, 2001), p.8; Steven Brindle, *Brunel. The Man who Built the World* (Paperback edition, 2006), p.91.

- Paddington-Maidenhead Riverside (Taplow) opened June 1838. Until 1854 and the completion of the present station, the London terminus was at Bishop's Bridge. The original station at Slough was one-sided, rebuilt 1886.

  1 - Great Western Railway: phase 1

- Maidenhead-Twyford, opened July 1839, including Maidenhead Bridge with its two 128ft span brick masonry arches. Maidenhead station not opened till 1871.

  2 - Great Western Railway: phase 2

- Twyford-Reading, opened March 1840, including the 1.7 mile long Sonning Cutting. Reading Station was originally (like Slough) one-sided, with two platforms laid end-to-end. This remained a bottleneck until its rebuilding in 1899.

  3 - Great Western Railway: phase 3

- Reading-Steventon, opened June 1840, including the four arch bridges over the Thames at Gatehampton and Moulsford and a deep cutting at Moulsford. The original Didcot station opened 1844.

  4 - Great Western Railway: phase 4

- Steventon-Farringdon Road (Challow), opened July 1840.

  5 - Great Western Railway: phase 5

- Farringdon Road (Challow)- Wootton Bassett, opened December 1840, including Swindon Station completed 1842 (on the works and railway village see para 2.6.5 below).

  7 - Great Western Railway: phase 7

- Wootton Bassett-Chippenham, opened May 1841, including the first notable gradient (84.5m to 86m from London). The first Chippenham station was rebuilt in 1858.

  8 - Great Western Railway: phase 8

- Chippenham-Bath, opened June 1841. This involved the most arduous works on the line, including Chippenham Viaduct, a 3 mile long cutting at Corsham, Middlehill Tunnel, Box Tunnel, and the approaches to Bath.

  9 - Great Western Railway: phase 9

- Bath-Bristol, opened August 1840, involving heavy works including eight tunnels, two viaducts, (St James's Viaduct and Twerton Viaduct) and the diversion of the River Avon.

  6 - Great Western Railway: phase 6

2.4 Additions And Extensions

Refer to the Construction Sequence maps in section 2.6 (No. & Title in italics below correspond to the map sequence).

Two of the subsidiary lines which are included in the electrification project were completed not long after the main line:

- **Didcot to Oxford (DCL)**. This 13 mile line was built to the broad gauge and was completed in 1844. It was intended to form part of a longer broad gauge route to Wolverhampton via Worcester, envisaged as challenging the monopoly of the London & Birmingham Railway. However Oxford remained the terminus for a number of years: the route to Wolverhampton was not completed till 1853-54

  10 - Oxford Branch

- **Reading to Newbury (BKE & BHL)**. The line to Newbury formed part of the route south of the Marlborough Downs which Brunel had dismissed as a result of his first surveys. In its planning stages it was the subject of a dispute between the GWR and the London & South Western Railway, which wanted to build a line from Basingstoke to Newbury. The resolution of that dispute allowed the Berks & Hants Railway (a subsidiary of the GWR) to go ahead: the line to Hungerford via Newbury was completed in 1847.

  12 - Berks & Hants Line

A large number of other lines which are not covered in this report were completed or authorised in the 1840s, including four projects which ultimately made up the route from London to Penzance. All were built to Brunel's broad gauge and although promoted as separate companies they were linked to the GWR and had Brunel as engineer. They were all absorbed into the GWR by 1889.

Three lines developed post 1840s are within the routes covered by this report:

- **South Wales Railway (SWM2)**, sanctioned in 1845 as a line to connect the GWR at Gloucester with Cardiff, Swansea and Fishguard. Opened from Gloucester to Milford Haven by 1852 (the link to Fishguard came much later). Operated as an offshoot of the GWR, designed by Brunel and built to broad gauge, it amalgamated with the parent company in 1863.

  13, 14, 15 - South Wales Railway phases 1-3

- **Bristol & South Wales Union Railway (BSW)**, from Bristol to New Passage Pier, built 1858-63 as an alternative to the line via Gloucester as a route to South Wales and Cardiff: from New Passage Pier there was a ferry to Portskewett in Wales. Brunel was the engineer. The railway became part of the GWR in 1868.

  16 - Bristol & South Wales Union Railway

- **South Wales & Bristol Direct Line (SWB)**, built 1897-1903 as a consequence of the opening of the Severn Tunnel in 1886. This line of 29 ¾ miles - known as the 'Top Road' to railwaymen, runs from the original main line at Wootton Bassett through the Cotswolds to Patchway, near the descent to the Severn Tunnel; it was the first of a number of 'cut off' routes completed by the GWR at the turn of the 20th century to accelerate its long distance services. It includes four viaducts and two tunnels (one of which, at Sodbury, is 2 ½ miles long).

  26 - South Wales & Bristol Direct Line

2.5 Subsequent History

From the administrative point of view the Great Western Railway, which had built the main line to Bristol, maintained its identity more successfully than almost any other railway company. Throughout the second half of the nineteenth century it expanded its territory through amalgamations with smaller companies, with many of which it already had leasing agreements. These included the Bristol to Exeter Railway and other companies on the route to Cornwall, all of which had been absorbed by 1889. By the time of the Railways Act of 1921, which brought all the country's railway companies together in four companies, the GWR already dominated its territory. It was only required to absorb various local railways in South Wales plus the Cambrian Railway.

Railway nationalisation in 1948 brought the long history of the GWR to a close, but as BR (Western Region) it again kept a separate identity and maintained many of its pre-nationalisation traditions. It still had a character all its own, much of which could be traced to the years when the Main Line was first built.

For the routes discussed in this report, the first physical changes were in connection with the conversion from broad to standard gauge, which took place gradually 1868-92 (*Section 2.6 maps 17-21 & 24*), (An earlier change, outside the scope of this report, was the construction of a new terminus at Paddington in 1851-4). On many routes there was a transitional phase of mixed gauge allowing standard gauge trains to run on broad gauge routes: London to Bristol was mixed gauge by 1875. Even then some broad gauge lines were still being built. The final conversion of 177 miles of track took place over two days in 1892. Once the conversion was complete, all that remained as a memory of the broad gauge was the scale of structures along the route.

The final removal of broad gauge was closely related to the doubling of the Main Line from two to four tracks, which took place in essentially two stages:

- London – Taplow (including Wharncliffe Viaduct) 1875-84

  21 - GWML widening: phase 1

- Taplow – Didcot 1890-1893 (though a bottleneck remained at Reading till the station was rebuilt in 1899).

  23 - GWML widening: phase 2

In addition, loops were constructed in and west of Didcot, between Uffington and Shrivenham and between Highworth Junction and Swindon, completed in two stages before and after the First World War (*27 - GWML widening: phase 3; 28 - GWML widening: phase 4; 29 - GWML widening: phase 5*).

The overall result of these widenings is that of the 118 miles London – Bristol only c.50 miles is two track as originally designed. In addition the line between the Severn Tunnel and Cardiff was progressively widened upto 1941 to serve the expanding South Wales steel industry (*25 - South Wales quadrupling: phase 1; 30 - South Wales quadrupling: phase 2*)

These widenings, plus the gauge conversions, were part of a concerted effort to bring the GWR up to date, in part by removing some of the flaws in the original designs. The other aspect of this modernisation campaign was the construction of more direct lines, including the Severn Tunnel (1872-86, Fig 2 part 22), the South Wales direct route (1897-1903), and the 'cut off' line between Hungerford and Langport (1895-1902) which created a more direct route to Exeter than the original route via Bristol. At the same time, the reinvigorated company began to promote its services more widely. All of these changes did much to enhance the reputation of the GWR. Ironically, although the high regard which many people had for the GWR was in part based on these modernisation projects, these lines were still seen as being Brunel's railway: the new construction projects received only a fraction of the attention that his designs had done.

2.6 Construction Sequence

01

Great Western Railway: phase 1

Paddington to Maidenhead Riverside (east bank of the Thames)

Start Date: Autumn 1835

Opening Date: 4th June 1838

02

Great Western Railway: phase 2

Maidenhead Riverside to Twyford

Start Date: Spring 1837

Opening Date: 1st July 1839

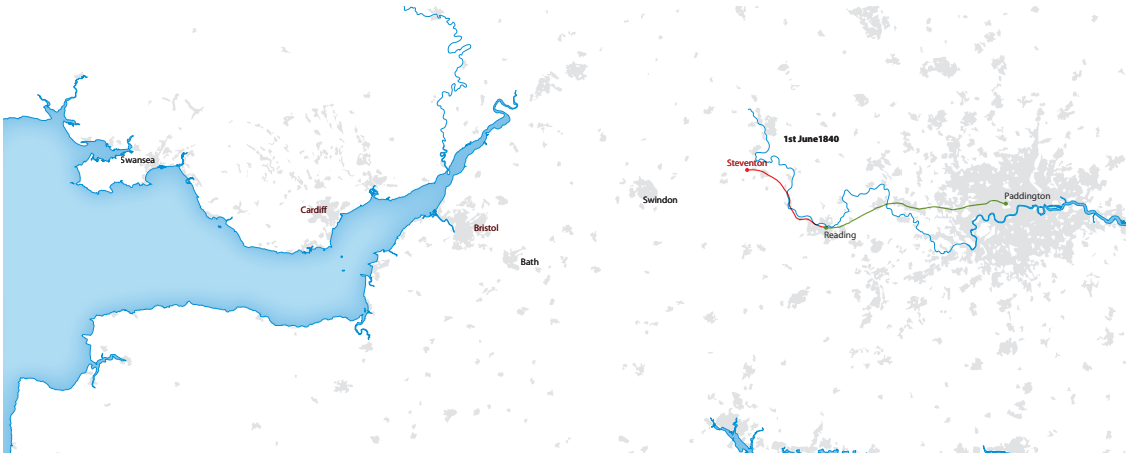
03 Great Western Railway: phase 3

Twyford to Reading

Start Date: Spring 1838

Opening Date: 30th March 1840

04 Great Western Railway: phase 4

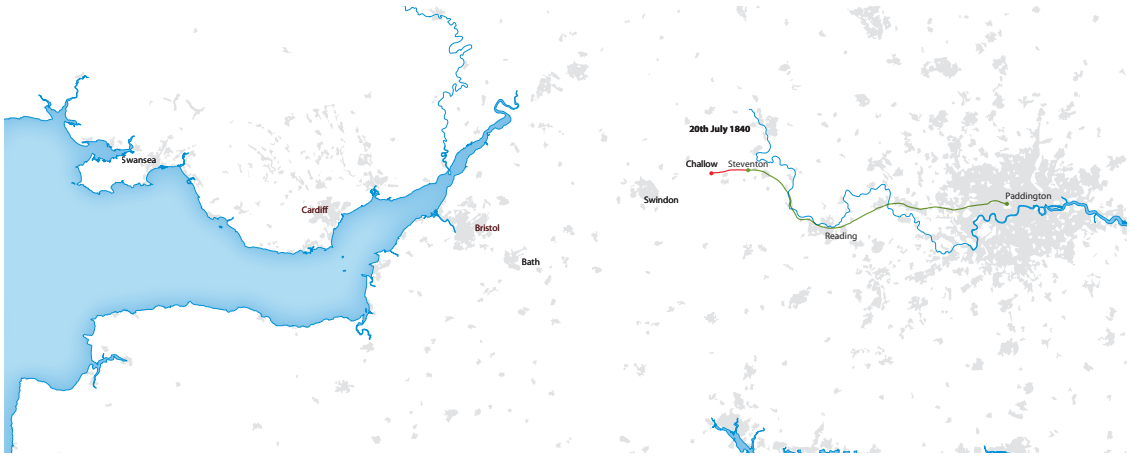


Reading to Steventon

Start Date: Spring 1838

Opening Date: 1st June 1840

05 Great Western Railway: phase 5

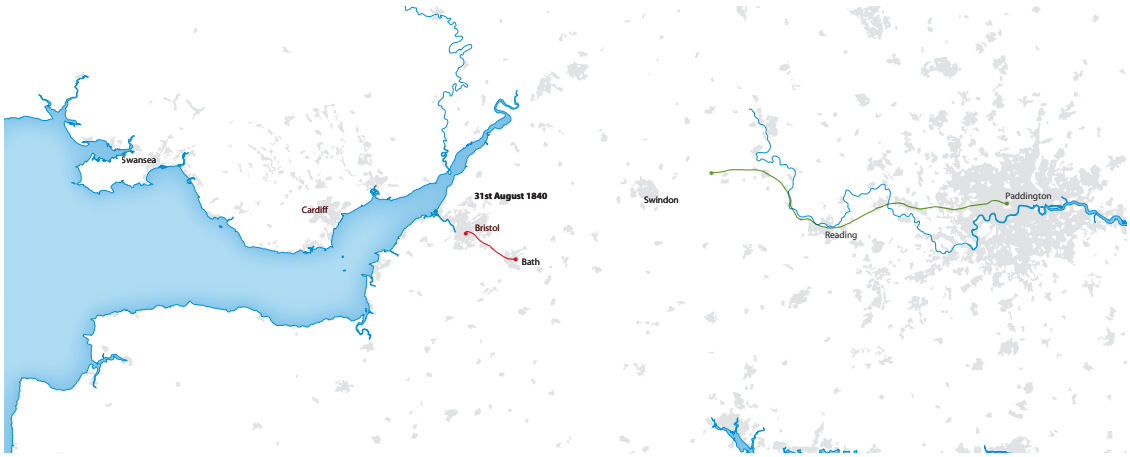


Steventon to Challow

Start Date: Spring 1839

Opening Date: 20th July 1840

06 Great Western Railway: phase 6

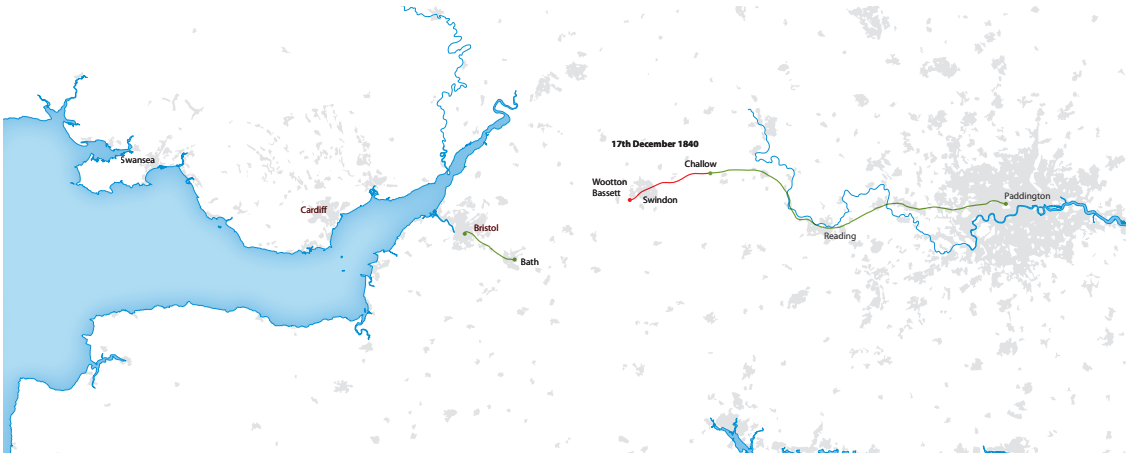


Bristol to Bath

Start Date: Spring 1836

Opening Date: 31st August 1840

07 Great Western Railway: phase 7

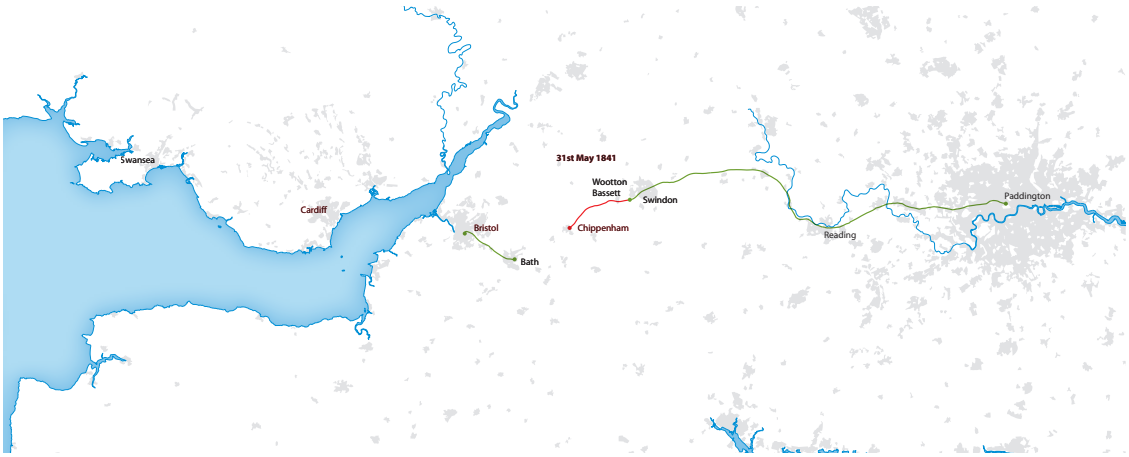


Challow to Wootton Bassett

Start Date: Spring 1839

Opening Date: 17th December 1840

08 Great Western Railway: phase 8

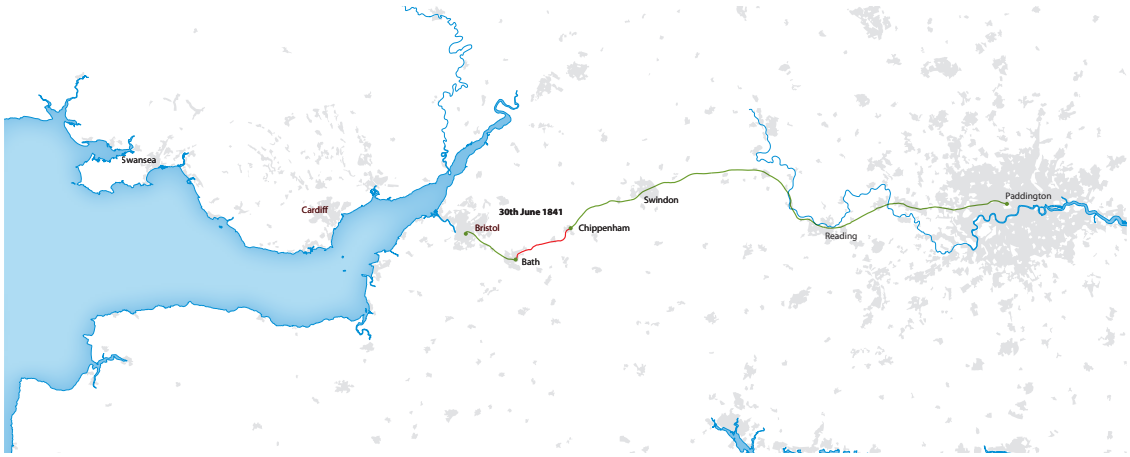


Wootton Bassett to Chippenham

Start Date: Spring 1839

Opening Date: 31st May 1841

09 Great Western Railway: phase 9

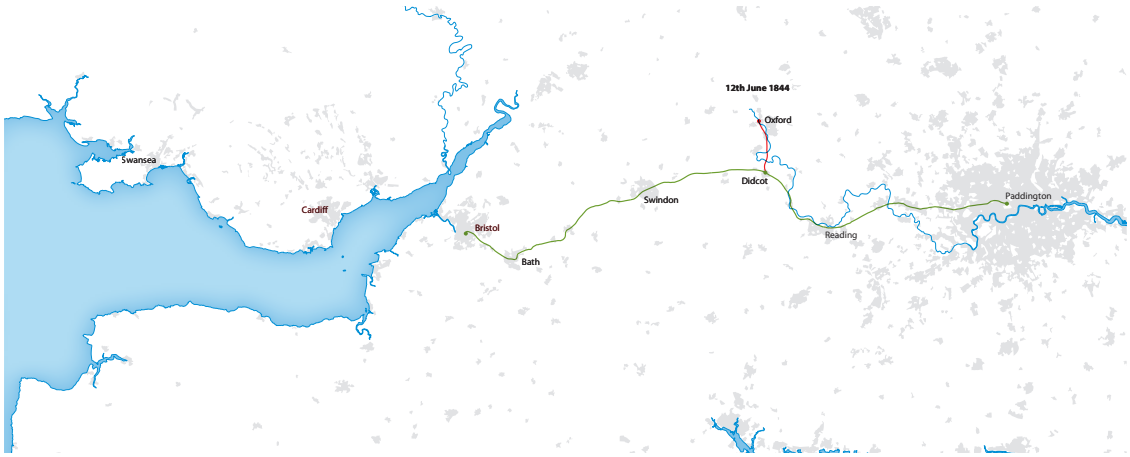


Chippenham to Bath

Start Date: Autumn 1836

Opening Date: 30th June 1841

10 Oxford Branch

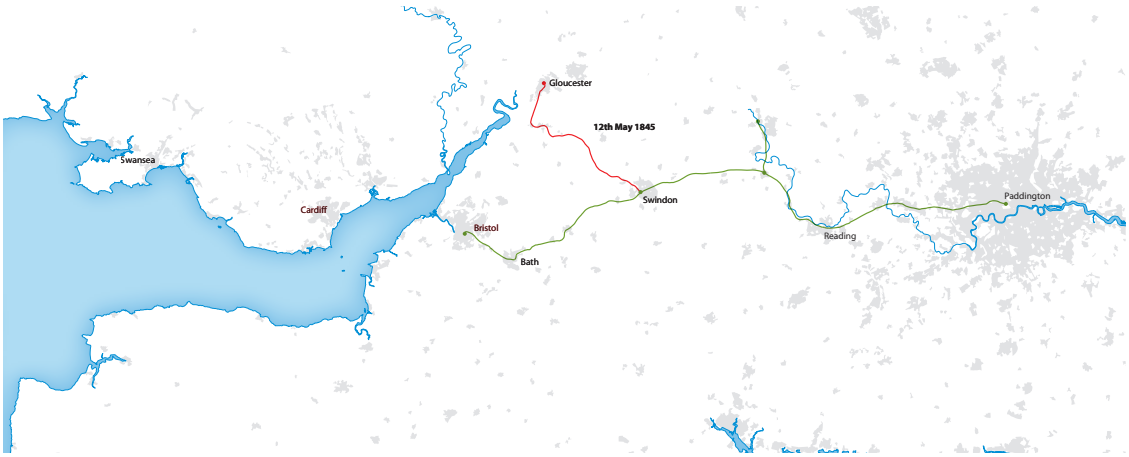


Didcot - Oxford (DCL)

Start Date: Autumn 1843

Opening Date: 12th June 1844

11 Swindon to Gloucester

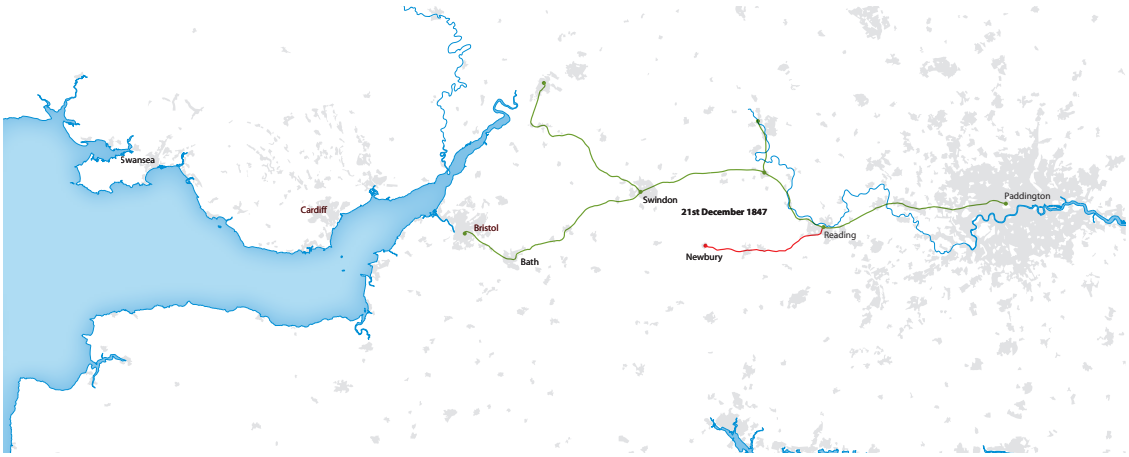


Cheltenham & Great Western Railway Union Railway (SWM1 - BGL1)

Start Date: January 1841

Opening Date: 12th May 1845

12 Berks & Hants Railway

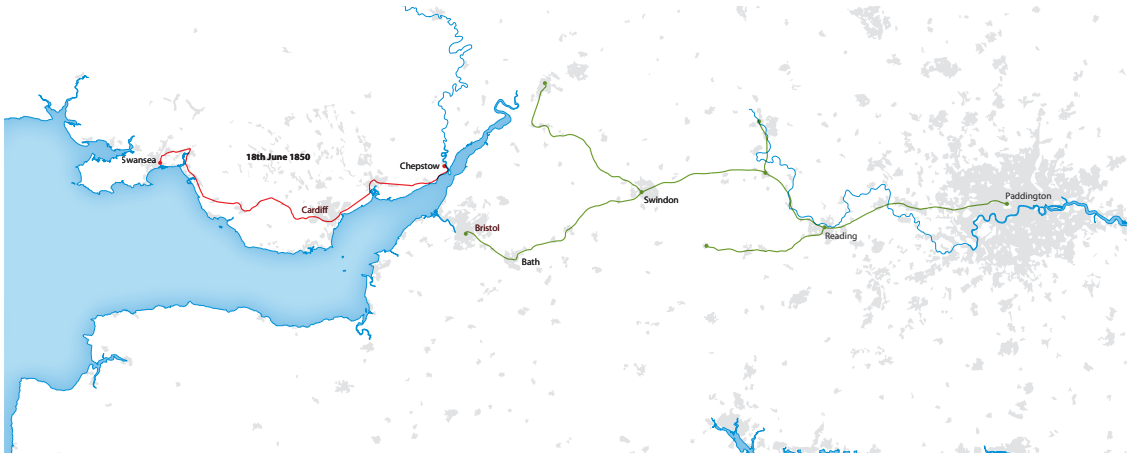


Reading to Hungerford Branch via Newbury (BHL)

Start Date: Spring 1845

Opening Date: 21st December 1847

13 South Wales Railway: phase 1

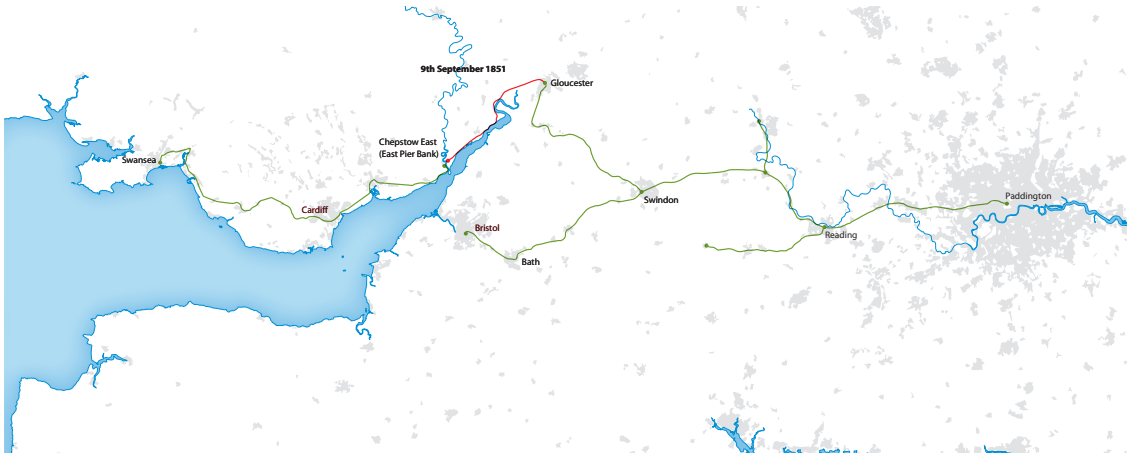


Swansea to Chepstow via what is now known as Severn Tunnel Junction (SWM2)

Start Date: Summer 1846

Opening Date: 18th June 1850

14 South Wales Railway: phase 2

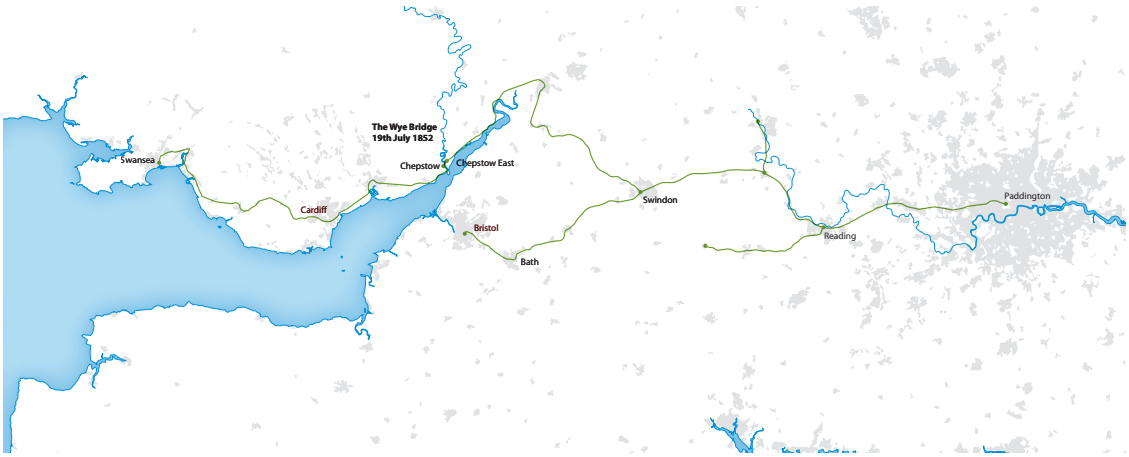


Gloucester - Chepstow (SWM2)

Start Date: Summer 1846

Opening Date: 9th September 1851

15 South Wales Railway: phase 3

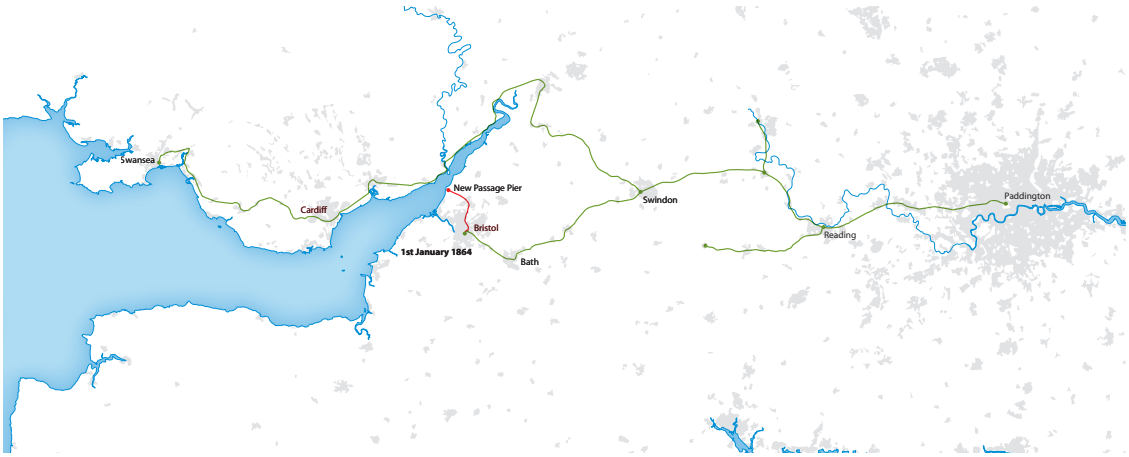


The Wye Bridge at Chepstow (SWM2)

Start Date: Spring 1849

Opening Date: 19th July 1852

16 Bristol & South Wales Union Railway

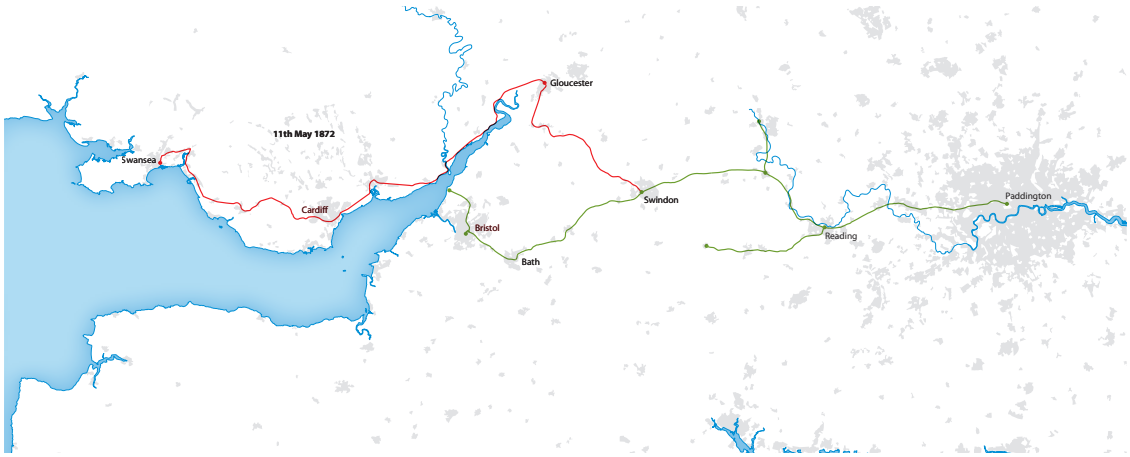


Bristol to New Passage Pier (BSW)

Start Date: Autumn 1858

Opening Date: 1st January 1864

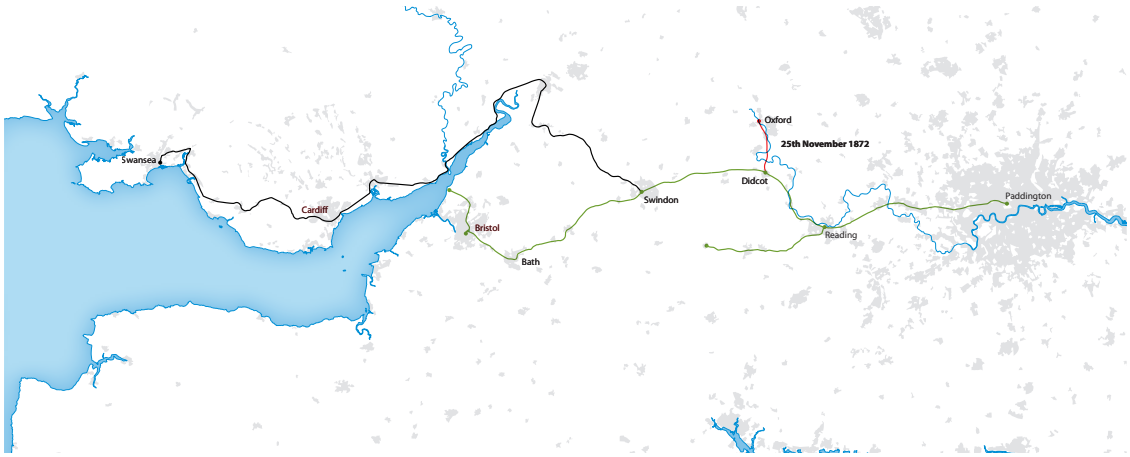
17 Standard Gauge Conversion: South Wales



Swansea to Swindon via Gloucester

Opening Date: May 1872

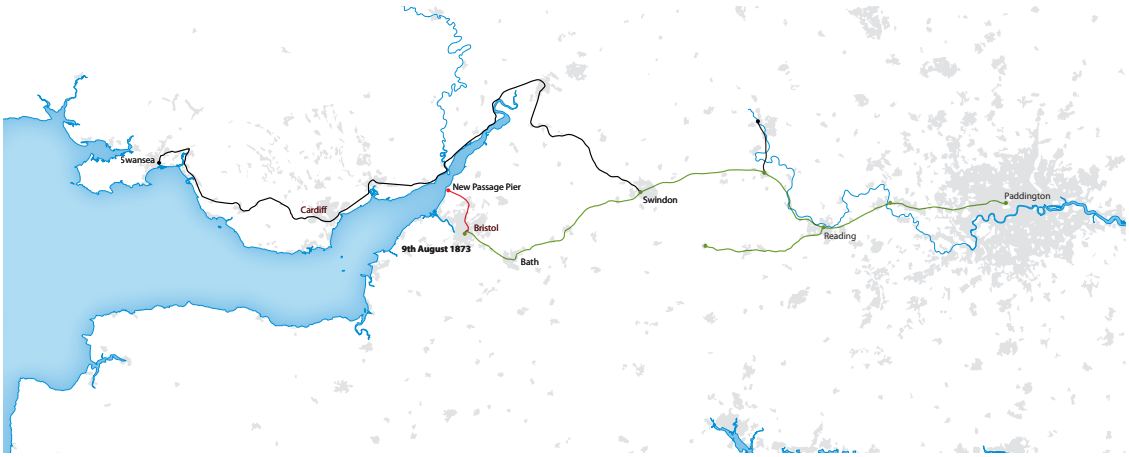
18 Standard Gauge Conversion: Oxford Branch



Name: Didcot to Oxford

Opening Date: November 1872

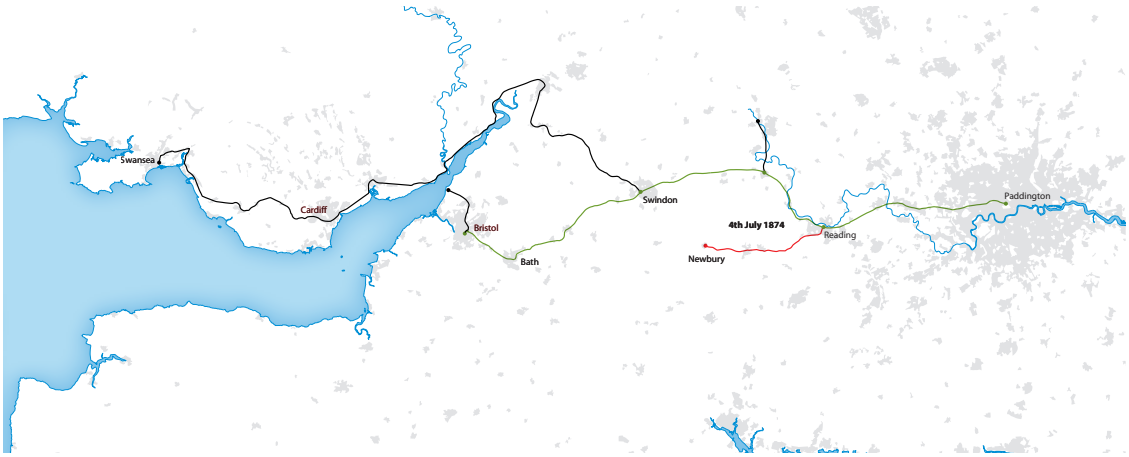
19 Standard Gauge Conversion: Bristol - New Passage Pier



Bristol to New Passage Pier

Opening Date: August 1873

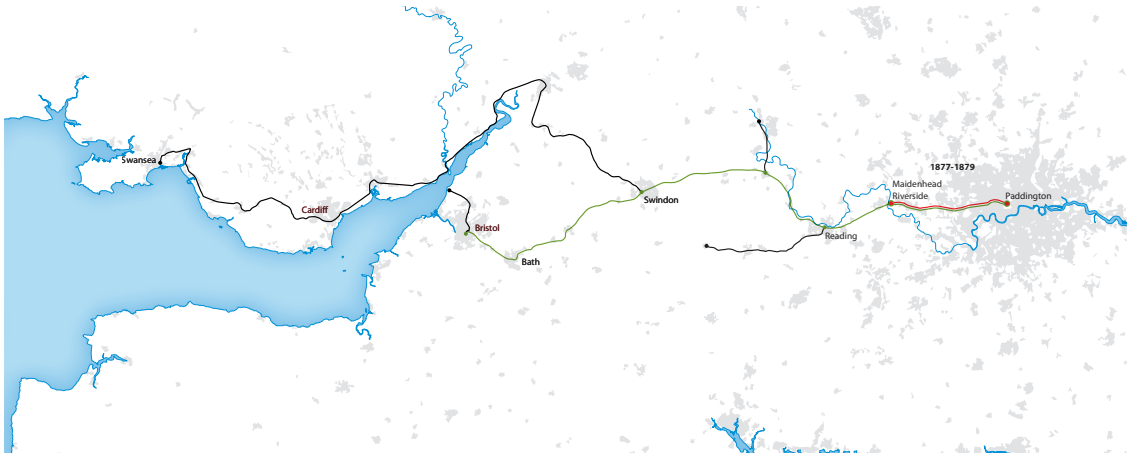
20 Standard Gauge Conversion: BHL



Reading to Hungerford via Newbury

Opening Date: July 1874

21 GWML widening: phase 1

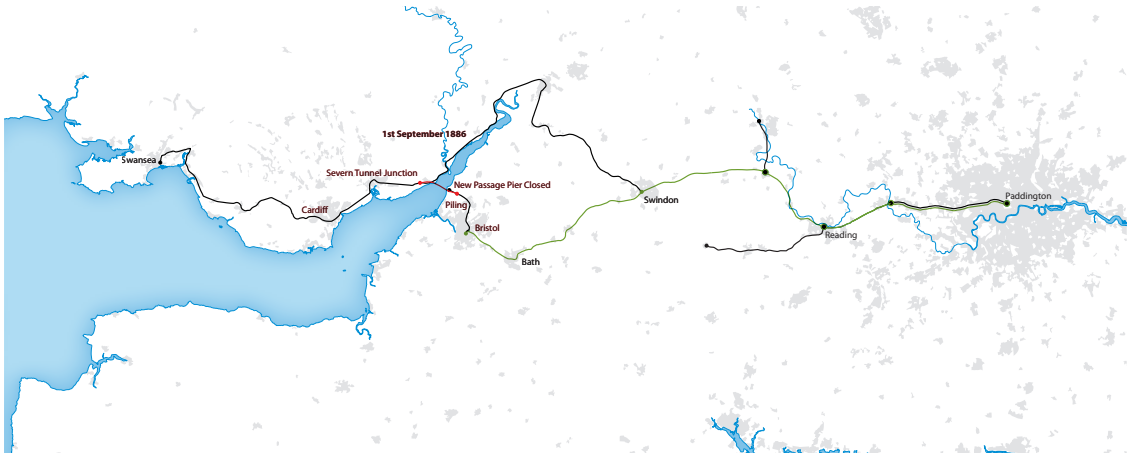


Paddington to Taplow quadrupling

Start Date: 1875

Opening Date: 1884

22 The Severn Tunnel

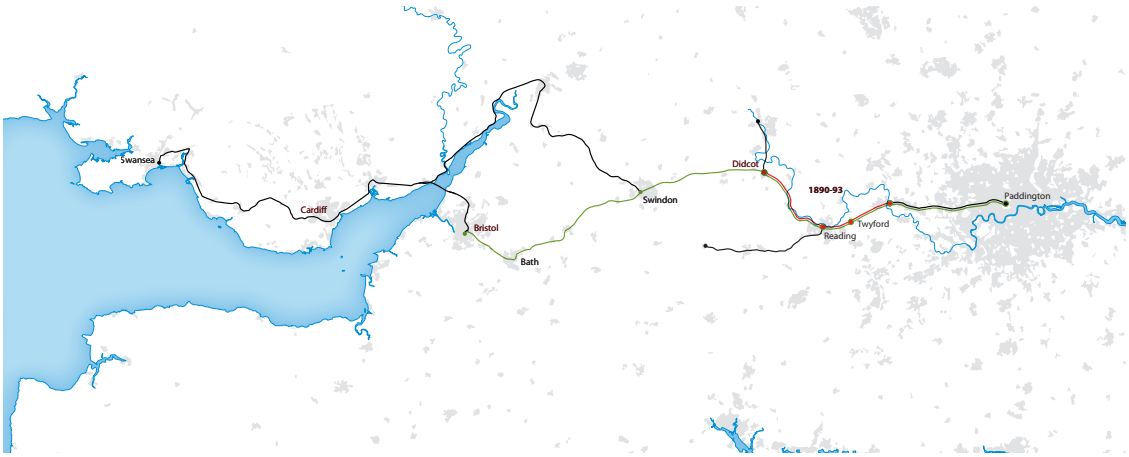


Piling Junction to Severn Tunnel Junction (BSW)

Start Date: Ground work began as early as Spring 1873, Contract signed Summer 1877

Opening Date: 1st September 1886

23 GWML widening: phase 2

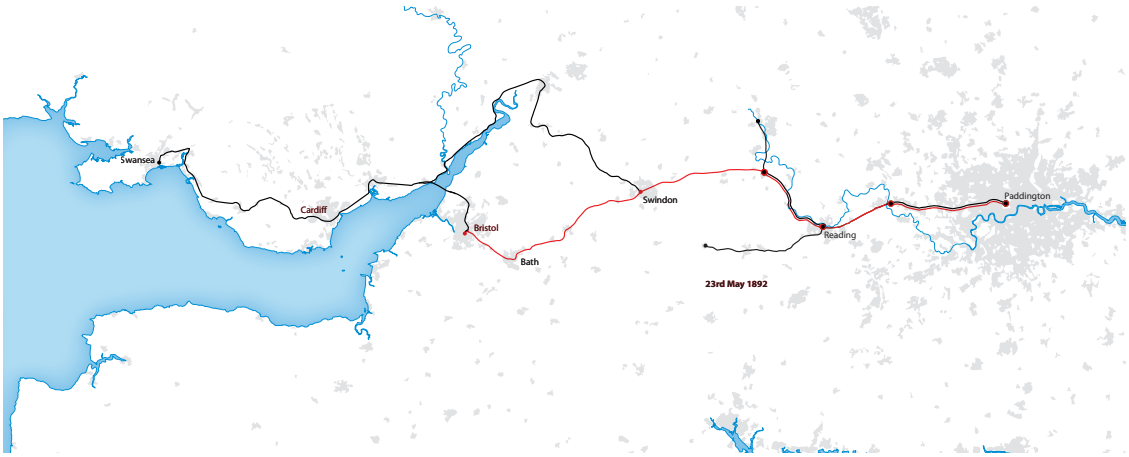


Maidnhead Railway Bridge to Didcot

Start Date: 1890

Opening Date: 1893

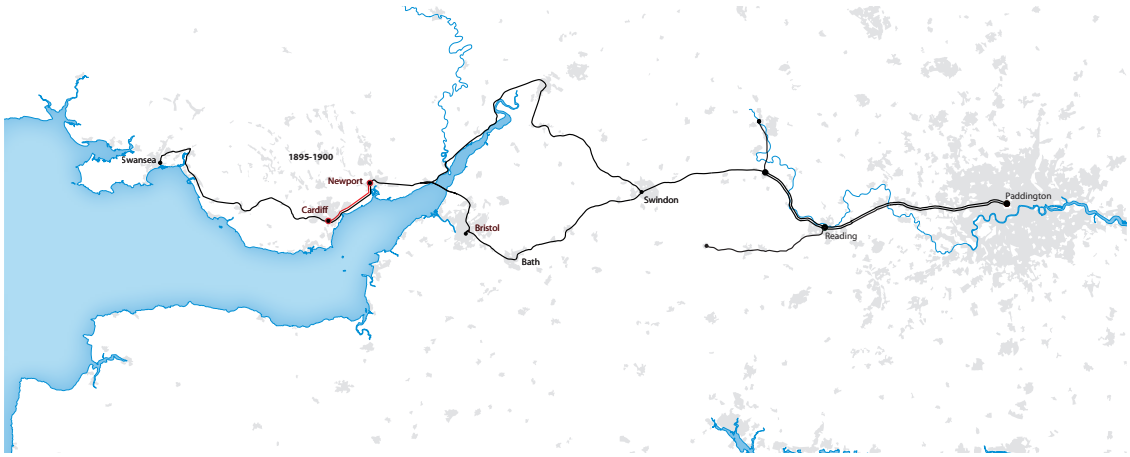
24 Standard Gauge Conversion: GWML



Paddington to Bristol

Opening Date: May 1892

25 South Wales quadrupling: phase 1

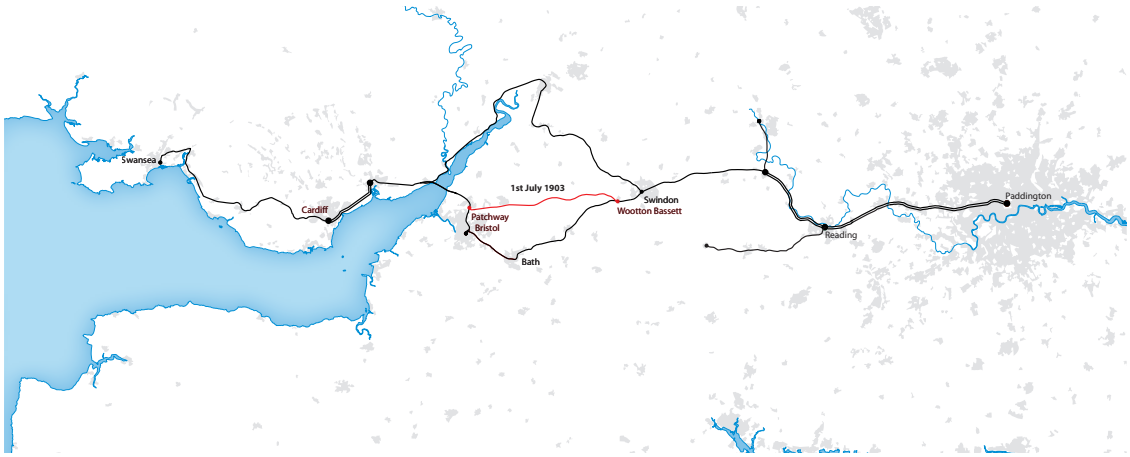


Cardiff - Newport

Start Date: 1895

Completion Date: 1900

26 South Wales & Bristol Direct Line

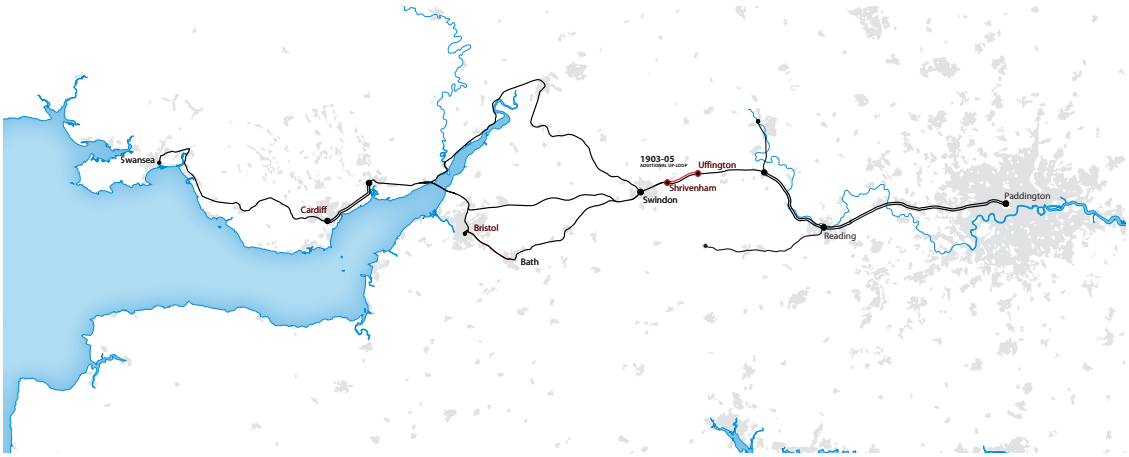


Wootton Bassett - Patchway (Badminton Line) (SWB)

Start Date: Early 1897

Opening Date: 1st July 1903

27 GWML widening: phase 3

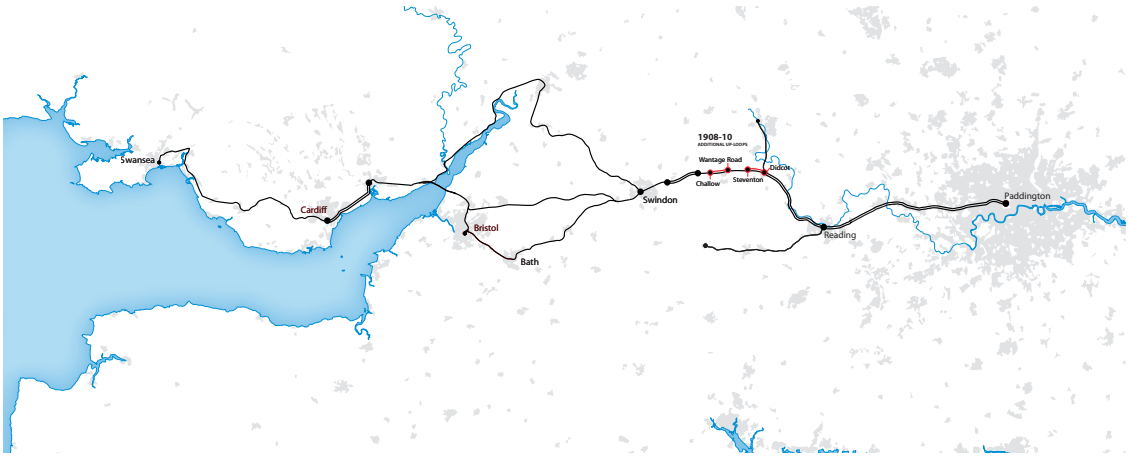


Shrivenham - Uffington loop

Start Date: 1903

Opening Date: 1905

28 GWML widening: phase 4

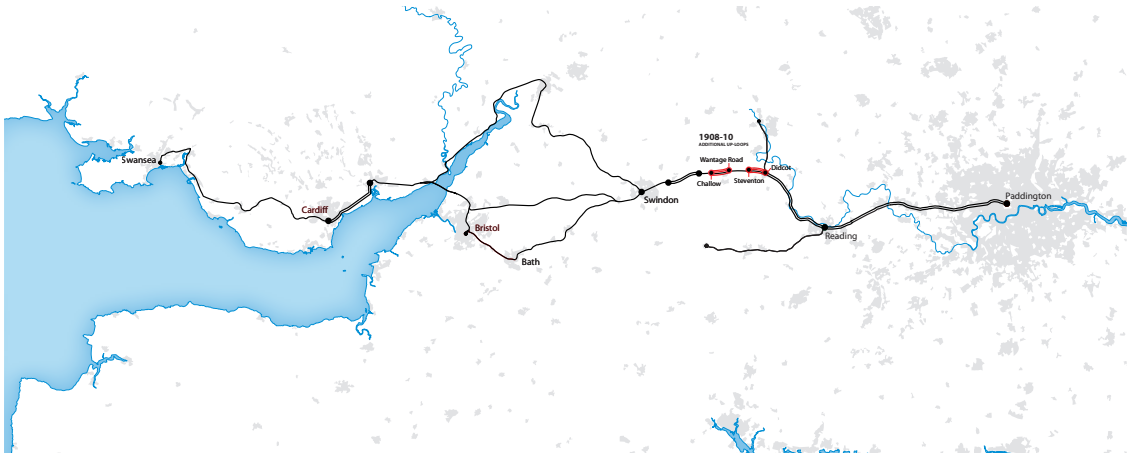


Didcot - Challow loops

Start Date: 1908

Opening Date: 1910

29 GWML widening: phase 5

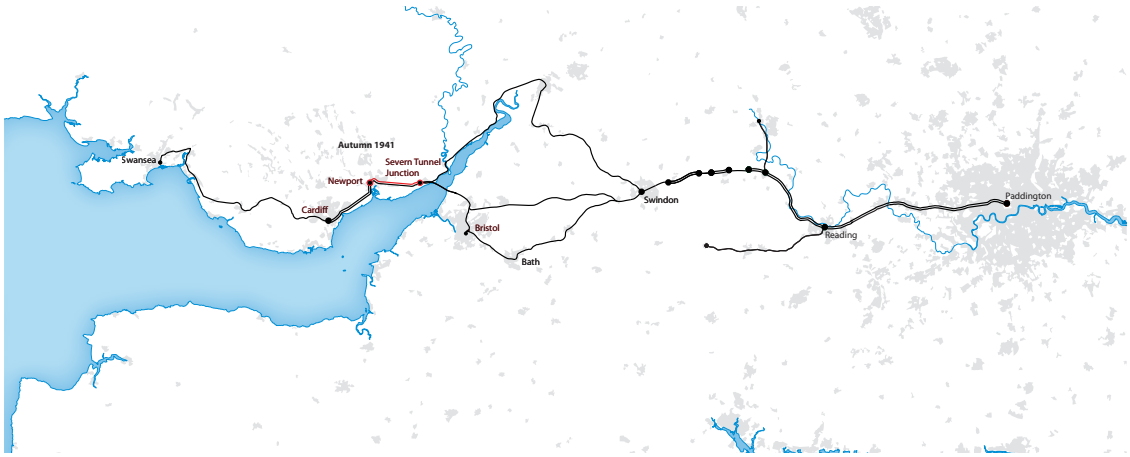


Didcot - Challow quadrupling (MLN1)

Start Date: 1931

Opening Date: 1932

30 South Wales quadrupling: phase 1



Newport - Severn Tunnel Junction (MLN1)

Opening Date: Autumn 1941

2.7 The Component Parts

The section looks at some of the key features of the routes, starting with the overall engineering of the lines before considering elements such as bridges and stations. As already emphasised, the focus here is on what has survived, though the surviving elements are discussed in the context of how the lines were originally designed and built.

2.7.1 Civil engineering

The engineering of the line comprised the selection of the route and the detailed engineering design of the line. Generally in railway building, route selection was determined by two factors:

- The need to link principal towns
- The decision to maintain favourable gradients. Main roads could have gradients up to 1:20 but railways demanded much easier gradients: for instance the London & Birmingham Railway was built to a ruling gradient of 1:330.

These considerations held for Brunel as much as any other engineer, but he also had two other thoughts in mind. First, although it was not finally confirmed by GWR Board until 1839, he conceived of the main line and the subsequent branches as broad gauge routes, to be designed for a 7ft ¼ inch gauge rather than the 4ft 8 ½ inch gauge which was to become the generally accepted standard. The justification for the broad gauge was that it would allow trains to be designed to a low centre of gravity, resulting in higher speeds and greater comfort. The standard width of a two track broad gauge line would be 30ft, allowing 6ft between the lines, and cuttings would have to be 38-40ft wide. [6] The trains would not be significantly higher than standard gauge trains, so the height of structures along the lines would not be obviously affected. However the radius of curves would have to be generous, ideally no sharper than a mile radius.

In addition to this matter of scale it would seem that Brunel also had in mind the overall visual appearance of the railway in the landscape. This is not something about which he left a written statement of his intentions but it can be inferred from the design of the line, drawings in his sketch books and the way it was described by contemporaries. J.C. Bourne, in his history of 1846, expressed the hope that "drawings sufficiently correct for the purpose of the engineer or architect will please also lovers of the picturesque."(Figs. 3 and 4)[7]

In referring to the picturesque, a mode of looking at the landscape which had been popular since the mid-eighteenth century, Bourne was primarily drawing attention to the way in which the views in his book were composed, but he was also thinking of the way in which the line had been designed. [8] Picturesque is the obvious word which comes to mind in describing how the railway is threaded through Sydney Gardens in Bath, but it can be equally applied to other stretches of the line. The architectural

[6] J.C.Bourne, *The History and Description of the Great Western Railway* (1846), p.30

[7] Ibid, p. iii

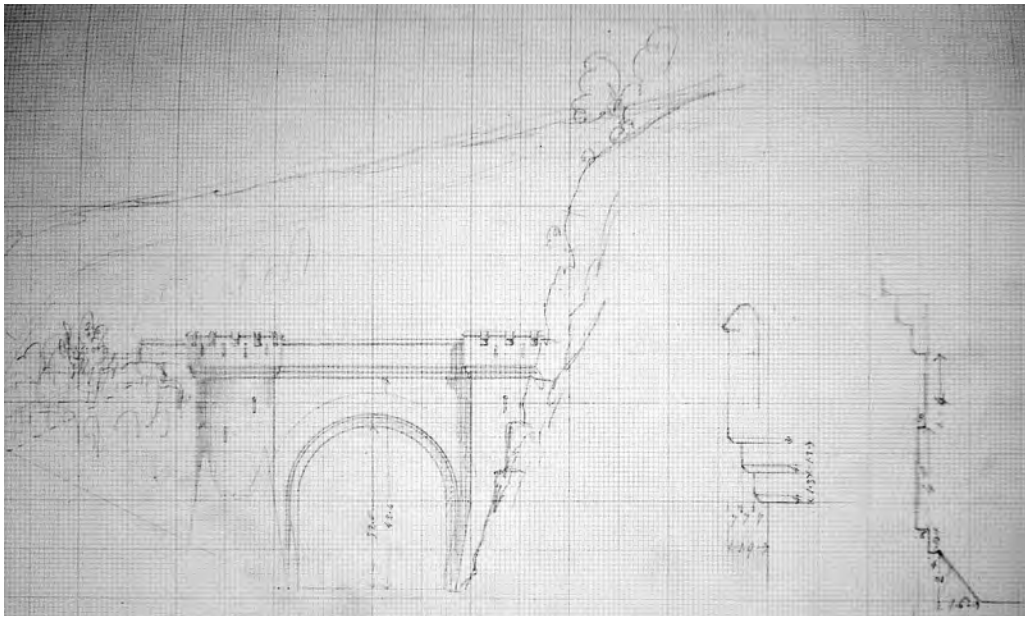


Fig 3 : The initial design for Fox Wood Tunnel west portal from one of Brunel's sketchbooks, showing the relationship between the architecture and its landscape setting (sketchbook in the Brunel Collection of the University of Bristol, at the Brunel Institute)

Fig 4 : Engraving from Bourne's *History* of the line at Bathwick, on the approach to Bath (1846)

progression - from Tudor-Gothic at the western end of the line via Classical in the Bath area to a more austere use of brick towards London - is much in the mode of the way buildings were treated in the Georgian landscape. Bourne responded to that architectural and landscape treatment, reflecting the fact that this was more than just a line designed for directness and speed.

[8] On the popularity of the picturesque in Brunel's time: Malcolm Andrews, *The Search for the Picturesque* (1989); Stephen Copley ed., *The Politics of the Picturesque* (1994)

As already mentioned (para. 2.3), Brunel surveyed the route for the Main Line in 1833. From London to Reading the route was an obvious one, avoiding the Northern Heights at the London end. After Reading, going westwards he chose to keep north of the Marlborough Downs by going up the Thames valley and across the Vale of the White Horse, rather than go via the Vale of Pewsey and Bradford-on-Avon. This took him closer to Oxford, though not to Oxford itself, and closer to a future junction for Gloucester. Thus far he could maintain an almost level line at 1:660. After 85 miles there were two inclines, one at Dauntsey and one through Box Tunnel. From Box to Bath and thence to Bristol the route became more complex but generally followed the River Avon, keeping to its southern bank.

This choice of route, and the way it used existing topography and contours, meant that the earthworks involved were not as great as for other main lines.

Railway	**Volume of excavation per mile (cubic yards)**
London & Brighton	145,000
London & Birmingham	115,000
Midland Counties	95,000
Liverpool & Manchester	90,000
Great Western	85,000 [9]

The main earthworks comprised:

- Cuttings; most famously at Sonning (1838-40), but also at Moulsford, between Hay Lane and Chippenham, and between Box and Bathford
- Bridges (see para 2.7.2)
- Tunnels (see para 2.7.3)
- Other works such as the diversion of the Kennet and Avon Canal in Bath and the River Avon near Bristol

The scale and extent of these works meant the Main Line as a whole was expensive to build; not as expensive in cost per mile as a line such as the London & Brighton which required substantial earthworks, but more expensive than the other principal main line of its time, the London & Birmingham. In part, this may have been because of the broad gauge but no doubt it was also because the grandeur of Brunel's vision and the way in which he applied that vision to every aspect of the works. As Angus Buchanan puts it: "unlike most other railways, the GWR was conceived of as a whole, like a work of art, with the mind of an artist establishing the guiding principles and ensuring that every detail harmonised in the overall pattern." [10] That vision was driven by engineering priorities but it also had a strong aesthetic ingredient which, like everything else, Brunel felt competent to determine.

[9] A.W. Skempton, *"Embankments and Cuttings on the Early Railways"*, Construction History Vol II (1995), p.65

[10] R. Angus Buchanan, Brunel. *The Life and Times of Isambard Kingdom Brunel* (2002), p.65

2.7.2 Bridges and viaducts

Introduction

All but the simplest railways require bridges over and under the track. Long bridges of multiple spans these are generally known as viaducts, though there is no clear-cut distinction between the two types. Early railway engineers adopted the principles of bridge design which had previously been developed by road and canal builders, extending those principles where necessary.

There were three types of bridge construction available to railway builders, all of which were used on the Great Western lines:

- *Brick or stone masonry*. The arches of masonry bridges could be semi-circular, segmental or elliptical. Ideally a railway would cross a road or river at right angles, but the route of a railway often dictated that the bridge arch be skewed. A skew arch has distinctive parallel, spiral courses of brick or stone laid so that the end of the arch consists of solid, not cut, bricks.
- *Timber*. Bridges constructed from timber beams or laminated arches had the advantage that they were relatively inexpensive and quick to build.
- *Iron*. Early railways made use of iron construction, principally cast iron beams, as in the Water Street Bridge at Manchester on the Liverpool & Manchester Railway, 1829-30 [11]. Subsequently, composite (wrought and cast iron) beams were used and, from the late 1840s, various forms of wrought iron construction.

Brunel deployed all three of these types of bridge construction on the GWML, though today, with one exception, it is only his masonry bridges which have survived. In the post-Brunel era, bridges were built in masonry, iron and steel, including the bridge extensions required when sections of the line were quadrupled. In recent years, precast and pre-stressed concrete designs have been used.

Before discussing the various bridge types in more detail, it is worth emphasising how they were designed. In the Brunel era and later all bridges were designed in the Engineer's Office of the GWR, i.e. they were not designed by contractors or external consultants. On the original main line of 1835-41, although there were clearly some generic types, each bridge was individually designed. Only a small proportion of the original drawings for these bridges (now in the Network Rail Archives) are signed, but it is known from Brunel's sketchbooks and letter-books that he had a direct hand in their design as part of his control over every aspect of the line (fig. 5). [12] Those drawings which are signed are generally contract drawings, and some of these are signed by Brunel e.g. Bourton Overbridge (7215) (Fig. 6) and Thornhill Overbridge (7450). In the post-Brunel era drawings generally carry the signature of one of the GWR engineers such as Lancaster Owen and the head of the Drawing Office Edmund Olander, but that may be signing-off a drawing rather than an indication of direct involvement in the design.

[11] Steven Brindle and Malcolm Tucker, *Brunel's Cast Iron Bridges. A Descriptive and Analytical Catalogue* (English Heritage, March 2011) p.17

[12] Steven Brindle, *Brunel – The Man Who Built the World* (Paperback edition, 2006) p.103

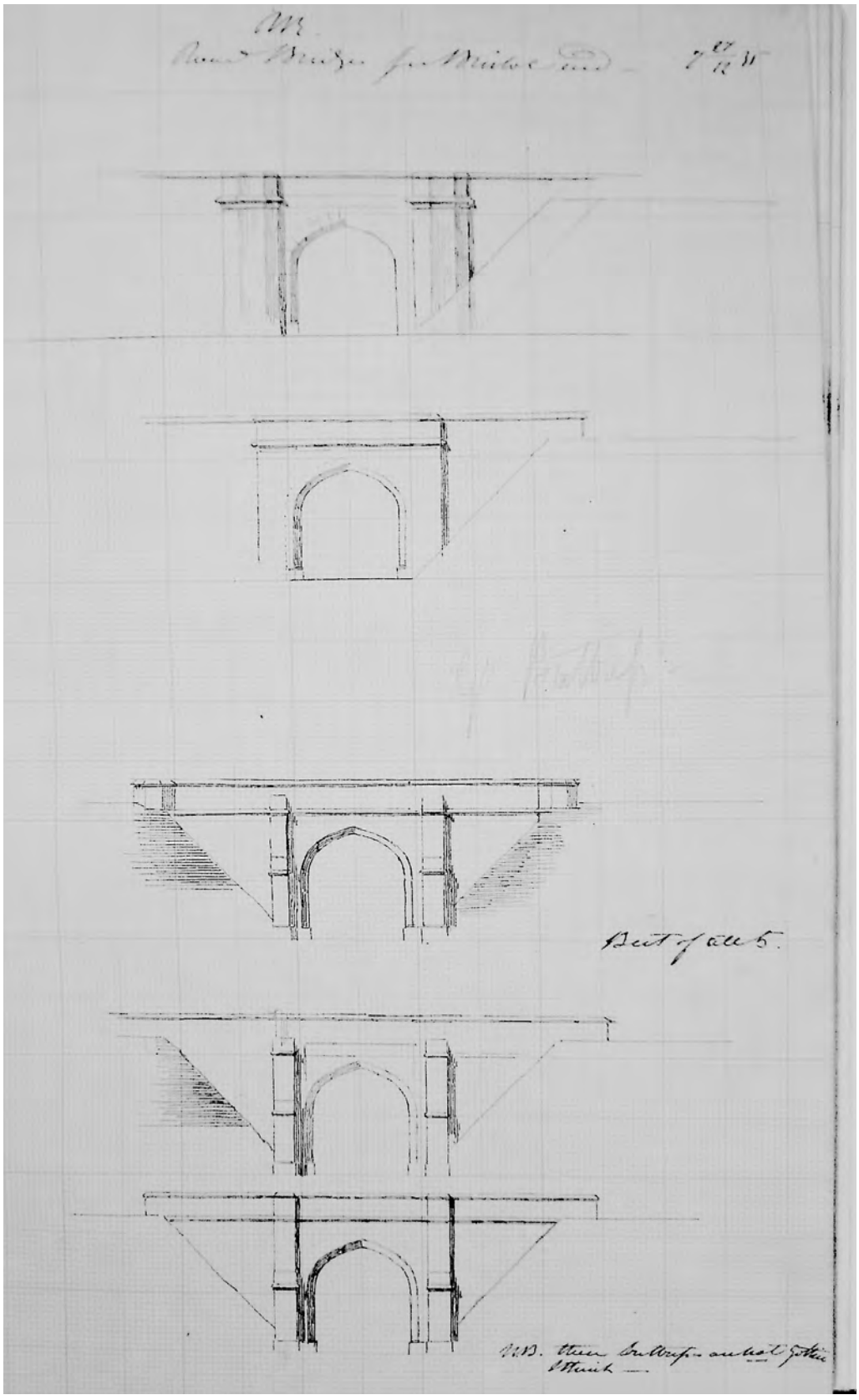


Fig 5: A page from one of Brunel's sketchbooks of 1835 entitled 'New Bridge for Bristol End'. Here Brunel tries five variations for a Gothic underbridge. The note alongside the third declares 'Best of all 5'. WIth minor variation this design was executed in a number of locations, as shown in fig. 17 (sketchbook in the Brunel Collection of the University of Bristol, at the Brunel Institute)

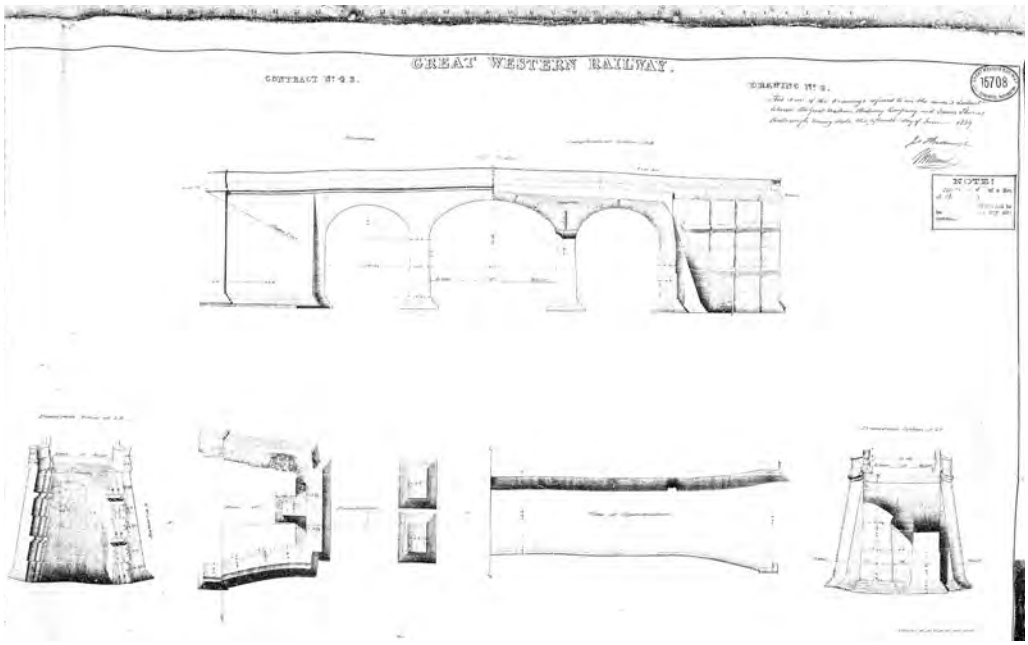


Fig 6: Bourton Overbridge (MLN1 7215) contract drawing, June 1839, signed I. K. Brunel. See next page for a photograph. The half section, bottom, shows an internal buttress in the abutment and the arch within the pier, both characteristic features of Brunel bridges on the GWML (drawing from the Network Rail National Records Centre)

The original designs

Most of the bridges on the Main Line and the subsidiary lines were originally of masonry construction. The simpler bridges, over and under the line, can be categorised as follows (Fig. 7):

- *Semi-elliptical single span arches* of 30ft span, with splayed or straight wing walls, e.g. Baulking overbridge (6615) and Hampton Mill Lane overbridge (10456). Underbridges for minor roads and tracks and accommodation bridges were generally of 15 ft or 12 ft span. The elliptical shape particularly suited a double track broad gauge line but it also helped keep the rise of the road over a bridge as low as possible.
- *Semi-circular arches*, also with splayed or straight wing walls, most often used for modest underbridges, but very occasionally in other circumstances too, e.g. Roman Road overbridge (7508).
- *Flying segmental arches*, such as the Thame Lane overbridge (DCL 5657).
- *Three-span arches*, the central 30ft span semi-elliptical, the two side arches generally semi-elliptical 10-30ft spans. The intermediate piers have transverse arches to reduce mass and expense, e.g. Bourton overbridge (7215), Fig. 6, Hampton Mill Lane (10456). Most surviving bridges of this type are on the Main Line west of Swindon.
- *Tudor, four-centred arches*, as used for both over and underbridges on the Bath-Bristol section. In this type the arches are almost invariably flanked by stepped buttresses, e.g. Stony Lane overbridge (10934), Clay overbridge (19226), Stone Wharf Underbridge (11042), Figs. 5 & 19.

All four of these types were produced in both conventional and skew arch versions.

Single semi-elliptical span: Baulking overbridge (6615)

Flying segmental arch: Thame Lane overbridge (DCL 5657)

Three-span semi-elliptical arches: Bourton overbridge (7215)

Tudor four-centred arch: Stony Lane overbridge (10934)

Fig 7: Categories of Brunel bridges

Materials

The choice of materials for these bridges depended on the availability of local brick or stone: in the 1830s, the railway network was not yet extensive enough to allow the transport of materials from distant places. On the Main Line the bridges nearest London are of London stock brick with Bramley Fall gritstone detailing and sometimes limestone imposts. Beyond Twyford to the Swindon area, red brick is the principal material, without stone imposts, followed by a gradual intermixing of Swindon limestone (e.g. Swindon Road Overbridge (8137), now part refaced in brick). From the Chippenham area to Bath, Bath stone was used, merging with Pennant stone for the Bath-Bristol section. On the subsidiary lines, brick predominates, e.g. red brick at Rockingham Road (BHL 5333) on the Berks & Hants Line and at Appleford Road (DCL 5518) on the Didcot-Oxford Line. Bridges carrying major roads, e.g. Box Road Overbridge (10106) or in sensitive settings (e.g. in the Bath area generally) were given grander architectural treatment. It would appear that Brunel used different materials as a way of reinforcing the engineering aesthetic of the line.

Major bridges and viaducts

A similar variety of materials characterises the larger bridges on the GWML, mostly built for river crossings. The most famous of these, Maidenhead Railway Bridge, falls outside the area of this study. In its use of exceptionally wide flattened semi-elliptical arches, it set a standard of extraordinary virtuosity for the time. Two other bridges over the Thames, at Gatehampton (4402) and Moulsford (4730) followed the same engineering principles, with 62ft skewed arches of red brick: both have large stone cutwaters. The Kennet Bridge at Reading (3437) has a single 60ft semi-elliptical arch and two side arches separated by broad pilasters. The Chippenham Viaduct (9408), stone-faced on one side, starts with a triumphal arch over a road, with a heavy cornice but little other embellishment, followed by a series of smaller arches. On the approach to Bath, the bridge over the River Avon (10407) has a single 60ft semi-elliptical arch, originally faced in Bath stone but now in engineering brick: St James's Bridge (10662), of similar form but architecurally more elaborate because of its prominent location in Bath, is closer to its original state. Finally the River Avon Bridge at Bristol (11725) has a 100ft wide central span flanked by smaller spans, all four-centred and Gothic as is characteristic of bridges at that end of the line.

Post Brunel bridges

The bridges on the approach to the Severn Tunnel on the South Wales & Bristol Direct Line of 1897-1903 are of a far more standardised character than any of the bridges on the original routes, and are similar to bridges built elsewhere on the GWR network at this time. The most frequently repeated type is a three span bridge with segmental arches framed by roll mouldings, built of engineering brick or quarry-faced sandstone (Fig. 8). There are also numerous single span flying bridges and underbridges. Many others have steel girder spans on brick abutments, the larger examples with brick jack arch decks. Such plate girder bridges can also be found the length of the Main Line and on the other branches where bridges have been altered or replaced in the late 19th and the 20th centuries. The brickwork of all these structures is laid in English bond using red and purple engineering brick, characteristic of the GWR from c. 1890.

Fig 8: Accommodation bridge west of Chipping Sodbury tunnel (SWB 11132). A typical bridge on the SWB, the 'cut off' line to South Wales (with later attached pipes).

Timber and Iron

Brunel also used iron and timber for bridges on the Main Line and its subsidiary branches. Although almost no examples of these bridges now survive they were important to the original engineering of the line.

Timber:

Simple beamed timber bridges were often used for minor road and farm overbridges, with the timber structure built off masonry piers. All of these have been either demolished or rebuilt using reinforced concrete beams on the original piers, as at Paradise Farm overbridge (8867). Better known, because they were illustrated in J.C. Bourne's *History* are the two-arched laminated timber bridge over the River Avon at Bath (10675) and the 240ft long bridge of timber beams and piers with raking struts over Sonning Cutting (Warren Road, 3329). Both these have been replaced. The Sonning bridge was a precursor of the numerous timber viaducts which Brunel designed for railways in Devon, Cornwall and South Wales, which stretched timber engineering for railways to its limits. [13]

Iron:

The recent research project by Steven Brindle and Malcolm Tucker for English Heritage has clearly demonstrated that Brunel was far less disdainful of using iron in bridges than had previously been thought. On the railway lines under consideration he turned to cast iron mainly to help achieve flattened arches in underbridges. This could be done by setting the rails in cast iron troughs within the arch. Brindle and Tucker have traced many examples of this in surviving drawings, but almost without exception these have been demolished or rebuilt in steel or concrete. e.g. at Westfield Underbridge (4831) and Shockerwick

[13] L.G.Booth, "Timber Works", in Alfred Pugsley ed., *The Works of Isambard Kingdom Brunel* (1976), pp.107-136

Underbridge (10270)[14]. His iron overbridge at Newton St. Loe was an interesting example of its kind, especially because it had to be designed at a 64 degree skew, but it has been replaced in reinforced concrete. [15] The cast iron footbridge at Sydney Gardens, Bath (10614, Fig. 9) – three arched ribs with open spandrels – is an elegant example of what could be achieved in iron, but is untypical of Brunel's work in that material.

Alteration and Survival

As originally built, both the Main Line and the subsidiary lines have more masonry bridges than bridges of timber or iron, and the survival rate of masonry bridges has been far greater. More than 60 of the pre-1841 original overbridges survive as a whole or in part, plus c. 80 underbridges. The rates of survival vary on different parts of the routes.

The main change that has affected the masonry bridges has been in connection with the widening of the lines, principally between London and Didcot in 1875-84 and 1890-93. [16] The widening involved the addition of two standard gauge lines alongside the original broad gauge lines, the new lines being generally for slow traffic because until 1892 the broad gauge remained in use for long distance expresses. In a few places an existing bridge of three 30ft arches was kept because all four tracks could be threaded through the arches, e.g. the Reading Road (A4) Overbridge at Sonning Cutting (3346). Generally the solution was to demolish one of the wing walls of the existing single span bridge and add a new, standard gauge arch, reproducing the original string course, buttressing and other details. Examples of this kind of alteration are particularly evident east of Reading, e.g. Leigh Road on the Crossrail part of the route (1974, Fig. 19, p.65). Some three arch bridges that were originally designed with a central 30ft arch and two 20ft side spans were widened by the enlargement of one of the side spans, e.g. at Silly Overbridge (4779, Fig. 21, p.65). Underbridges were widened by extending the existing arches.

These alterations for the quadrupling of the line were extremely sympathetic to the original designs except in the use of a slightly different colour of brick for the bridges widened west of Maidenhead in 1890-93 (the purple/red combination in contrast to the original red brick, see Fig. 21, p. 65). The larger bridges and viaducts over the Kennet at Reading (3477) and over the Thames at Gatehampton (4402) (Fig. 10) and Moulsford (4727) were treated with even greater care, including the choice of brick. As at Maidenhead Bridge, the designs of the additional structures were so respectful towards Brunel's original work that most people cannot tell the difference. At Gatehampton and Moulsford there is a small gap between the old and new structures, with small cross arches; on the River Kennet bridge at Reading the old and new are directly linked. The River Avon Bridge at Bristol was treated with far less respect when the original masonry bridge was supplemented by the addition of flanking steel lattice spans, all but obscuring Brunel's handsome structure.

[14] Brindle and Tucker, op. cit, pp.126-9

[15] Brindle and Tucker, op. cit, pp.205-14

[16] E.T. MacDermot, *History of the Great Western Railway Vol II* (revised edition, 1964) pp.169-70,197,205

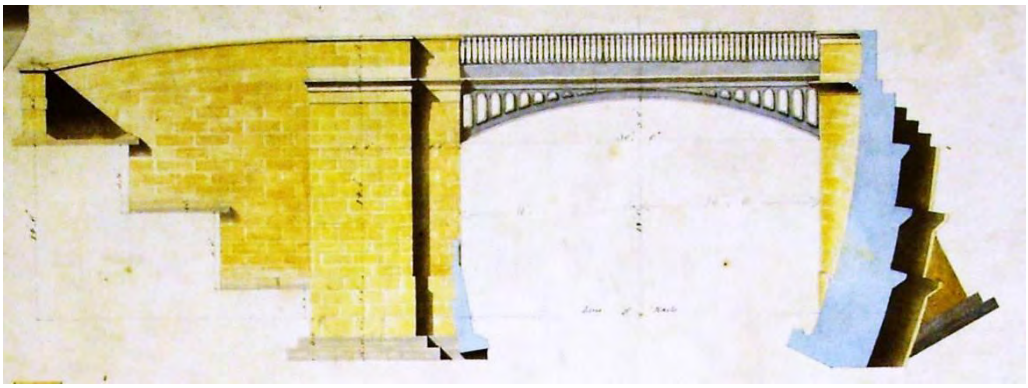


Fig 9 : Sydney Gardens Footbridge (MLN1 10614). Contract drawing, c.1840, showing the cast iron span. All the contract drawings are beautifully washed like this. (Network Rail National Records Centre)

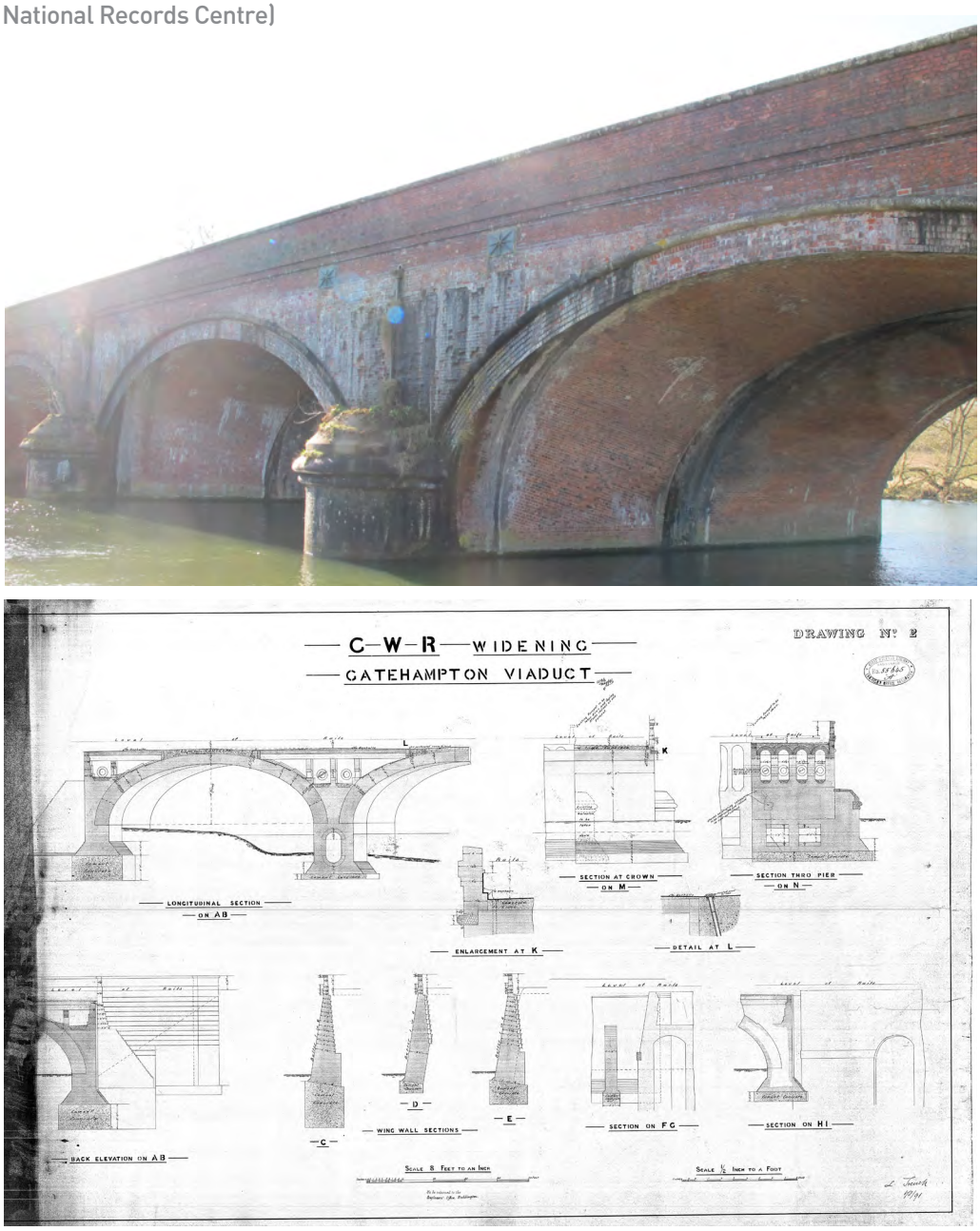


Fig 10 : Gatehampton Viaduct (4400), top, and historic drawings for its widening in 1890-93, bottom. (Network Rail National Records Centre)

After the major phase of quadrupling completed in 1893, there was a far less conscientious approach to the alteration or replacement of bridges. For instance, at Foxhall Lane, west of Didcot (5341), a three arched bridge was widened in 1931 by replacing one arch with a steel girder span, crudely abutted against the original structure. In the Bath area, fewer alterations have been called for, but the repair of Bath stone or Pennant stone bridges in brick detracts from their original quality, e.g. at St James's Bridge (10662) and Brook Lane Overbridge (10776). Replacement bridges of recent date, generally in reinforced concrete, reflect none of the original design idiom of the line, or the immense care which Brunel and his assistants took to tailor their structures to the local landscape.

Because of the widening of the line between London and Didcot, the greatest concentrations of bridges which survive as originally built are on the Main Line west of Didcot and on the subsidiary lines to Oxford and Newbury. Using the categories of masonry bridge already discussed, some of the best examples are as follows:

- Semi-elliptical single span: On the Main Line, Baulking Road Overbridge (6615) though refaced. On the Oxford Line (DCL), Appleford Road (5518) and Culham (5618). On the Newbury Line (BHL), Frouds Lane (4551).

- Semi-circular arches: mostly modest accommodation underbridges, but Bath Road underbridge (9503) is an example on a much grander scale. Roman Road (7508, Fig. 17, p.62) is unusual in being a semi-circular overbridge, possibly because Brunel deemed the classical form appropriate for a bridge on the route of a Roman road.

- Three span semi-elliptical arches: Steventon (5638), Bourton (7215, Figs. 6 & 7), Green (9303) and Hampton Mill Lane (10456), but often with very extensive subsequent refacing in engineering brick.

- Flying segmental: the least common type, except for Potley Lane on the Main Line (9850) and Thame Lane on the Oxford Line (DCL 5657, Fig. 7).

- Tudor, four-centred arches: these are confined to the Main Line between Bath and Bristol, e.g. the overbridges at Stony Lane (10934, Fig. 7) and Clay (11226) and underbridges at Stone Wharf (11042, Fig. 19, p. 63) and Durley Lane (11439).

The *GWML Route Structures Gazetteer* gives further details of surviving examples. Where there is more than one example of a type that did not mean that the designs were fully standardised. As already emphasised, each was designed for its location, and within the generic types there was a considerable variation in dimensions as well as matters of detail and the materials used.

2.7.3 Tunnels

Tunnels were not a new building type. They had been built in their hundreds during the late eighteenth and early nineteenth centuries as part of Britain's pioneering network of canals, which was mostly complete by the 1830s. Brunel himself had cut his teeth working on his father's ambitious project for the underwater Thames Tunnel (1825-43). However, the greater dimensions of tunnels for a broad gauge railway presented new challenges, both in terms of engineering and architectural treatment.

Brunel constructed nine tunnels on the GWML, all of them within the hilly terrain between Chippenham and Bristol, where cuttings were not feasible (two have since been demolished). They were generally 30 feet in width by 30 feet in height, although the entrance portals were sometimes made higher for visual effect. Their length varied considerably, from short tunnels of a few dozen feet to the unprecedented Box Tunnel of 1 mile and 1,452 yards.

The tunnels between Chippenham and Bristol completed by 1841 were:

- Box Tunnel (3.212 yards long)
- Middlehill Tunnel (200 yards)
- Bathwick Covered Way, Bath (two tunnels, 77 and 99 yards)
- Twerton Tunnel (37 yards)
- Twerton Wood (or Long) Tunnel (264 yards)
- Saltford Tunnel (176 yards)
- Fox's Wood No. 2 Tunnel (37 yards, demolished in the 19th century)
- Fox's Wood No. 1 Tunnel (57 yards, demolished in the 19th century)
- Fox's Wood (Long) Tunnel (1017 yards)
- St Anne's Tunnel (or No. 2 Tunnel, 154 yards)
- No. 1 Tunnel (326 yards, demolished 1887)

In South Wales there was the Newport Tunnel (1848), also constructed to broad gauge dimensions. The tunnelling technique used by Brunel was already well established, though he made modifications and refinements to suit the scale of his task. Vertical shafts were dug along the line of the tunnel, which were then excavated outwards in both directions as narrow 'driftways', 7 feet wide by 8 feet high, which were subsequently widened out to form the tunnel itself, the shafts eventually being retained for ventilation. Brunel sometimes used more shafts than was usual in order to speed up the work. Driftways were also created from cuttings at either end.

Much of the work was done by sheer manpower, using picks, shovels and bars to cut through hard sandstone and shale, though gunpowder was also used extensively. At the height of activity on the Box Tunnel, c. 4000 men were employed in this back-breaking labour, and it is thought about a hundred lost their lives. Tunnels were only lined with masonry where necessary, depending on the properties of the strata, which often varied within the same tunnel. Brunel's intention to leave the eastern half-mile of the Box Tunnel unlined had to be revised due to the crumbling Bath stone, and as a result much of it was lined in brick in 1895.

The architectural expression of a tunnel is usually confined to its entrance portals, which Brunel chose to emphasise as great stone gateways that would serve as an ornament to the line. Brunel's sketchbooks and the text and plates of J. C. Bourne's *History and Description of the Great Western Railway* (1846) show that the portals were conceived along the principles of picturesque design, whereby variety and irregularity are introduced in order to complement the natural qualities of the landscape, particularly where it is beautiful or 'sublime' (awe-inspiring). This would not have seemed unusual in Brunel's time, as the idea of the picturesque was indelibly linked with middle-class travel and tourism.

The portals of **Middlehill Tunnel** and **Box Tunnel** (west side) were given a grand classical treatment, with finely carved keystones and other neoclassical details. These were surely treated like this because they formed the approach to the Roman city of Bath. Along the Avon valley west of Bath, however, the picturesque takes over and the portals are generally given a castellated or Tudor treatment, like the bridges on that stretch of the line. One of the most unusual was the 'No. 1' tunnel near Bristol, given a grand Romanesque treatment with an overscaled rope moulding; it was demolished when widened into a cutting in c. 1889. A fine surviving example is **Fox's Wood Tunnel** west portal between Keynsham and Bristol, in an asymmetrical castellated style, with one square tower and one round tower, complete with mock arrow slits. As sketched by Brunel (Fig. 3) and illustrated by Bourne it is an architectural response to the drama of the rocky landscape. The east portal was in some ways even more romantic: unfaced like the mouth of a cave in the rockface (it was later ringed with brick). The neighbouring **St Anne's Tunnel** west portal was

Fig 11: St Anne's Tunnel west portal, engraving from Bourne (1846) before landslide damage was made good

originally given a regular, castellated front, including mock machicolations, but it was damaged by a landslide during construction. As recounted by Bourne, it was deliberately left as a picturesque ruin (Fig. 11) - further evidence of Brunel's interest in the picturesque. Less romantic minds have since rebuilt it to the original design.

During the subsequent years of expansion, by far the greatest project was the **Severn Tunnel** (1873-86), undertaken with great ingenuity by the GWR engineer Charles Richardson, the consultant Sir John Hawkshaw and the contractor Thomas A. Walker. At 4 miles and 629 yards, it remained Britain's longest tunnel until the construction of the Channel Tunnel in the 1990s, and its contruction was one of the most onerous engineering projects of its time. It was given simple but monumental stone portals. Smaller tunnels, however, were generally treated quite plainly in the later nineteenth and early twentieth centuries, often in unembellished engineering brick, as designs became more standardised. Amongst the exceptions are **Alderton and Chipping Sodbury Tunnels** (1896-1903) on the South Wales & Bristol Direct Line, the latter with castellated vent shaft towers forming landmarks within the Badminton estate.

2.7.4 Stations

By the end of 1841, there were 27 stations along the line from London to Bristol, each one designed by Brunel. As his sketchbooks show, he would first plan the optimal track layout for the rolling stock, then fit the buildings around it. The results varied depending on the size of the stations, from isolated lodges at small country stops, to larger complexes in towns, to the great roofed termini of the cities. As a general rule, whilst Brunel's bridges and viaducts were treated with a simple, monumental grandeur, his stations, as habitable buildings, were given a more polite and ornamental treatment.

It was in the design of the large terminus stations that Brunel proved most ingenious and influential. The challenge was to reconcile the operational demands of a steam railway with the comfort and convenience of passengers. At **Bristol Temple Meads** (1839-41) this was achieved with an overall roof that was wide enough to shelter platforms and track from the weather and high enough to allow steam to disperse, but also free of columns for maximum flexibility. By contrast, the contemporary Trijunct Station in Derby by Robert Stephenson and Francis Thompson had three narrower sheds divided by rows of columns. Brunel's structurally daring timber roof was cantilevered out on cast-iron columns and given ornamental hammer-beams as part of a programme of Neo-Tudor decoration. Brunel designed a similar roof for **Bath Spa** (c. 1840), though this was removed in 1897, so that today that station is chiefly remarkable for its entrance building in a deliberately picturesque Jacobethan style. The capital city itself had to make do with an ad hoc temporary station until Brunel was allowed to build the present **London Paddington** in 1851-54, by which time techniques of iron construction had progressed. Fresh from his experience on the building committee of the Crystal Palace (1851), Brunel designed three unprecedented arched spans made of wrought iron sections, supported on cast iron columns (these were later replaced with a different design in steel).

Fig 12: Swindon Station, 1842. The surviving block of a pair. The far end has been cut back

Of Brunel's medium-sized stations in towns, only a much-altered fragment of **Swindon** (c. 1842) survives – a free-standing building on the island platform built of stone in a plain classical style (Fig. 12). It was once one of a matching pair on twin island platforms at this important junction station. The buildings functioned both as the refreshment rooms for passengers travelling the length of the line and, on the upper floors, as a hotel, with a footbridge between the two joining the public rooms in one block to the bedrooms in the other. This was the first instance of a hotel and station buildings being combined on any scale (earlier examples, such as the original Slough Station, had the hotel in a separate building).

The layout of Swindon was unusual for the line (and quite influential). Where there was no interchange, larger intermediary stations often had a peculiar one-sided layout, with both platforms in line on the same side of the tracks (Exeter, Taunton, Reading and Slough, all since rebuilt) – an eccentric and entirely impracticable arrangement which became unworkable because it required departing and arriving trains to cross paths.

Brunel's small 'wayside' stations were conceived as lodges in the countryside. The grand civic treatment used in urban areas was considered inappropriate where a station had sprung up in hitherto unspoiled countryside. The sole remaining example in the study area is **Culham** (c. 1844, Fig. 15 p. 54), on the Didcot to Oxford line. It is picturesquely treated in a Neo-Tudor style, rather like a gatehouse to a gentry estate. It actually represents one of four interrelated types, each with differing roof profiles and chimney shapes. This once achieved an effect of 'family resemblance' which can no longer be appreciated. The station master was provided with a separate, plainer house (surviving at Culham). An utterly different, perhaps unique, approach was adopted at **Twerton**, where the Tudor Gothic stationmaster's house was integrated into the viaduct, so that the platforms were at the level of the upper floor and reached

by an external staircase. Also surviving from this period is the larger Wallingford Road Station of c. 1841 (later **Moulsford**, now closed), which was built to serve the small market town a couple of miles away. The inspiration may have been coaching inns, since the building apparently combined ticket office, station master's house and hotel. There are also separate staff cottages.

Throughout the 1850s and 1860s, GWR stations continued to be designed according to the patterns set down by Brunel. A surviving example is **Chippenham** (1856-58, Fig. 22 p. 68), designed by the engineer Rowland Brotherhood within Brunel's lifetime, in a simple classical style. It relies for aesthetic effect on the qualities of the local Bath stone. All of the early stations were necessarily built of local materials, a common practice which was to change as the railways made goods transport easier. **Reading** (1865-67), for instance, also in a plain classical style, is built of buff brick from Coalbrookdale with dressings of Bath stone, to the designs of Chief Engineer Michael Lane.

After 1870, stations became increasingly standardized in their design and were generally less architecturally distinguished. Commuter stations were rebuilt following the quadrupling of tracks in 1877-79 between Paddington and Taplow. Typical examples include **Langley** (1878), **Southall** (c. 1880) and **West Drayton** (c. 1884), each in robust polychrome brickwork and affecting French pavilion roofs as a nod to the fashionable Second Empire style (also used for the extension in 1865-78 of Bristol Temple Meads). They originally had attractive canopies with timber valences, often symmetrically treated at the ends, as shown by Langley and the well-preserved **Hanwell** (c. 1875-77). Some of these stations may have been designed by Lancaster Owen, others by J. E. Danks. The latter was responsible for the rebuilding of **Slough** (1882), in a far more distinguished version of the Second Empire style.

Following the widening of Maidenhead Bridge, the tracks were quadrupled between Maidenhead and Didcot in 1890-93, resulting in the rebuilding of **Twyford**, **Tilehurst**, **Pangbourne**, **Goring & Streatley** and **Cholsey** (all c. 1892). They are robustly built in red brick with blue engineering brick to the corners and few other architectural embellishments. An exception was the platform canopies, which continued to be decorated with timber valences, by then part of the accepted vocabulary of railway architecture. The GWR had standard patterns for valences in the late nineteenth century, as well as standard designs for footbridges and, to an extent, whole stations.

The success of the GWR up to the First World War meant it continued to rebuild busy stations, such as **Reading** (completed 1899) and **Newbury** (1908-10, Fig. 13), which was designed in a Free Jacobethan style (the columns of its platform canopies are of riveted steel, instead of cast iron, which was gradually phased out for columns after 1890). The decades after the First World War saw less activity. During the Great Depression of the 1930s, the government offered funds to kick-start employment, which allowed improvements to Bristol Temple Meads (1930-5) and London Paddington, both of which were given extra platforms with traditional canopies and valences. There was also some rebuilding on the Berks & Hants Line in that decade.

Fig 13: Newbury Station, 1908-10

Fig 14: Cardiff Central booking office, 1930-34

In South Wales, **Cardiff Central** was totally rebuilt in 1930-4 with a new frontage and booking office and distinctive faience-faced buildings on the island platforms (fig.14), thanks to the financial assistance of the Development (Loan Guarantees and Grant) Act 1929. Station building on this scale was exceptional in the UK between the wars. With the same impetus, **Newport** was given an imposing Neo-Georgian entrance building, complete with panelled rooms for a gentleman's club upstairs!

Many early stations survived after nationalisation in 1948, but the withdrawal of stopping station facilities in the mid 1960s led to widespread demolition, continuing into the mid 1970s, even of Brunel-period stations such as Steventon, Challow and Shrivenham. More recently, unstaffed stations have been furnished with small prefabricated steel shelters. The most common type is the Paragon Anti-Vandal shelter (from 1998), developed for Railtrack by Macemain & Amstad to be robust, economical and largely maintenance free.

2.7.5 Works & other buildings

Like all railways, the GWR relied on a large number of subsidiary buildings and structures to run its trains and other services. Steam locomotives required engine sheds, coaling points and water towers and columns. Signalling along the line needed signal boxes as well as the signals themselves, often conspicuous structures crossing the tracks. In particular, goods traffic called for specialised buildings, often much larger than the passenger stations, and mechanised handling equipment.

The closure of stations and lines following the Beeching Report of 1963, combined with the transfer from steam to diesel and electric power, resulted in the surviving routes being stripped of many of their characteristic minor buildings and structures. The effect of this is that travelling along Main Line and the subsidiary routes to Newbury and Oxford the railway reveals itself much less in terms of its buildings and equipment. Almost all of the paraphernalia of railway equipment has gone.

The most conspicuous difference has been the closure and demolition of smaller stations: c.18 along the Main Line were closed in the 1960s. Many of these stations had subsidiary buildings which have also gone, for instance the goods shed at Challow, demolished in 1965. They also had individual signal boxes, now taken out of use and demolished following the introduction of route-wide power signalling. The only surviving GWR signal box on the routes that form part of the electrification project is at Colthrop Lane level crossing on the BHL (BHL 4874).

Much larger buildings have also gone, notably the huge goods handling sheds at major stations. The Paddington Goods Depot, largely rebuilt in 1925-7, was demolished in the 1970s, and the goods shed at Kings Meadow Reading of 1896 went in 1987.[17] Nothing survives of the fascinating 'Depot' Brunel designed for Temple Meads, illustrated by Bourne. Most of the equally large engine sheds have also been demolished: the last part of the Old Oak Common depot of 1903-6 is being removed as part of the Crossrail project.

Because of all these changes, the only place on the routes under consideration where it is possible to see typical GWR buildings and equipment is in the recreated museum world at the Didcot Railway Centre. The buildings and structures there include:

- A transfer shed of c.1863, used for transferring goods from broad to standard gauge trains.
- An engine shed, coaling stage and water tank, all of 1931.
- Two signal boxes, one of 1875 moved from Frome and one of c.1900 moved from Radstock

[17] Steven Brindle, *Paddington Station. Its History and Architecture* (2004), pp.127-133; John Minnis, *Britain's Lost Railways* (2011), pp.152-3

The other major place where the railway environment still survives is at **Swindon**. The decision to locate the GWR railway works there was made in 1840, partly because that was to be the junction with the line to Gloucester but also because it was thought that locomotives would have to be changed or refuelled at a half way point to Bristol. The station at Swindon has already been discussed (see para 2.6.4). The works established there – to build and repair locomotives, carriages and other equipment, and for a time to roll rails for the track – became one of the largest of its kind in the country. It employed 1800 men in 1848 and ten times that number by 1900. By 1939 the works extended over 326 acres, mostly in the triangle between the Main Line to Bristol and the branch to Gloucester. The works did not close until 1986. [18]

The history and building archaeology of the Swindon railway complex have been analysed in detail in John Cattel and Keith Falconer, *Swindon.The Legacy of a Railway Town* (1995). The main surviving buildings can be summarised as:

- The Works: The General Offices (1842-3) now the National Monuments Record Centre; the machine and fitting shop (1842; the chain test house (1874); 'R' shop (1846 and 1865), now 'Steam, the GWR Museum'; various other smitheries, foundries and machine shops, now converted for retail use as the 'Great Western Designer Outlet Village'. The major loss in the Works complex is the 'A' shop, a locomotive repair shop of 1902-21, the site of which is now a car park. [19]

- The Railway Village: housing and facilities laid out by Brunel in 1842-3 to help accommodate the works labour force. Stone-built terraces arranged on a formal E-W layout, with a single cross axis at Emlyn Square, where were located a cottage hospital (1871), the Mechanics Institution (1855) and a model lodging house (1854), later converted to a Methodist Chapel). Nearby is the Gothic Revival St Marks Church (1845).

2.8 The Designers

Discussion of how the Great Western Main Line was designed and built is always dominated by the figure of I. K.Brunel; rightly so because he made all the significant decisions and allowed his subordinates very little freedom of action. Therefore this section on the designers associated with the Great Western Lines starts with a summary of his career, placing his work for the railway in the context of his other achievements. It then moves on to give details of some of those who worked with Brunel, plus the later designers who contributed to the evolution and upgrading of the lines.

[18] Victoria County History, Wiltshire Vol 4 (1959), pp.207-19: John Cattel and Keith Falconer, *Swindon.The Legacy of a Railway Town* (1995), passim.

[19] John Minnis, op.cit, pp.168-9

I. K.Brunel (1806-1859)

In the course of a short, incessantly energetic career I. K.Brunel achieved a reputation as one of the leading engineers of his time. The number and variety of the projects for which he took responsibility was by any measure astonishing, and the fact that some were failures only seem to confirm the fertile originality of his overall output. Since his death, particularly since the publication of L. T. C. Rolt's biography in 1957, he has been classed by many as one of the heroes of England's industrial past.

Brunel's father, Sir Marc Isambard Brunel (1769-1849) was himself an illustrious engineer. He sent his only son, born in 1806, to France to be educated, first in Normandy and then at the Lycée Henri-Quatre in Paris. Brunel stayed on in Paris to be apprenticed to a clock and instrument maker before being summoned back to England by his father, who was about to start his most daring project – the making of a tunnel between Rotherhithe and Wapping. Begun in 1825, the tunnel had to be abandoned in 1828 half complete (it was not finally finished till 1842), but in the course of the first borings the young Brunel won his spurs as a courageous and highly practical engineer.

Brunel's first independent work was the Clifton Suspension Bridge at Bristol, for which one of his designs was accepted in 1831. Like his father's tunnel, this was a protracted project which was not in fact completed until after his death in 1864. Though bereft of the decorative panels which Brunel wanted and altered in other minor details, it was essentially his conception of a 702ft span high above the River Avon which was carried out.

In 1833 through his Bristol connections, Brunel was appointed engineer for the railway to link that city with London, soon known as the Great Western Railway. Because of his conscientious attention to every detail, the London to Bristol line, together with subsidiary lines to Cornwall, South Wales and the West Midlands, were laid out to a coherent pattern of design based on the use of the broad gauge track.

Many of the principal aspects of his railway projects have already been referred to in this report, including the original station at Bristol Temple Meads (1839-40), Maidenhead Bridge (1837-9) and the second London terminus at Paddington (1851-4). Others, such as sixty or so timber railway viaducts he built in Devon and Cornwall, have not survived but his last major work, the Royal Albert Bridge at Saltash (1857-9) – a brilliant design based on two closed suspension spans each of 455ft – is still the main railway link to Cornwall.

The Bristol contacts which led to Brunel's railway career also resulted in his involvement in ship building. At Bristol two ships were built to his design, the timber-hulled paddle steamer Great Western (1837) and the iron-hulled screw propulsion

[20] *Quarterly Review* Vol. 112 (1862) pp.38

[21] R. Buchanan, "Working for the Chief", in *Isambard Kingdom Brunel. Recent Wales* (2000), p.25

Great Britain (1843). But it was at Millwall in London that his most famous ship was built, the colossal 692ft Great Eastern (1854-9). The construction of this monster, intended for the Indian and Australian trade, was of a scale and novelty which over-stretched even Brunel's capacities, and partly accounted for his early death at the age of 53.

In the midst of all these projects Brunel played a part in some of the major public events of his time. As a member of the building committee for the Great Exhibition of 1851 he conceived of housing the event beneath a huge sheet-metal dome. With architectural additions made by the committee, it was this design which was howled down in favour of the submission by Paxton and Fox Henderson. In 1855 he devised a pre-fabricated hospital of 1000 beds, erected at Renkioi in Turkey for the casualties of the Crimean War. Though none of its features were particularly original (the roof structure was a variant of his timber viaduct designs) the speed with which he worked brought public acclaim.

Samuel Smiles described Brunel as 'the very Napoleon of engineers, thinking more of glory than of profit, and of victory more than dividends.'[20] Brunel was jealous of his fame and his authority, but he inspired great loyalty from his assistants and backers. 'I cannot act under any supervision, or form part of a system which recognises any other adviser other than myself, or any other source of information than mine, on any question connected with the construction or mode of carrying out practically this great project on which I have staked my character,' he wrote about the Great Eastern during one of the crises in its construction. Part of his fame has derived from the position he created for himself as a single-handed manager, a role which subsequent generations of engineers have found hard to repeat.

In his work on the Great Western Railway, Brunel employed a number of assistant engineers and resident engineers, and on one occasion he sought the assistance of a well-known architect. Angus Buchanan has published a useful list of all the engineers who served with him on his railways and other projects. None of them achieved prominence in their own right.[21]

The principal names associated with him on the GWR are:

- **R. E. Brereton** (c.1818-94). Worked on the Cheltenham and GW Union Railway and on the Great Western Main Line, especially the No. 1 and Middlehill Tunnels. Closely involved in the erection of the Royal Albert Bridge, Saltash, about which he read a paper at the Institution of Civil Engineers. Having been Brunel's Chief Assistant 1847-59, he took over the practice after Brunel's death.
- **Charles Richardson** (1814-96) was an early assistant to Brunel on the Thames Tunnel and Clifton Suspension Bridge before joining the engineering team on the GWR, where he worked on Box Tunnel and the subsidiary branch to Gloucester. He became Resident Engineer on the Bristol & South Wales Union Railway, which involved designing the piers for ferries across the Severn. Following on from that he was the first designer of the Severn Tunnel 1872-79, and subsequently joint designer with Sir John Hawkshaw.

- **G. E. Frere** (1807-87), resident Engineer on the Shrivenham-Bristol section of the project. He later left engineering to become an ironmaster.
- **George Thomas Clark** (1809-98), sub-assistant to Frere on the Bristol end of the line. He also assisted Brunel on the Parliamentary Surveys for the route in 1835. After 1843 he worked in India and in the later part of his life he was proprietor of the Dowlais Ironworks in South Wales. Clark wrote a Guidebook to the Great Western Railway (1839) and he was responsible for the text in J.C.Bourne's History of 1846.
- **John Hammond** (c.1800-47), Brunel's Chief Assistant 1836-47 and Resident Engineer for the London-Shrivenham section of the project (including Maidenhead Bridge and Sonning Cutting).
- **Sir Matthew Digby Wyatt** (1820-77). M.D. Wyatt was one of the long dynasty of Wyatts in the architectural profession. Having collaborated with Brunel on the so-called Committee Design for the Great Exhibition of 1851 which was turned down in favour of Paxton's alternative scheme, he then went on to assist Brunel in designing the decorative elements of the second Paddington station. These included interesting cast iron embellishments to the trainshed structure, reflecting Wyatt's concern to explore a "consistent theory of mechanical repetition as applied to art." Some time after Brunel's death he acted as architect for the development of Bristol Temple Meads (1871-8).

  Wyatt's other major works included various architectural courts at the Sydenham Crystal Palace (1854) and the Indian Office part of the Government Offices in Whitehall, including the Durbar Court, completed in 1868. His interest in the progressive use of new materials never resulted in a wholly new architectural vocabulary.

Brunel remained the Chief Engineer of the GWR until his death in 1859. None of the engineers who succeeded him achieved a similar status as household names, indeed most of them are only known to specialists. However they all played an important role in the gradual transformation of the GWR, including the conversion from broad to standard gauge. The key names are:

- **Michael Lane** (1802-68). He had worked for (Sir) Marc Brunel on the Thames Tunnel, and as assistant to G. E. Frere, on the construction of the Bristol end of the Great Western Main Line (including river walls in the Bath and Bristol area). He was Superintendent of Permanent Way for the GWR 1845-60, and Chief Engineer 1860-68.
- **William George Owen** (1810-85) followed Lane in the post of Chief Engineer 1868-85, the era which saw the construction of the Severn Tunnel and the conversion of nearly 900 miles of track to standard gauge.

- **Lancaster Owen** (1843-1911), son of W. G. Owen, became a district engineer on the GWR in 1866, and subsequently New Works engineer 1875-85 and Chief Construction Engineer 1885-90. Many of the drawings for the quadrupling of the Main Line carry his signature, e.g. Westbury Lane (4010), Gatehampton Bridge (4400) and Moulsford Viaduct (4727).
- **Sir John Hawkshaw** (1811-91), a major figure in mid-Victorian railway, dock and drainage engineering, was consulting engineer for the construction of the Severn Tunnel 1879-86. As Mike Chrimes has said, that project was "arguably Hawkshaw's greatest engineering achievement." [22]
- **Edmund Olander** (1834-1900), Swedish by birth, had an extremely varied early career, including work in Sweden, Denmark and India. He was in charge of the GWR's Engineering Drawing Office at Paddington 1874-1900. His signature is on many of the drawings issued from that office.
- **Sir J. C. Inglis** (1851-1911) entered railway service in 1885 working for the South Devon & Cornwall Railways. In c.1887 he became a consultant engineer to the GWR, and in 1892 joined the staff as an assistant engineer and later Chief Engineer. One of the particular responsibilities was the replacement of many of Brunel's timber viaducts in Cornwall. In 1903 he became the GWR's General Manager and consulting engineer. His era saw the completion of the direct route to the Severn Tunnel, as well as major improvements on the route to Birmingham.
- **W. Y. Armstrong** (1851-?) joined the GWR in 1883 as principal assistant to Lancaster Owen. He was promoted to Assistant for Construction in 1891 and to New Works engineer in 1904. Amongst the many works with which he was involved were the rebuilding of Reading Station, the construction of the 'cut-off' route to the West Country and the design of the Span 4 Arrivals Side trainshed at Paddington (1913-1916).

[22] *Oxford Dictionary of National Biography* Vol 25 (2004), p.948

3.0
Assessment of significance

3.1 Assessing significance

'Significance' is the means by which the cultural importance of a place and its component parts can be identified and compared, both absolutely and relatively. By identifying structures and buildings of high, medium and low significance (plus those of no significance) it is possible to provide a clear set of guidelines to those responsible for the management and development of a place. The assessment will indicate where minimal changes should be considered, as well as locations where change might help preserve and enhance what is valued as significant. The attribution of significance is based on the analysis of the different values to be found in a building, structure or a place.

The primacy to be given to the analysis of significance in plan-making and planning decisions is at the heart of government conservation advice in the *National Planning Policy Framework (2012)*. That advice states: "Local planning authorities should identify and assess the particular significance of any heritage asset that may be affected by a proposal…. taking account of the available evidence and any necessary expertise. They should take this assessment into account when considering the impact of a proposal on a heritage asset, to avoid or minimise conflict between the heritage asset's conservation and any aspect of the proposal" (para. 129).

The values to be used in the assessment of significance are set out in greater detail in English Heritage's *Conservation Principles, Policies and Guidance* (2008). The same assessment methodology is used in Cadw's *Conservation Principles for the Sustainable Management of the Historic Environment in Wales* (March 2011).

In addition to the familiar architectural-historical texts used in assessments, English Heritage's *Conservation Principles* takes account of how a building, structure and place is generally valued and the associations which it carries. Four different types of value which can contribute to significance are described:

- **Evidential value**: that a building, structure or place provides *primary* evidence about the past. This can be natural or man-made and applies particularly to archaeological deposits, but also to other situations where there is no written record.
- **Historical value**: that it *illustrates* some aspect of the past, and this helps to interpret the past, or that it is associated with an important person, event or movement;
- **Aesthetic value**: this may derive from conscious *design*, including the work of an artist or craftsman; or it may be the fortuitous outcome of the way a building or place has evolved;
- **Communal value**: regardless of their historical or aesthetic value, many buildings or places are valued for their symbolic or social value or the local identity which they provide.

Obviously with the GWML, as in other cases, any assessment of significance will be an amalgam of these different values and interests. In this section of the report the aim is to set out how these four values and interests apply to the route, focusing on both the route as a whole and its different components. The last section of the chapter, 3.5, brings all the threads together into a summary statement of significance. The underlying question is whatever its significance has been adequately understood, and if not where the gaps in that understanding lie.

The accompanying *Route Structures Gazetteer* identifies the significance of each structure, based on the overarching analysis given here.

3.2 What makes this assessment different

This assessment exercise is quite unlike the typical exercise of assessing a single building or group of buildings. What is under consideration is a railway route 118 miles long, plus additional routes, all made up of various elements which form part of a total project. The Great Western Main Line has only once before been the subject of an overall assessment such as this, in the document produced in 2006 to justify its inscription as a World Heritage Site. [23] However that report, although dealing with the whole line, appears not to have not been based on a comprehensive analysis of every aspect of the route or its branches.

One other assessment is worth referring to. In 2010 the Yorkshire Dales National Park Authority produced an appraisal of the section of the Settle-Carlisle Railway Conservation Area which lies within its boundaries. The Conservation Area as a whole covers a line 76 miles long, originally built in 1866-76. The appraisal is a pioneering example of the assessment of a linear structure, taking account of all the alterations it has undergone, but compared to the Great Western the line has fewer buildings, bridges and other features along it. However it passes through a spectacular landscape, and the appraisal provides a particularly useful analysis of the relationship between the railway and the landscape.

In the case of the Great Western Main Line, as for the Settle-Carlisle Railway, there are distinct advantages in using a comprehensive overview:

- This approach allows a proper balance between the parts and whole to be maintained. This includes taking account of elements which no longer survive.
- The significance of repetitive elements can be more easily assessed, an important consideration for a line built by a single company under tightly centralised control of design. This consideration applies to features such as bridges, signal boxes and standardised station buildings.
- It is easier to achieve a holistic view including elements, such as the engineering of the railway route through the landscape. Engineering has generally been thought of in terms of individual structures or machines, rather than the overall design of infrastructure.

[23] *Great Western World Heritage Site. Justification for Inscription* (2006)

3.3 The overall significance of the lines

The significance of the Great Western Main Line relates to when it was built, its design and construction, and the degree to which it has survived. These qualities can be clearly related to the values of evidence, history and aesthetics as described in English Heritage's *Conservation Principles* and the conservation policies adopted in Wales. The fourth type of value, communal value, is also an important factor in the significance of the line. Each of these qualities is discussed in the sections which follow.

Date of construction

English Heritage's *Listing Selection Guide* for Transport Buildings distinguishes between the pioneering first phase of railway building up to 1841 and the subsequent 'heroic age', 1841-50. It is clear that the Great Western London-Bristol line falls within the pioneering phase since 1841 is the date which saw completion of the line on which work had started in 1835. At 118 miles, the line was the longest of its time; slightly longer than the London & Birmingham Railway (112 miles), authorised in 1833, and markedly longer than the Grand Junction Railway from Birmingham to Warrington (78 miles, 1833) and the London & Southampton Railway (77 miles, 1834). All of these lines were on a scale which far outclassed the first significant freight and passenger-carrying railways, the Stockton and Darlington of 1825 (30 miles) and the Liverpool & Manchester of 1830 (30 miles). Like the other pioneering trunk lines, the Great Western demanded a far-reaching transformation in transport planning and finance. The lessons from these lines – in design, finance and operation – were of fundamental influence on the subsequent expansion of the railway system, at home and overseas. Most of the major main lines in Britain had been completed or authorised by 1852 and together were of immense importance to the success of the mid-Victorian economy. Because of the date when the main line to Bristol was constructed its historic value makes it highly significant, not just in Britain but internationally.

The other four principal lines covered in this study all fall outside the pioneering phase of railway construction and thus do not have such a great historic value or interest. The Didcot-Oxford line and the Reading-Newbury Line both opened shortly after the pioneering phase, in 1844 and 1847 respectively and the South Wales Railway was completed in 1852: the cut off line to the Severn Tunnel opened in 1903 as part of the route shortening improvements of that period.

Design of the GWML

Of the pioneering (pre-1841) railways, what distinguished the Great Western were the extent of control exercised by one man, it's chief engineer I. K. Brunel, and the character of the line which he designed. Because of the abundant archival documents and drawings which have survived, mostly in his hand, historians have been able to analyse his role in detail. It is indisputable that on the London-Bristol line he had a hand in everything, from the original survey of the route in 1833, to the engineering

design of the line, the design of the buildings and structures along it, the letting of contracts and the supervision of construction. He knew every mile of the route and put his stamp on every aspect.

In terms of the route miles of railway built under his supervision, Brunel built less than the other two principal engineers of the pioneering era. He was responsible for 1,100 miles whereas Joseph Locke completed 1,600 miles and Robert Stephenson 2,000 miles. [24] But Locke and Stephenson exercised less personal control over every detail and were more prepared to delegate work to colleagues. In the words of the Great Western's locomotive superintendent Daniel Gooch, Brunel 'fancied that no man could do anything but himself.' His contemporaries such as Locke and Stephenson more often took on the role of manager or leader of a team.

Apart from the choice of route, what most obviously distinguished Brunel's designs for the line was his insistence on the adoption of the broad gauge. The inevitable consequence was that the works were on a larger scale than standard gauge lines and this may account, for instance, for the use of semi-elliptical arch overbridges rather than the more usual arched bridges on other lines. Station layouts, and the design of station buildings, were not so obviously influenced by the use of the broad gauge, but that did not prevent him giving his full attention to all those aspects as well. He also set his imprint on the way the railway related to the landscape, especially at the Bristol end of the line where funding was more generous.

No other engineer or architect was as influential in the development of the Great Western, in Brunel's time (up to 1859) or afterwards. Names which recur in later years include William George Owen (1810-85), William Lancaster Owen (1843-1911), and in the design of the Severn Tunnel, Charles Richardson (1814-96) and Sir John Hawkshaw (1811-91). Whatever their contribution, none of these gave a character to the line to the extent that Brunel had done. Except where the Severn Tunnel is concerned these engineers following conventional engineering practice of their time, thus their work is of lesser historic value.

Degree of survival

All infrastructure is subject to alteration and renewal as demand changes and technologies improve. Neither the Great Western Main Line nor its subsidiary lines survive as originally built. Details of where changes have occurred are presented elsewhere in this report and in the accompanying Gazetteer. What is given here is a summary, as a means to understanding how far the significance of the line has been affected by the changes that have happened since it opened.

The most obvious changes are as follows:

- The conversion from broad to standard gauge, completed by 1892.

[24] Michael R.Bailey, 'I.K.Brunel – Exploding the Myth', *Trans of the Newcomen Society* Vol 78, No.1 (2008), p.3

- The widening of lines. In the late nineteenth century 68 miles of the London-Bristol route were doubled, requiring modifications to bridges, the rebuilding of stations and changes to the engineering of the line (embankments, cuttings, etc). The main line in South Wales has all been widened.

- Replacement of bridges. As well as changes to bridges with track widening, a number of bridges have been replaced especially those of timber and cast iron (see para 3.4.3 below).

- The closure or redevelopment of stations. On the London-Bristol line c. 18 stations have been closed and demolished. Of the 12 which survive between Maidenhead and Bristol, only Swindon, Bath and Bristol have recognisable elements from the original construction of the line. None of the stations in South Wales survive in their original form.

Taken together these add up to a considerable degree of change affecting the evidential value of the line, yet this is no different to what has happened to other main lines of the pioneering and heroic eras. The London & Birmingham Railway, now part of the West Coast Main Line, was the other principal trunk line of the pioneering era. It was altered at various times to accommodate additional traffic, especially freight traffic, and then lost most of the original buildings and structures which had survived when the line was electrified in 1959-66. The route of the London & Southampton Railway has been similarly transformed in response to the growth of suburban traffic. The Liverpool & Manchester Railway has survived with a higher proportion of its engineering structures intact, but was a far smaller enterprise than the great trunk routes and has not been subject to same subsquent pressures.

Although stripped of many original features, the Great Western has undergone fewer changes than other main lines, in part because of the type of traffic it has handled and the fact that it has not been electrified. It has also benefitted considerably from the broad gauge dimensions of the track and structures, which have proved adaptable for new types of train service such as the introduction of High Speed Trains in 1976.

Turning the equation around to ask how much has survived, rather than how much has changed, produces a different answer. In terms of survival, what is remarkable is that the Great Western Main Line starts and finishes at stations substantially or in part of the Brunel era, and at Bath, Swindon and Chippenham it has stations partly or wholly of his time. The route as a whole is still recognisably his broad gauge line, in its engineering and many of its structures, especially where the track has not been quadrupled. Of the overbridges c. 64 have survived as a whole or modified, and many modest underbridges have also survived unaltered. The result is that on parts of the Main Line – from Chippenham through Bath on the main line, and for a short stretch through Culham station on the Oxford branch (Fig.11) - the route can be experienced largely as originally laid out.

Fig 15: Culham Station

For a line of the pioneering era, this degree of survival is highly significant. The subsidiary lines, not of the pioneering era, have varying degrees of survival:

- Reading-Newbury: most of the buildings and structures along the line have been rebuilt.
- Didcot-Oxford: One original station (Culham) survives and at least two overbridges. Because of their design and date these are of historic and aesthetic interest.
- South Wales & Bristol Direct Line (the 'cut off' line of 1903) Most of the original over and underbridges survive, plus tunnel portals, but stations have been closed and demolished.
- The South Wales Railway: because of route widening and the rebuilding of stations there are almost no original features which have survived along this part of the line.

Reputation and public appreciation

The heading 'communal value' in English Heritage's *Conservation Principles* embraces the meaning of a place to people, including how it figures in their collective memory and the associations which it evokes. In the present case this helps focus attention on two matters – the enduring reputation of the Great Western Railway and the fame of I. K. Brunel.

In neither case is the question of reputation or public appreciation as simple as it seems. The reputation of the line and the man appear to be indissolubly linked, but they have grown in different ways and have not always been combined as they are today. As regards the line, its construction was the subject of considerable public attention and reportage, culminating in J. C. Bourne's famous history of 1846.[25] In practice, in the years after 1860 the line never quite lived up to expectations in speed or service. In the words of the historian Jack Simmons, it "had sunk down into the lethargy of repletion." [26] Its reputation only began to recover in the 1880s, with the opening of the Severn Tunnel (1886), the end of broad gauge, the shortening of routes through the construction of 'cut off' lines, and improved locomotives. Faster trains over shorter lines meant that more people could get to attractive parts of the country more quickly. At the same time, the GWR began to publicise itself much more effectively. It is these changes which have given the GWR a special place in people's memory. In addition, the GWR undoubtedly benefited from the fact that it preserved its historic identity at the time of railway amalgamation in 1921-23.

The reputation of I. K. Brunel has also undergone a number of changes since his lifetime. The present high regard in which he is held by many can probably be dated to the publication of L. T. C. Rolt's biography in 1957 and the return of the SS Great Britain to Bristol in 1970. Amidst the publicity which attached to the bicentenary of his birth in 2006 there were a number of attempts to produce a measured account of his achievements, set in the context of the work of other early railway engineers. However these reassessments could not avoid acknowledging his extraordinary creativity across a whole range of engineering projects. This, plus the documentation which allows so much to be known about his life, helps explain why he is rated so highly.

The communal value attached to a place, or in this case a railway, will of course overlap with other values, especially historical and aesthetic. They can add to significance because of memories and associations. Where the Great Western Main Line is concerned, the historic and aesthetic values are of a high order, but they are enhanced by the historic reputation of the railway and the esteem in which its original engineer is now held. No other major railway is regarded in quite the same way.

Summary of Overall Significance

The significance of the GWML lies mainly in its status as a railway of the pioneer era much of which have survived, as a civil engineering totality and in many of its parts. To this historic value is added the aesthetic value of its design by a single person and the communal value arising from the reputation of the GWR and Brunel. As discussed, the subsidiary lines have elements of the same significance, but not the same status as pioneering projects nor, except in certain sections, the same highly-regarded engineering aesthetic.

[25] J.C.Bourne, *The History and Description of the Great Western Railway* (1846)
[26] Jack Simmons, 'The End of the Great Western', in his *Parish and Empire* (1952), p.172

3.4 The Constituent Elements

3.4.1 Introduction

This section looks at the different elements of the Great Western routes with a view to understanding their relative importance, measured against similar elements along the routes or in the context of the wider railway system. The key elements considered here are the engineering of the route, bridges and viaducts, tunnels and stations. The focus throughout is on features on the routes which may be affected by overhead electrification. Thus other aspects such as the railway works at Swindon or surviving sheds and structures distant from the line are not considered, nor is anything said about signalling because no items of historic signalling survive along the routes. The Route Structure Gazetteer gives details of all the structures and buildings along the route, ranked in significance.

3.4.2 Civil engineering

The engineering of a railway line depends on the overall choice of route and subsequently the engineering design of the line (including embankments, cuttings, bridges and tunnels) and the design of the permanent way.

In all of these aspects Brunel, as engineer of the Great Western Main Line, sought a solution based on first principles. The visionary character of his approach to design shows itself in many features of the route. Although individual features may not be unusual or innovative, seen together they are of considerable historical and aesthetic value.

Route selection

In selection of the route from London to Bristol Brunel gave primacy to the ruling gradient of the line. Whereas the London & Birmingham Railway, the other great trunk line of the time, has a ruling gradient of 1:330, Brunel designed his line to a gradient of 1:660 except for two short stretches, near Dauntsey and through Box Tunnel. The route his line followed, down to the Thames Valley to beyond Reading and then via the Vale of White Horse to Swindon, meant that a number of towns were bypassed but the line was ideal for speed and directness. Beyond Chippenham it becomes more circuitous, but for 85 miles its 'billiard table' quality is fundamental to the route, and sets it apart from other lines of its time.

In terms of route selection the other lines under consideration are not so significant. The Didcot-Oxford line is a short stretch through easy terrain; Reading-Newbury was conceived of as a secondary line and did not become part of the main line to the West Country till 1906; the South Wales Railway took a predictable route through relatively flat country; and the 'cut off' line between Wootton Bassett and the Severn Tunnel though well-engineered was not as original in conception as the Bristol main line - it took the best direct route, without the same landscape aesthetic as the original main line.

Engineering the line

Like other railway engineers, Brunel aimed to work with lie of the land in order to create the best gradients and to avoid major earthworks. That was an important factor in his choice of route. However it was inevitable that some major earthworks were involved, though in totality the earthworks for the line from London to Bristol were not as great as those required for other trunk lines (Fig. 16).

The Great Western required the excavation of 85,000 cubic yards per mile, whereas the London & Birmingham Railway required 115,000 cubic yards per mile and the London & Brighton 145,000 cubic yards per mile.[27] The most notable works on the Great Western were the 2 mile cutting at Sonning, the 1 ¾ mile Box Tunnel and tunnels between Bath and Bristol. These are features which a traveller down the line will be aware of. What may be less obvious to anyone on the train is how carefully he threaded the line through the landscape.

Brunel's construction techniques were not wholly different to those of other railway engineers, based like theirs on the experience of canal and turnpike road construction. Wherever possible he balanced the excavation of cuttings with the construction of embankments, for instance by using the excavated soil from Sonning Cutting to build up the embankment through Reading. As on other early railways, Brunel's contractors relied on man and horse power; as many as 1,000-1,200 men on Sonning cutting and even more at Box Tunnel.

Fig 16: Engraving from Bourne showing the railway under construction in Bath

[27] A.W.Skempton, 'Embankments and Cuttings on Early Railways', *Construction History* Vol. II

Brunel had to deal with a number of earth slips on his works, two of them (at Wharncliffe Viaduct and at Wootton Bassett) while embankments were under construction and one (at Sonning Cutting) in a completed cutting. His understanding of such slips – generally in clay soils – was little different to that of other engineers, and his remedial measures were similar to theirs.

Looked at in its totality what is most significant about the engineering of the route from London to Bristol is not the construction techniques used but the way it was engineered to achieve the best levels and the way it was moulded to the landscape, often with picturesque effect in mind. What is also significant is that the late nineteenth century widenings were carried out with immense sympathy to the original design.

The engineering of the other routes (Reading-Newbury, Didcot-Oxford, Severn Tunnel - Cardiff and the 'cut-off' route to the Severn Tunnel) is less historically significant, though as much fortuitously as by design, they have became an accepted part of their surroundings. The South Wales & Bristol Direct Line did require a series of tunnels, viaducts, deep cuttings and numerous bridges to drive a fast new line through the Cotswolds, but nothing of this was technically challenging or innovative by the date of its construction in 1897-1903.

Permanent Way

The character of the Great Western Main Line in part derives from the larger dimensional structures which Brunel's 7ft 0 ¼ inch gauge dictated. The reasons for his advocacy of the broad gauge, plus its final abolition in 1892, have already been discussed. Its use meant that overbridges and tunnels were wider than on lines built to the standard 4ft 8 ½ in. gauge, and that the trackbed was of course also wider. Generally bridges and tunnels were not built much higher because it was width rather than height that Brunel believed to be the key to smoother running.

The generously-dimensioned structures along the line, designed for broad gauge, are part of its overall significance; historically, as illustrative of Brunel's engineering ambitions, and aesthetically because of their scale. Where alterations have been made at standard gauge as part of route widenings these have often been done in a sympathetic way.

Brunel also devised his own type of track, based on 'bridge section' rails fixed to longitudinal timbers and the whole track piled. In practice this design was highly unsatisfactory and it was replaced by track laid on the arrangement which is universally used today. Since no examples of Brunel's original arrangement survive, and it had no lasting impact, it cannot be said to contribute to the present significance of the line, or the development of the railways.

3.4.3 Bridges & Viaducts

Travellers on the Great Western will be aware of overbridges as they flash by, but much less aware of the underbridges and viaducts which the railway crosses. However these may be important to people living in the locality, or generally those seeing the railway from below. This section of the assessment deals with all types of bridge, both over and under the line.

Applying the criteria laid down in English Heritage and Cadw's *Conservation Principles*, the following broad considerations apply to the bridges:

- **Evidential.** All of the bridges are recorded in one way or another; in photographs and in most cases in drawings held at the National Rail Archives. However for the engineering historian interested in the performance of a bridge structure, the fabric of the bridge itself provides essential primary evidence.

- **Historical.** Bridges illustrate how the engineering of the line was achieved, and different bridge types illustrate the availability of materials and the solutions to different kinds of problems.

- **Aesthetic.** The quality of the bridges is in all cases the result of design decisions by Brunel and his assistants and their successors. In addition, in many cases the aesthetic value of a bridge derives from the way it relates to its setting, including its relationship to the engineering of the line.

- **Communal.** Many of the bridges are significant features in a local landscape, in some cases providing the key to local identity, for instance the River Kennet Bridge in Reading (3479) and the Huckford Viaduct (SWB 10965).

In addition to those considerations there are some more precise criteria to be applied in the assessment of these bridges. These may be summarised under three headings:

- **Date of construction**. The English Heritage Listing Selection Guide for Transport Building (2011) states that "most pre-1840 bridges, where substantially intact, will warrant serious consideration for listing." (p.6). This priority is reinforced where a railway falls within the pioneering period, which is the case for the Great Western Main Line, completed in 1841 (p.3). The degree of survival is important. It is assumed that where a bridge has been extended or partially rebuilt it will be less significant, unless it is considered that those subsequent alterations are in themselves significant.

- **Repetition**. Generally the original masonry bridges on the GWML were of five types:
    - Three-arch overbridges
    - Single semi-elliptical arch overbridges
    - Four centre single arch overbridges
    - Single segmental arches
    - Single arch underbridges

They vary along the route depending on the materials used and the importance of their location (the four-centred arches are confined to the Bath area). The uniqueness or otherwise of a particular bridge may contribute to its significance. Acknowledging the issue of generic structures, the English Heritage Guide states: "the rapid increase of transport projects for turnpikes, canals and railways created the need for standardised and less spectacular bridges: for these, greater selection will be required." (p.6)

- **Innovation and influence**. Engineering history generally follows a narrative of progressive innovation in which key bridges play a major role. Where an innovative or influential structure survives it may be significant, even if it lacks other qualities such as aesthetic value.

- **Group value**. In the case of a railway such as the Great Western, group value can refer to two things. First, how a bridge or viaduct relates to other railway components of the railway such as stations, and other bridges or to the overall engineering of the line. The English Heritage guide makes reference to linear group value in such cases (p.5). Secondly, a group may be formed from the relationship between a railway bridge and other non-railway buildings and structures, plus their landscape setting.

The architectural and historic interest of a number of bridges along the line has already been recognised through designation. This may be summarised as follows:

- The major underbridges and viaducts of the pioneering (pre 1841) era are all listed. These include Wharncliffe Viaduct, Maidenhead Bridge, Gatehampton Viaduct, Moulsford Viaduct, Twerton Viaduct and the bridge over the Avon at Bristol.

- A large number of over and underbridges in the Bath area are listed: 19 between Box Tunnel and Twerton.

- A few other overbridges are listed: the three-arch bridge at Steventon, a single semi-elliptical arch bridge at Appleford on the Didcot-Oxford Line, and three bridges on the Crossrail route between Heathrow Junction and Maidenhead (all of them extended in widening of the line 1878-82).

Looked at in greater detail, the significance of the bridges can be assessed in a number of ways.

Innovation and Influence

First, as regards innovation and influence, the significance of Brunel's major masonry arched bridges, especially Maidenhead Bridge, is widely recognised. By contrast, there has been very little discussion of Brunel's smaller bridges (Professor J. B. B. Owen's classic article on his arch bridges makes no reference of the smaller types).[28] Brunel was unusual in using semi-elliptical arches, a design which has practical advantages for railways, especially broad gauge lines, but was not in itself an innovation: such designs has already been developed for road, river and canal bridges. His four-centred arch bridges were also not innovatory.

Brunel was also extremely interested in the use of cast iron, far more than has usually been thought. Steven Brindle and Malcolm Tucker have recently completed a report for English Heritage on his cast iron bridges, identifying 58 bridges and aqueducts, many of them on the GWML.[29] Of his cast iron railway bridges, the footbridge in Sydney Gardens (bridge 10614) is the sole survivor. Although not typical of his cast iron designs this example has added significance as representing his generally unacknowledged interest in the material.

Brunel also made great use of timber in bridge construction, in the knowledge that timber provided a speedy, cost-effective solution to even if it had to be renewed or replaced later. The most famous of his timber bridges were the 43 viaducts he built in Cornwall, some of them simple trestles but others consisting of timber 'fans' springing from masonry piers to support the trusses carrying the line. There were comparatively few timber bridges on the GWML, though two of them became well-known – a high bridge over Sonning Cutting and a laminated timber arched bridge over the Avon at Bath. Neither of these survive as built, and indeed none of Brunel's other timber bridges have survived. Therefore although his work in timber is an important factor in Brunel's reputation, there are no examples of that work which contribute to the significance of the present works.

In the post-Brunel era, none of the new bridges or the extensions to existing bridges were path-breaking designs. His successors often maintained the language of his engineering designs or used widely-adopted solutions.

The Pioneering Era

The Great Western Main Line being as a whole significant as a pioneering railway development (see para 3.3), the surviving bridges from that era will be important as components of that achievement. At present that significance is recognised in the case of major bridges, plus other bridges in the Bath area, but generally speaking the status of smaller bridges on the route has not been fully appreciated.

On the GWML the original bridges which survive in an unaltered state are on sections of the route which have not been quadrupled, mainly east of Swindon (Fig. 18).

[28] J.B.B.Owen, 'Arch Bridges', in Alfred Pugsley, ed. The Works of Isambard Kingdom Brunel (1976), pp.89-106

[29] Steven Brindle and Malcolm Tucker, *Brunel's Cast Iron Bridges. A Descriptive and Analytical Catalogue* (March, 2011)

As already mentioned, many of the bridges in the Bath area have been singled out for attention, perhaps as much for their role in the landscape or townscape as for their role as railway structures. Elsewhere on this original line only the overbridge at Steventon is listed. However there are three other clusters of overbridges which merit attention as survivals of their type:

- East of Swindon, including Bourton Church Bridge (7169), Bourton Bridge (7215), and Roman Road Bridge (7508, Fig. 17).
- Between Swindon and Chippenham, including Wootton Bassett Bridge (8333), Dauntsey Bridge (8849) and Green Bridge (9303, Fig. 18).
- West of Bath, including Clay Bridge (11226), Pixash Bridge (11263) and Newbridge Road Bridge (11664).

In some of these areas, especially west of Bath there are also representative underbridges, such as Stone Wharf Bridge (11042, Fig. 19) and Keynsham Hams Bridge (11404).

Fig 17: Overbridges of the Pioneering Era - Roman Road Bridge (sketchbook from the Brunel Collection of the University of Bristol, at the Brunel Institute) (7508)

Fig 18: Overbridges of the Pioneering Era - Green Bridge (9303)

Fig 19: Underbridges of the Pioneering Era - Stone Wharf Bridge (11042)

Other Unaltered Bridges

Disregarding the finishing date for the Pioneering Era at 1841, there are other surviving bridges which are either representative of the Brunel era or which merit attention as complete examples of subsequent eras. In the first category would fall two bridges on the Didcot-Oxford line, at Culham Station (DCL 5616) and Thame Lane (DCL 5657). That line was opened only three years after the main line and is clearly of the same parentage. The two bridges form a group contemporary with the listed Culham station. In the second category would come bridges rebuilt as a result of widenings, such as Sonning Road (3329), or even bridges on the 'cut off' route to Wales (the Bristol & South Wales Relief Line), completed in 1903.

Altered and Extended Bridges

It is an axiom of most assessments of historic buildings and structures that a late alteration may be significant in itself, or may add interest to the original construction. Applying that principle to bridges on the GWML has the effect of classifying far more bridges as having aesthetic and historic value and thus significance especially since many of the extensions made to structures when the line was widened were carried out with great sensitivity. Three of the existing listed overbridges, on the Crossrail part of the line, are of this kind especially Leigh Road Bridge east of Slough (1974, Fig. 20).

Further details of altered bridges are given in the Route Structures Gazetteer. A number of them on the GWML, especially between Reading and Didcot where the route was widened in 1890-93, may be classified as significant (1) because of the design quality of the structure in its altered form, and (2) because the alterations illustrate an important aspect of the overall history of the route, and thus add historic value (Fig. 21).

3.4.4 Stations

Stations are crucial to the way people experience a railway. They are the first and last point of contact – the 'public face' of the line. When people think of the GWR, they may often think first of a station, perhaps most of all Paddington and Bristol Temple Meads. Stations are, however, tremendously varied in their size, age and in the survival of their historic fabric. More so than many building types, they are subject to frequent alteration as technical improvements are required.

Applying the criteria laid down in English Heritage and Cadw's *Conservation Principles*, the following considerations apply to stations:

- **Evidential.** All of the stations are recorded in one way or another; in photographs and in most cases in drawings held at the National Rail Archives. However for the railway historian interested in station design and its evolution over time, the fabric of the stations themselves provide essential primary evidence.

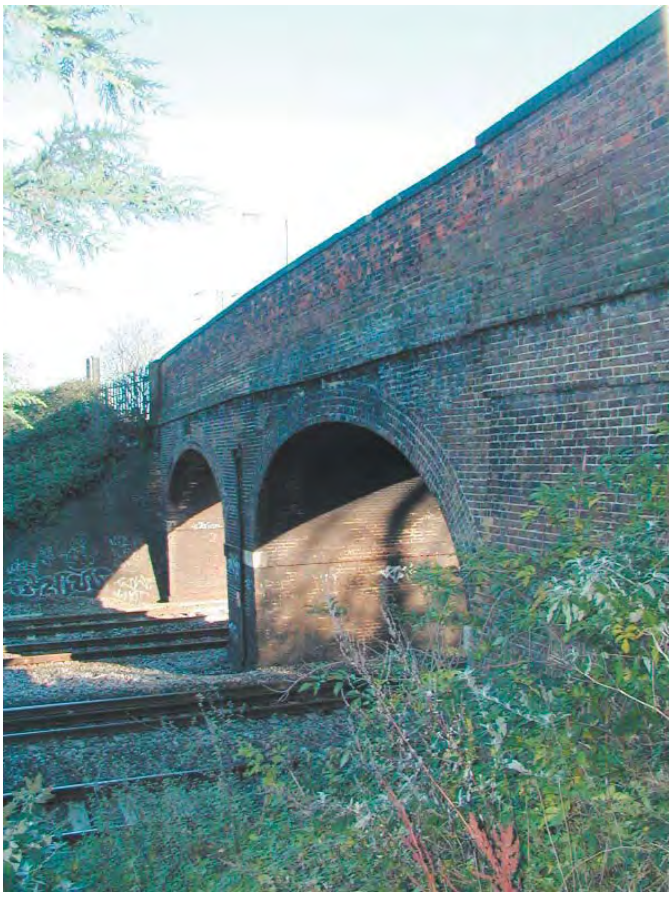


Fig 20: Bridges adapted for route widening during the first phase, 1875-84 – Leigh Road (1974)

Fig 21: Bridges adapted for route widening during the second phase, 1890-93 – Silly Bridge (4779)

- **Historical.** Early stations provide a unique insight into how the railway operated and was presented to the public in its earliest days. In so far as stations have been altered through the years, they also illustrate how operational demands and passenger provision have evolved over time.

- **Aesthetic.** From the earliest stations by Brunel and into the twentieth century, stations were designed to be attractive as well as functional. Many aspects of station design are particularly striking, from the great arched roofs of the large termini to the timber canopies of smaller stations. The aesthetic value of a station may also derive from the way it relates to its setting, particularly in the case of isolated country stations.

- **Communal.** People interact with the railway firstly through its stations. They are remembered as meeting places as well as points of departure, often for fondly-remembered holidays. For these reasons, the communal significance of a station may be strong even where its aesthetic or historical significance is weak.

In addition to those considerations there are more precise criteria to be applied in the assessment of stations. These may be summarised under three headings:

- **Date of construction**. The English Heritage *Listing Selection Guide* for Transport Buildings (2011) states that "when it comes to purpose-built railway structures, most pre-1840 buildings will often be of international significance as being among the earliest railway structures in the world" (p.7). The 1840s is also an important period, where "great care should be taken in seeking out work of this date because it is often hidden by later alterations and extensions" (ibid). Lastly, the English Heritage guidance states that "increasingly rigorous selection is required for buildings after about 1860: this reflects both the quantity of what remains, and the standardisation of design which was applied to buildings and structures erected along different railway lines. A number of factors should be taken into account when assessing buildings of the latter half of the nineteenth century, which have often undergone considerable replacement (greater significance having been attached to the first-generation railway buildings). Railway companies had different approaches to construction and different house styles and, where possible, a representative sample of structures from each company should be designated if the architecture is distinctive" (pp.7-8).

- **Rarity and Group Value**. As the English Heritage guide notes, "rarity of survivals by company may be a factor here, as is the case with the later Victorian 'Domestic Revival' stations, designed for the Great Eastern Railway in East Anglia from the 1880s. Other regional factors may be relevant too – surviving smaller station buildings in urban areas such as Lancashire, Yorkshire, and Tyneside are very thin on the ground due to the de-staffing of stations and subsequent demolition in the 1970s. As with industrial buildings generally, group value can be a key determinant. Some stations and goods yards need to be assessed as a whole, especially where they demonstrate the phased evolution of the railway system,

through alteration and extension. Rarity is, however, an issue which needs to be factored in when assessing more recent railway buildings: attrition rates for some later Victorian railway buildings have been high, and it is not simply a question of 'the older, the better'" (p.8).

- **Intactness of complex**. The English Heritage guidance notes that "smaller stations comprising the main station building sometimes with staff accommodation, canopies, waiting shelters, footbridge, signal box and goods shed, survived in vast numbers at the beginning of the twentieth century but have suffered grievously from attrition and clearance...extra care needs to be taken to ensure that less obvious ancillary structures are fairly considered, alongside principal station buildings" (p.8).

- **Canopies.** Platform canopies are of particular relevance to the electrification project. The English Heritage guidance does not go into any detail about canopies, but the following observations can be made:

    - Canopies are valued not just for the shelter they provide but also for their decorative qualities, particularly where they incorporate valences.
    - As a result, they may be aesthetically significant even when they are not historically important, e.g. in the case of late nineteenth century canopies.
    - Canopies have often been designed to be seen from various angles and sometimes create a symmetrical composition as seen from the end of a platform.
    - Throughout the line, canopies have often been altered or replaced, e.g. due to the decay of timber or because of changing technical requirements. In these cases, although the fabric and form of the canopy may not be historic, its overall appearance is still an important consideration.

The architectural and historic interest of stations on the GWML has already been recognised through designation. This may be summarised as follows:

- Stations from the pioneering era (pre 1841) or designed by Brunel are generally listed: London Paddington (Grade I), Bath Spa (Grade II*) and Culham (Grade II). Both the Brunel part of Bristol Temple Meads and the subsequent additions are listed (Grade I).

- From the pre-1860 period, Chippenham is listed (Grade II) (Fig.15).

- From the post-1860 period, Hanwell is listed (Grade II) because of its high level of intactness, Slough is listed (Grade II) because of its high architectural quality, and Cardiff is listed (Grade II) as an intact example of an inter-war station.

A further assessment of the significance of the stations must start from the fact that c.18 of the smaller stations on the line have been closed or demolished. Of the 12 stations which survive, the following considerations apply:

Fig 22: Chippenham Station, 1852

Innovation and Influence

The significance of Brunel's two major trainsheds at Bristol and London is widely recognised. They were structurally innovative in their day and have proved highly influential since. Before Bristol Temple Meads, the only comparable roofs were those associated with the engineer Robert Stephenson, namely the original Euston Station (1836-37) and Derby Trijunct Station (1839-41), both now demolished. Brunel improved on Stephenson's model at Bristol by eliminating the columns, whilst later at Paddington he used columns but created very wide spans between them, using new techniques of composite iron construction. Bristol was also pioneering for accommodating the other railway facilities within the same building, such as offices and passenger waiting rooms.

The Pioneering Phase

As the GWML is considered a pioneering railway, original stations will be significant as components of that achievement even where they are not demonstrably innovatory. Therefore, Culham Station, Bath Spa Station, Twerton Station (closed) and Wallingford Road (closed) are all signfiicant as surviving stations from the opening of the line, designed by Brunel. They illustrate the variety of plans he tried, before station planning became standardised.

Other early stations

Swindon has on its island platform an unlisted stone building which dates from Brunel's station of c. 1842. Although much altered and with later canopies attached, it is an interesting surviving fragment because it contained the refreshment rooms used by passengers before te advent of restaurant cars, and incorporated - for the first time on any scale - a hotel on the upper floors. The island platform layout was also influential. The later Chippenham, 1852 (Fig. 22), is better preserved.

Later stations of high quality

Both Slough and Hanwell (on the Crossrail part of the route) are undoubtedly buildings of very high architectural quality that, particularly in the case of the latter, are extremely well preserved. As with other structures along the line, however, GWML stations have not hitherto been considered thematically, raising the question of whether other stations are of special interest.

Bearing in mind the English Heritage guidance, most of the unlisted late nineteenth century and Edwardian stations have some significance. They are aesthetically unremarkable but where they survive reasonably intact they add to the historical understanding of the line. Newbury Station, rebuilt in 1908-10, is the largest and most complete. Newport Station (South Wales), mainly of two dates (1878 and 1930), has elements of historical and aesthetic value but overall it is of low significance because the result is neither cohesive or exceptional in its constituent elements. Cardiff Central, however, rebuilt in 1930-4 in a late Beaux Art classicism, is both of these: the most complete and unified large station in the UK of the interwar period, a time when little station building on this scale was undertaken in this country. It is therefore of considerable historical and aesthetic value.

3.4.5 Tunnels

The significance of the tunnels needs to be considered from both the engineering and the architectural points of view. In terms of the techniques used to construct them, the seven surviving tunnels on the Main Line are not exceptional, even though Box Tunnel is exceptional for its length and the difficulties in boring it. The Severn Tunnel (1873-86) has already been mentioned because of its crucial role in the evolution of the route to Wales. It was a remarkable engineering achievement, as important in tunnelling history as the Forth Bridge (completed four years later) was in bridge design.

Looked at architecturally, the tunnels on the GWML are amongst the most interesting of their kind in the country. This is partly a matter of architectural scale. The tunnel portals were inevitably larger than on other lines because of the broad gauge, but Brunel seems to have enlarged them even further to enhance their grandeur. He then treated them as major architectural features, classical east of Bath and Tudor-Gothic between Bath and Bristol. Nothing demonstrates more clearly his search for picturesque effect, and J.C. Bourne recognised this in the way he illustrated them in his history. The variations between each portal are themselves interesting, for instance the use of rusticated quoins and an open parapet on the West portal at Box followed by the broad pilasters bearing Roman fasces and a closed parapet at Middlehill Tunnel. The way the architectural sequence between Box and Bristol is experienced adds to the significance of the individual tunnels.

Fig 23: Newport (Stow Hill) Tunnel. The original (1848) portal and bore on the right, the left hand bore added 1911

There are no tunnels on the Didcot-Oxford and Reading-Newbury lines. On the line from the Severn Tunnel to Cardiff, the older part of the Newport (Stow Hill) Tunnel is of similar grandeur to the tunnels on the Chippenham-Bristol route, its broad arches finished with rock faced voussoirs. The tunnels on the South Wales & Bristol Direct Line are of a much later date than those on the original Main Line and are of low significance, for that reason.

3.4.6 Other structures

As already emphasised, (para 2.6.5) the Main Line and its subsidiary branches have lost most of the minor buildings and structures which once served the railway. Had they survived they would have contributed to its significance, if only as illustrating how the lines operated in their heyday. Without them aspects of the history of the lines are harder to appreciate, even though the overall engineering design has recognisably survived.

The buildings of the Swindon Railway Works and Railway Village will not be directly affected by the electrification project, but they form a major aspect of the Main Line without which its significance would be less complete.

Other early works have survived, e.g. Derby, parts of which date from 1839 and Doncaster dating from 1853, but none are as extensive as Swindon, nor do they exist alongside company housing and institutions as at Swindon.

3.5 Summary of significance

It remains to draw together the different strands discussed in this review of significance. The opening part of this discussion made reference to English Heritage's *Conservation Principles* and its Welsh equivalent, and it is useful to open these concluding remarks by returning to the criteria set out in the document.

The four types of value which constitute significance can be applied to the Great Western Main Line as follows:

- **Evidential value**: as primary evidence of the past (i.e when no other record exists) the line is highly significant as a total engineering achievement which can only be experienced as a physical entity. This is especially true of the engineering of the line and its relationship to the landscape. Individual structures such as Maidenhead Bridge, the viaducts at Gatehampton and Moulsford and the Severn Tunnel are of evidential value for the understanding of engineering design.

- **Historical value**: the degree of survival of GWML line makes it highly significant as illustrating the pioneering era (pre-1841) of railway building. As the English Heritage Listing Guidance suggests, any line of that era which survives as a whole or in part will aid historical understanding of the way early railways evolved. In this case, this applies in particular to sections of the main line which have not been quadrupled, where surviving structures can still be seen in relation to the original width of trackbed, chiefly west of Chippenham. It also applies to a short section of the Didcot-Oxford line (opened 1844) through Culham station. The Reading-Newbury (opened 1847), the line in South Wales, and the 'cut-off' line Wootton Bassett- Severn Tunnel (completed 1903) are less significant.

- **Aesthetic value**: the fact that Brunel was involved in every aspect of the design and construction of the London-Bristol route adds to its significance as being the conscious design of one man. It is also significant for what that design achieved, in the engineering of the line in relation to the landscape, the railway version of the picturesque aesthetic. The subsidiary lines (Didcot-Oxford, Reading-Newbury, Severn Tunnel - Cardiff and the 'cut off' line to the Severn Tunnel), are less significant in this respect, though they also are valued as part of the landscape through which they pass.

- **Communal value**: as explained above (para 3.3), there is considerable overlap between this value and historical and aesthetic values. Put simply, the GWML has significance because of the affection in which the memory of the Great Western Railway is held, and that affection has been reinforced since the 1950s by the increasing reputation of I. K. Brunel. This value is a general one which cannot easily be applied to particular structures or sections of the line, but nonetheless it accounts in part for the special status given to the GWML.

Perhaps the most important conclusion from this review of significance is the importance that should be attached to the overall engineering design of the line, from the choice of route to the specific design of embankments, cuttings and other features. Hitherto there has been considerable attention given to individual structures along the line, but much less to the line itself. The significance of the GWML and the other routes is highest where the engineering design of the line is complemented by the quality of the surviving elements. Because of its historic status as a railway of the pioneering era, this relationship of the whole and parts is most significant for the GWML, but it also exists for parts of the other lines.

As made clear in the Introduction to this report, the lines which are proposed for electrification are historically of five different periods of construction. Their relative significance can be summarised as follows:

- The **Great Western Main Line**, London to Bristol (MLN1), embodies all the values which constitute high significance, because of its pioneering date, the engineering aesthetic which informed its development and the degree of survival of buildings and structures along the line.

- The **Didcot-Oxford Line** (DCL), completed in 1844, is of medium significance as falling within the 'heroic age' as defined by English Heritage. Part of line, from Appleford Overbridge (DCL 5518), through Culham Station, to Thame Lane Overbridge (DCL 5657) is highly significant because of the survival of a group of intact features which are seen as a group in relation to the engineering of the line.

- The **Reading-Newbury Line** (BKE and BHL), completed in 1847, is also of medium significance as being part of the 'heroic age', but the intact structures along it do not benefit from the same group value as some of the structures on the Didcot-Oxford line.

- The **South Wales Main Line** (SWM2), from the Severn Tunnel to Cardiff, was built by an offshoot of the Great Western Railway and designed by I.K. Brunel but has undergone substantial alterations: none of its original stations and bridges survive, and its one surviving tunnel (Newport Tunnel SWM2 15903), though significant, has been altered by addition of a second bore. The line as a whole is therefore of low significance. Cardiff Station is significant as a remarkably complete example of the improvements made to major G.W.R. stations in the 1930s.

- The **Bristol & South Wales Union Line** (BSW) is a short line of 1858-63 incorporating no surviving structures or buildings of significance.

- The **South Wales & Bristol Direct Line** (SWB), constructed in 1897-1903 as a more direct route to the Severn Tunnel, has some historical value as a reminder of the unusual scale of works undertaken by the G.W.R. at that time but most of the structures along it are, by virtue of their date and aesthetic quality, of low significance.

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