Science Transit and Bus Strategy
Didcot-Harwell Public Transport Study

Vale of White Horse District Council & Oxfordshire County Council

14 August 2014

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This document has 26 pages including the cover.

Document history

Job number: 5132863.015			**Document ref:**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Draft v1	Draft for client review	PC	-	-	-	29/07/14
Draft v2	Draft for client review	PC	-	-	-	14/08/14

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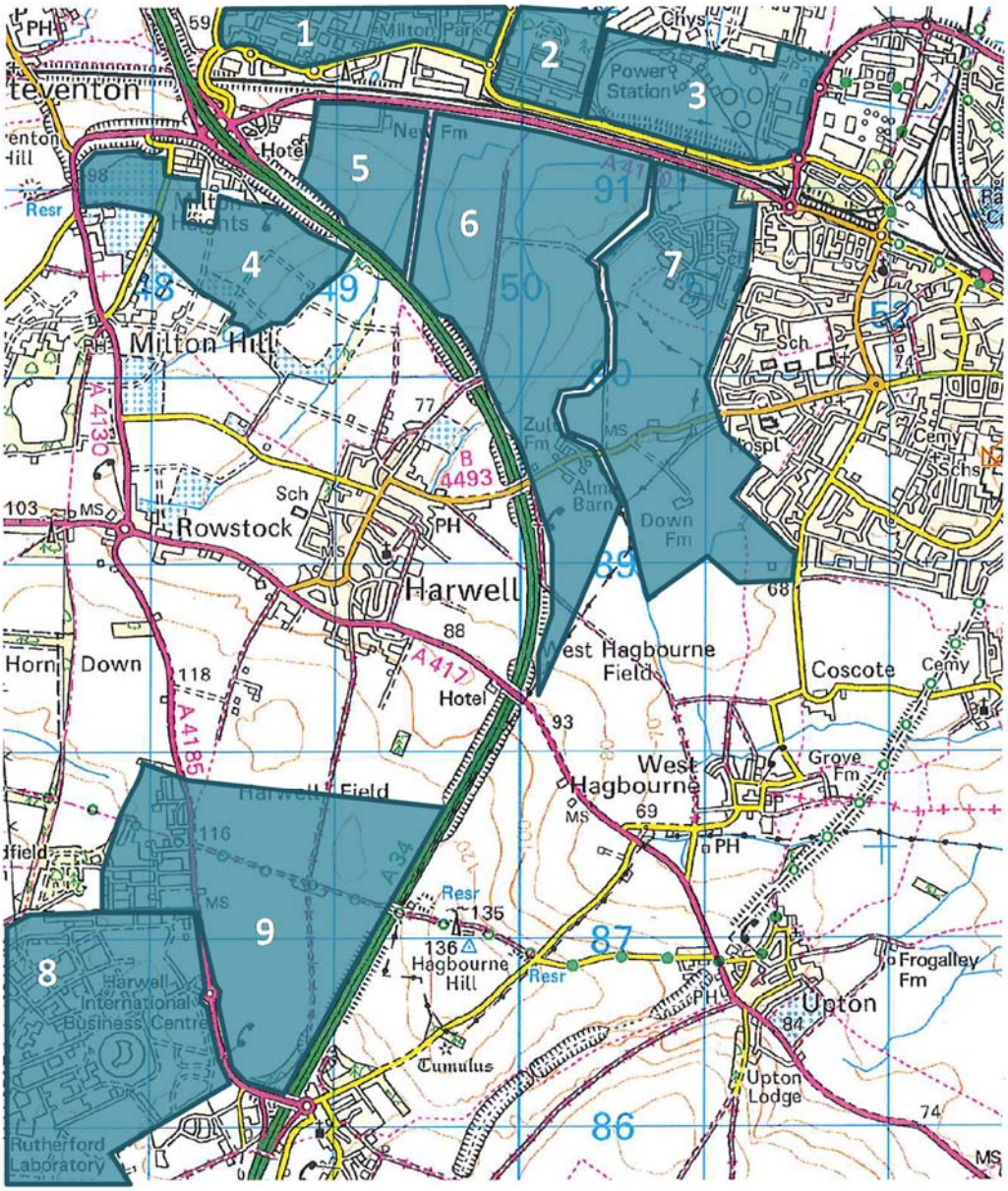
1. Introduction and Objectives

1.1. Context

Science Vale (Didcot-Harwell-Wantage) is a rapidly growing area of Oxfordshire, with major growth planned. In particular, significant new residential and employment growth is planned immediately to the west of Didcot, in the Milton and Harwell areas[1]. Growth areas immediately to the west of Didcot are listed in Table 1-1 and mapped in Figure 1-1, with indicative dwelling and employment forecasts for each area[2]. In total, approximately 13,000 new jobs and more than 8,000 new dwellings are to be catered for by 2031, at the strategic sites within the area shown in Figure 1-1. Additional housing is also proposed at a number of smaller sites, increasing the total number of new dwellings across Science Vale to more than 11,500 by 2031.

Figure 1-1 Growth areas to the west of Didcot



[1] Growth to the west of Didcot is primarily within the area covered by the Vale of White Horse District Council, although some of this growth will take place within the South Oxfordshire District Council area.
[2] Employment forecasts obtained from *Vale of White Horse Employment Land Review Addendum 2014, URS* and housing forecasts directly from VoWHC officers.

Table 1-1 Indicative additional dwelling and job forecasts to 2031

Map ref #	Growth area (strategic sites)	Additional dwellings	Additional jobs
1	Milton Park Enterprise Zone	-	1,600
2	Business premises at Didcot Power Station	-	1,500
3	Didcot A	-	2,100
4	Milton Heights & Milton Hill	300	1,300
5	North-west Valley Park	800	-
6	Valley Park	2,550	-
7	Great Western Park	3,300	-
8	Harwell Campus (Harwell Oxford Enterprise Zone)	-	6,400
9	East Harwell Campus (incl land n/o Harwell Campus)	1,400	-
	Strategic Site totals:	**8,350**	**12,900**

The level of projected residential and employment growth will place considerable pressure on the local transport network. Significant improvements to the road and public transport networks are therefore proposed by Oxfordshire County Council (OCC) and the Vale of White Horse District Council (VoWHC). Two examples of specific transport improvement proposals are the 'Science Vale Highway Improvements Plan' and the 'Science Transit' concept.

The 'Science Vale Highway Improvements Plan' comprises various junction improvements, road upgrades and new link roads, with a particular focus on making improvements in the Didcot-Harwell corridor. The 'Science Transit' concept is for a set of high quality public transport core routes connecting the major development areas within Oxfordshire. High quality public transport routes are intended to reduce the number of trips that would otherwise be made by private car.

1.2. Purpose of this Study

The Didcot-Harwell Public Transport Study is a high-level feasibility study to:

- Examine potential public transport options for addressing the future needs of the Didcot-Harwell area, but with an emphasis on developing the 'Science Transit' core public transport route concept;
- Investigate whether any of the public transport options could be developed into a favourable business case, in strategic and economic terms;
- Identify what the headline conclusions might be for the strategic and economic elements of the business case;
- To make a recommendation on which options, if any, might be worth pursuing further; and
- To inform the Evaluation of Transport Impact (ETI) work, which is being undertaken by VoWHC to forecast the impact of growth in Science Vale. The Didcot-Harwell Public Transport study will provide information on the potential that may exist for increasing public transport use.

The remainder of this report is structured as follows:

- Section 2 establishes the objectives that would need to be met by any public transport options proposed for the Didcot-Harwell area. Initial options, in terms of places served and general route options, are then presented;
- Section 3 compares the potential passenger demand for each of the initial options, based on trip rate estimates from the TRICS database, adjusted to take account of potential service quality improvements;
- Section 4 assesses the infrastructure needs for the initial options, using information on traffic congestion hotspots;
- Section 5 provides outline proposals for packages of measures and indicative cost estimates. High and medium investment packages are presented;
- Section 6 sets out an initial Benefit to Cost Ratio (BCR) estimate for a range of options, using a conventional approach to assessing transport economic benefits; and
- Section 7 presents the conclusions and recommendations from the study.

2. Objectives and Option Scoping

2.1. Establishing Objectives

At the study inception meeting, held on 8th July 2014 with officers from OCC and VoWHC, future transport problems in Science Vale and objectives for solutions to these problems were discussed. Figure 2-1 summarises the key points from this discussion and establishes the objectives that would need to be met by any public transport options proposed for the Didcot-Harwell area.

Figure 2-1 Objectives for Didcot-Harwell public transport options

Transport problem / issue	Future requirements	**Objectives** for transport solution
•Increased traffic congestion as area develops, even with highway improvements delivered. • On-road public transport services will become increasingly unreliable and unattractive due to congestion • Connectivity between Didcot and Harwell growth areas, in terms of both journey time and transport options, will worsen. •Science Vale will continue to develop and evolve, putting further pressure on the road network • Majority of the built-up area of Didcot is within walking distance of the town centre and rail station. This situation will change as the town expands to the west.	•Reduce the growth in trips made by private car • Deliver public transport alternatives that are attractive and which encourage car users to shift to an alternative mode • Ensure that residents are able to access employment opportunities by modes other than the private car - this includes ensuring access to the rail station. • Ensure that local businesses' access to the labour market and their customers is not restricted by transport-related problems • Allow for flexibility in the transport system, so that it can be adapted to suit changing economic and development circumstances.	• To provide for a reliable alternative to the private car on the Didcot-Harwell corridor, which remains reliable under the future development scenario • To encourage mode shift on the Didcot-Harwell corridor, by providing for a high quality service between multiple trip generators and attractors • To provide a direct public transport connection between residential growth areas and employment growth areas •To be capable of evolving over time, allowing for extensions or alternative routes if this becomes necessary in the future.

The objectives listed in Figure 2-1 are not fully SMART[3] objectives at this stage. If a decision is made to progress with a new public transport option for the Didcot-Harwell corridor, then the objectives would need to be refined.

In order to meet the objectives set, in particular relating to reliability and mode shift, the options assessment process must focus on a transport solution that can achieve priority over general traffic on the road network, or one which follows a segregated alignment. An option assessment process which focuses solely on vehicle specifications, timetable specifications or simply recasting the bus network without supporting infrastructure would not be sufficient. Therefore this study avoids dwelling on these issues and primarily considers new infrastructure provision.

The need for the transport solution to be capable of evolving over time means that, at present, a bus-based solution is likely to be the most appropriate solution for the Didcot-Harwell corridor.

[3] SMART objectives are 'specific, measurable, realistic, achievable, and time-bound'.

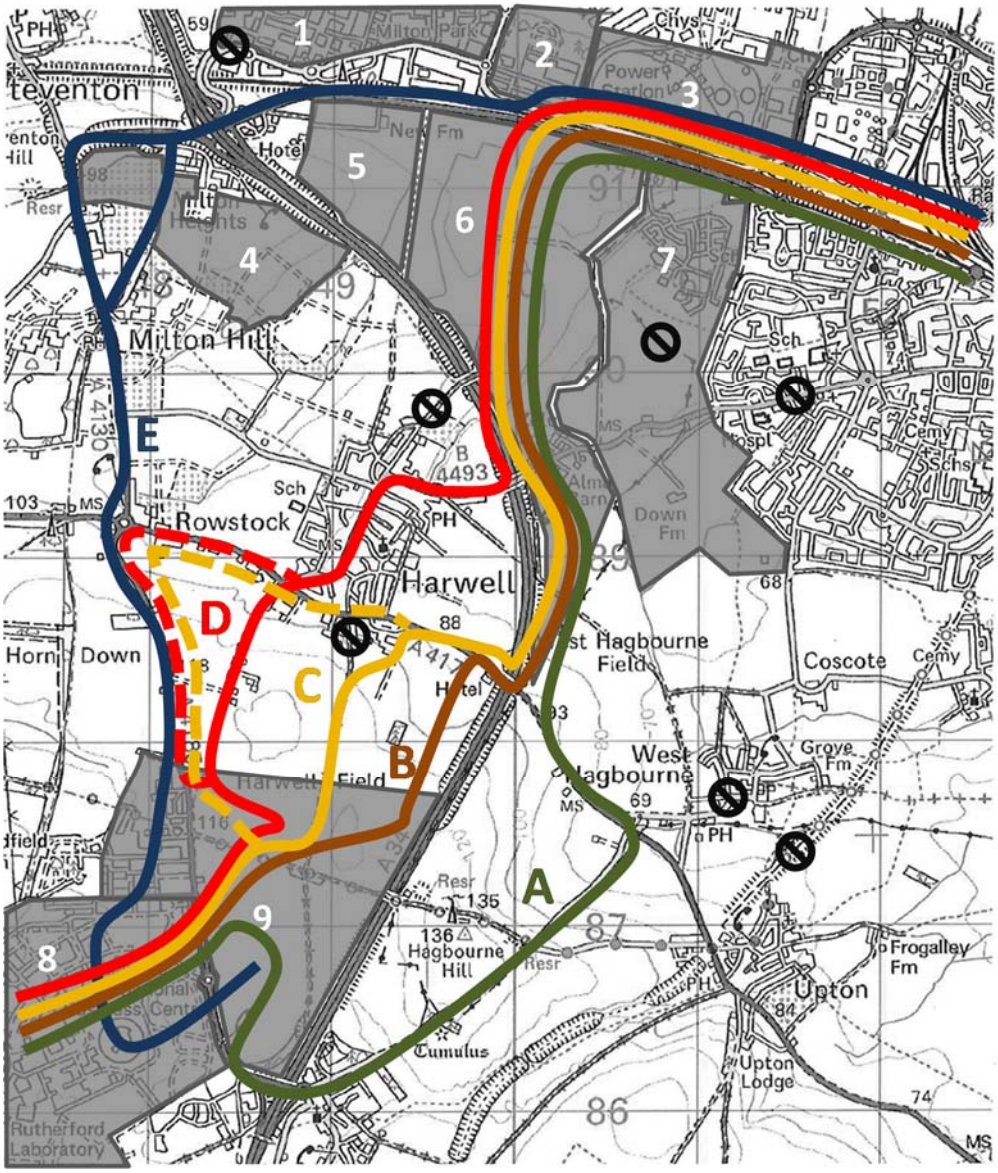
2.2. Initial Option Scoping

The first consideration is the general alignment that should be followed within the Didcot-Harwell corridor. One of the objectives (Figure 2-1) is to provide a direct public transport connection between residential growth areas and employment growth areas, so any proposed alignments should ensure that this is achieved.

Figure 2-2 shows five general alignments that have been identified for a core public transport route on the Didcot-Harwell corridor:

- Hagbourne Hill (alignment A)
- East of Harwell (alignment B)
- Central Harwell / A417 (alignment C)
- Harwell village (alignment D)
- Milton Hill (alignment E)

Figure 2-2 Potential core public transport alignments



⃠ symbol indicates a potential alignment that is not considered further in this study.

Other potential alignments exist for a core public transport route, as shown on Figure 2-2. However, these have been discounted for a range of reasons:

- B4493 Wantage Road / Broadway between Great Western Park and Didcot town centre. A number of pinch-points have been identified along this route, which are likely to be far more challenging to resolve in order to provide for public transport priority, when compared to the parallel A4130 route;
- Alignments via West Hagbourne. This would not allow for connections with the major residential growth areas at Valley Park and Great Western Park;
- Alignments via the Didcot-Upton Cycleway and Chilton Road. Similarly, this alignment would not allow for connections with the major residential growth areas;
- Directly through Great Western Park between the A4130 and B4493 Wantage Road. The north-south road which has been constructed through this development site is not wide enough to accommodate a core public transport route, particularly when vehicles are parked on both sides of the road;
- Alignments via Park Drive (Milton Park). This alignment would not allow for proper connections with the major residential growth areas at Valley Park and Great Western Park;
- Townsend / Cow Lane to the north of Harwell village, as a direct route between Harwell and Valley Park. Townsend, at the southern end of this potential link, is not a suitable road for a core public transport route; and
- The Holloway at Harwell village, as part of a direct route between East Harwell Campus and Valley Park. Similarly, the northern end of The Holloway is not a suitable road for a core public transport route.

3. Demand Assessment

3.1. Method Overview

This section compares the potential passenger demand for each of the initial core alignment options (A-E) for the Didcot-Harwell corridor, based on trip rate estimates from the TRICS database. These estimates are then adjusted to take account of potential service quality upgrades. The demand assessment presented here is a best estimate based on currently available information and would need to be refined if any of these alignments are progressed.

The following steps have been taken to assess potential demand:

- Assess which of the core alignments best capture the areas of potential demand. This is a straightforward assessment based on proximity of the alignment to the main growth areas listed in Table 1-1;
- Estimate the level of public transport trip-making to and from each of the growth areas over a 12-hour period, using the TRICS database, and match this to the alignments. This estimate is based on a conventional bus-based public transport service; and
- Adjust the public transport trip estimates based on passenger growth evidence from schemes implemented elsewhere. This will take into account any increase in passenger numbers that might be expected as a result of providing a high quality public transport service.

3.2. Potential Demand

Table 3-1 assesses which of the growth areas, and the proportions of those growth areas, could be served directly by each of the core public transport alignments A-E. Where the whole growth area cannot be served, the assumption for this assessment is that it would be possible to capture demand (whether from housing or employment) that exists within an 800-metre (approximately half a mile) walking route of the alignment. At this stage, it is also assumed that demand would be distributed relatively evenly within each growth area. Table 3-2 translates the percentages into the number of households or jobs that could be served.

Table 3-1 Proportions of growth areas served by core alignments

Map ref #	Growth area	Core public transport alignments – % coverage				
		A	B	C	D	E
1	Milton Park Enterprise Zone	-	-	-	-	20%
2	Business premises at Didcot Power Station[4]	75%	75%	75%	75%	75%
3	Didcot A[5]	90%	90%	90%	90%	90%
4	Milton Heights & Milton Hill	-	-	-	-	75%
5	North-west Valley Park	-	-	-	-	100%
6	Valley Park	95%	95%	95%	90%	25%
7	Great Western Park	50%	50%	50%	40%	25%
8	Harwell Campus (Harwell Oxford Enterprise Zone)	95%	95%	95%	95%	95%
9	East Harwell Campus (incl land n/o Harwell Campus)	60%	90%	90%	90%	90%

[4] Assuming that the proposed Science Bridge over the Great Western mainline is constructed, allowing pedestrian access to the core public transport alignment.
[5] Assumes the Science Bridge is constructed to allow pedestrian access to the core public transport alignment from the western part of the site.

Table 3-2 Number of new households and jobs served by core alignments

Map ref #	Growth area	Core alignments – numbers served				
		A	B	C	D	E
1	Milton Park Enterprise Zone - *jobs*	0	0	0	0	320
2	Business premises at Didcot Power Station - *jobs*	1125	1125	1125	1125	1125
3	Didcot A - *jobs*	1890	1890	1890	1890	1890
4	Milton Heights & Milton Hill - *dwellings*	0	0	0	0	225
	Milton Heights & Milton Hill - *jobs*	0	0	0	0	975
5	North-west Valley Park - *dwellings*	0	0	0	0	800
6	Valley Park - *dwellings*	2423	2423	2423	2295	638
7	Great Western Park - *dwellings*	1650	1650	1650	1320	825
8	Harwell Campus (Harwell Oxford Enterprise Zone) - *jobs*	6080	6080	6080	6080	6080
9	East Harwell Campus - *dwellings*	840	1260	1260	1260	1260
	Total – dwellings:	4913	5333	5333	4875	3748
	Total – jobs:	9095	9095	9095	9095	10390
	Total:	**14008**	**14428**	**14428**	**13970**	**14138**
	% of new dwellings served:	59%	64%	64%	58%	45%
	% of new jobs served:	71%	71%	71%	71%	81%
	Overall % of dwellings and jobs served:	66%	68%	68%	65%	67%

The alignments which appear to offer the greatest potential for serving the main growth areas are alignment B (East of Harwell) and alignment C (Central Harwell / A417), both passing directly through Valley Park and serving the majority of the East Harwell Campus and Harwell Oxford Enterprise Zone. Both alignments could serve up to 65% of new dwellings and 70% of new jobs. Nevertheless, all five alignments have the potential to serve more than 65% of new dwellings and jobs.

Although alignment E via Milton Hill can serve all of the main growth areas in some way, it does not provide for strong connections with the two largest residential growth areas at either Valley Park or Great Western Park in comparison to alignments A-D. Providing a direct public transport connection with the main residential growth areas is one of the objectives listed in Figure 2-1. **Alignment E is therefore not taken forward as a core public transport alignment to the next stage of the study.**

The number of public transport trips over a 12-hour period (0700-1900) that we might expect to be made to or from each of the growth areas, based on trip rates obtained from TRICS, is shown in Table 3-3. This assumes that a conventional bus-based public transport service is provided without any significant level of bus priority. The following should be noted regarding the trips shown in Table 3-3:

- A number of trips have been removed from the arrivals forecasts to avoid double counting, based on the assumption that 25% of new trips arriving in one of the employment growth areas will have departed from one of the new residential growth areas. A similar type of assumption is applied to avoid double-counting trips returning from the new employment areas to the residential growth areas;
- Approximately 35% of trips take place during the two peak hours (0800-0900 and 1700-1800). The remaining 65% of public transport trips take place outside of those two hours; and
- The trips in the table are additional to the trips that currently take place on bus services in the Didcot-Harwell corridor. Background bus patronage will need to be added to these figures.

Table 3-4 provides forecasts for additional public transport trips, assuming a conventional bus service, for each of the initial core alignments (A-E). The forecasts are based on multiplying the public transport trip estimates in Table 3-3 by the percentage of the growth area served in Table 3-1.

Table 3-3 Forecast public transport trips from growth areas, 12 hours, no improvements

Map ref #	Growth area	Public transport trips (12hr), whole area		
		Departures	Arrivals[6]	Combined
1	Milton Park Enterprise Zone - *employment*	44	34	**78**
2	Business premises at Didcot Power Station - *employment*	40	23	**63**
3	Didcot A - *employment*	57	45	**102**
4	Milton Heights & Milton Hill - *residential*	15	13	**28**
	Milton Heights & Milton Hill - *employment*	35	28	**63**
5	North-west Valley Park - *residential*	73	62	**135**
6	Valley Park - *residential*	232	197	**429**
7	Great Western Park - *residential*	300	255	**555**
8	Harwell Campus (Harwell Oxford Enterprise Zone) - *employment*	174	136	**310**
9	East Harwell Campus - *residential*	71	59	**130**
	Totals:	1042	850	**1892**

Table 3-4 Forecast public transport trips from growth areas served by core alignment

Map ref #	Growth area	Public transport trips (12hr), by alignment				
		A	B	C	D	E
1	Milton Park Enterprise Zone	0	0	0	0	15
2	Business premises at Didcot Power Station	47	47	47	47	47
3	Didcot A	92	92	92	92	92
4	Milton Heights & Milton Hill	0	0	0	0	68
5	North-west Valley Park	0	0	0	0	135
6	Valley Park	408	408	408	386	107
7	Great Western Park	278	278	278	222	139
8	Harwell Campus (Harwell Oxford Enterprise Zone)	294	294	294	294	294
9	East Harwell Campus	78	117	117	117	117
	Totals:	**1197**	**1236**	**1236**	**1159**	**1015**

Assuming that a conventional bus network is in place, Table 3-3 shows that a total of approximately 1900 public transport trips might be expected to be made to or from the main growth areas, over 12 hours on a normal weekday. Table 3-4 then shows that alignments B and C could serve almost two thirds (1236) of these public transport trips. Alignments A and D have the potential to serve 60-65% of these trips, while alignment E has the potential to serve just over 50% of these trips.

[6] Arrivals totals have been reduced to avoid potential double-counting of trips that may take place between the residential growth areas listed and the employment growth areas listed. Arrivals totals are therefore lower than departures totals.

3.3. Service Upgrade Additional Demand

The forecast public transport demand in Table 3-4 is based on the assumption that conventional bus services would be available along the core alignment, with little improvement above the existing situation in relation to bus priority measures and improvements to the passenger waiting environment.

However, as outlined in Section 2, the public transport solution for the Didcot-Harwell corridor will need to achieve priority over general traffic, and potentially follow a segregated alignment. This type of upgrade would lead to a higher quality experience for passengers and can be expected to increase patronage. Additional patronage as a result of improved service quality and reduced journey times therefore needs to be included in the forecasts.

Evidence of patronage increase along key bus corridors and individual routes as a result of bus-based public transport improvements in Cambridgeshire, Kent and Bristol is set out in the remainder of this section. Forecasts for additional public transport trips by alignment are shown in Table 3-5.

The following headline statistics for increased passenger numbers have been identified:

- Evidence from the Cambridgeshire Guided Busway, which enables bus services to use a fully segregated alignment for a large proportion of their journey, has shown a 33% increase in bus ridership along the busway corridor[7];
- A 25% increase in passenger numbers has been experienced along the Kent Fastrack corridors, with two core routes operating between Gravesend and Dartford. As with the Cambridgeshire busway, this is an infrastructure-led solution to improving bus-based public transport[8];
- The main bus operators across the ten Greater Bristol Bus Network (GBBN) corridors have seen an 18% increase in passenger numbers[9]. The GBBN programme contains a mix of conventional bus priority measures and bus stop improvements. In comparison to the new infrastructure delivered for Cambridgeshire and Kent Fastrack it is relatively low key. Nevertheless it demonstrates that a patronage increase can be achieved without delivering largely segregated alignments; and
- Elsewhere in the UK, where specific routes have been upgraded with new vehicles and leather seating, along with distinctive liveries and a targeted marketing campaign, 15-20% increases in passenger numbers have been observed[10].

Given the evidence available, it is reasonable to assume that passenger number increases within the range 15-33% are possible where clear improvements are made to service quality. Therefore, instead of a maximum potential of approximately 1200 trips from the growth areas along any of the proposed core alignments (Table 3-4), it might be reasonable to assume that this could be increased to somewhere in the region of 1400-1600 public transport trips over 12 hours (Table 3-5). The percentage uplifts which are applied in appraising scheme options varies according to the level of journey time saving being offered by the infrastructure measures proposed.

As with the passenger numbers presented earlier in this section, forecast trips in Table 3-5 are additional to the trips that currently take place on bus services in the Didcot-Harwell corridor. Background bus patronage therefore needs to be added to these figures in order to estimate total passenger flows.

[7] Taken from evidence presented in *Brett A. & Menzies B, Cambridgeshire Guided Busway – Analysis of Usage, 24 April 2013 paper for Proceedings of the Institution of Civil Engineers* and *Cambridgeshire Guided Busway: Post-Opening User Research, Atkins for Cambridgeshire County Council, September 2012.*

[8] Estimated from statistics provided on modal shift in *The One Billion Challenge, Greener Journeys, 2010.*

[9] *Greater Bristol Bus Network Monitoring Report, CH2M Hill for The West of England, June 2014.*

[10] Examples reported in *Shires J & Wardman N, Demand Impacts of Bus Quality Improvements, 2009 paper for Association for European Transport.* For Route 36 Ripon-Leeds, further information obtained from Transdev – press release *Route 36 – Ideas in Action, 3 October 2011.*

Table 3-5 Forecast public transport trips following service upgrade

Trip type	Public transport trips (12hr), by alignment				
	A	B	C	D	E
Forecast new trips to/from main growth areas, assuming conventional bus service (totals from Table 3-4)	1197	1236	1236	1159	1015
Additional trips to/from main growth areas resulting from service upgrade (maximum 33% increase)	395	408	408	382	335
Totals:	**1592**	**1644**	**1644**	**1541**	**1349**

3.4. Demand Segments

This section has made the distinction between three demand segments; existing bus passengers in the Didcot-Harwell corridor; new passengers to/from the main growth areas who would be likely to use a conventional bus service anyway; and new bus passengers who would be attracted to use the bus if high quality improvements are made to improve the passenger experience.

Given the existence of these three distinct demand segments, the economic appraisal presented in Section 6 also makes this distinction in relation to who receives a benefit. The following benefit types are therefore assumed:

- Existing bus passengers are likely to gain a time saving benefit from any improvements made, when compared to the journey time that would otherwise be experienced on the conventional bus services once housing and employment growth in the Didcot-Harwell corridor starts to be delivered;
- New passengers making trips to/from the main growth areas will also gain a time saving benefit from any improvements made, when compared to the journey time they would otherwise experience on the conventional bus services; and
- New passengers who might otherwise have travelled by private car (the 15%-33% increase identified earlier in this section) might gain a time saving when compared to the journey time they would have experienced when driving in congested traffic conditions. A further wider benefit might also arise from this demand segment, with the potential marginal external decongestion and environmental benefits of reduced car trips on the highway network.

4. Infrastructure Needs Assessment

4.1. Current Infrastructure Needs

This section assesses the infrastructure needs for the initial core alignment options, using information on traffic congestion hotspots. For current needs, information on junction volume to capacity ratios, and junction and link delay, has been obtained from the Oxfordshire Strategic Model (OSM) 2013 base year scenario.

The following specific locations have been identified as experiencing unreliable journey times, and therefore requiring priority measures should public transport be routed through these locations. Alternatively, and if feasible, these locations could be avoided by public transport services:

i. A4130/B4493 between the Milton Interchange and Didcot town centre. This single-carriageway road connects Didcot with the A34 trunk road and suffers from congestion particularly during the morning and evening peak periods, in both directions;
ii. A4130 Abingdon Road approaching the Steventon lights (junction with the B4017 High Street), in both directions. Measures would only be required here if Alignment E were to be selected;
iii. A417 Reading Road and A417 Wantage Road, eastbound and westbound approaching Rowstock Roundabout (A417/A4130/A4185); and
iv. A4185 Newbury Road, northbound approaching Rowstock Roundabout.

Improvements are already proposed as part of the Science Vale Highway Improvements Plan to address local congestion issues at Milton Interchange (A34/A4130), Steventon lights, and Rowstock Roundabout. However, these are focused on improving conditions for all vehicles and therefore do not currently include proposals to afford additional priority for public transport.

4.2. Future Infrastructure Needs

The information in this section is based on discussions with officers from OCC and VoWHC at the study inception meeting on 8th July 2014. Current opinion suggests that public transport priority infrastructure measures will need to be implemented at the locations listed in section 4.1, even with the measures undertaken through the Science Vale Highway Improvements Plan. The following additional locations are also expected to experience regular traffic congestion in future years, as residential and employment growth takes place across Science Vale:

v. Hagbourne Hill, northbound approaching the A417 London Road, and southbound approaching the Chilton Interchange (A34/A4185);
vi. A4185 Newbury Road, southbound from the Harwell Campus to the Chilton Interchange, and the bridge across the A34 at the Chilton Interchange;
vii. The road network within and surrounding Didcot town centre and Didcot Parkway station; and
viii. Exit roads from the Harwell Campus (Harwell Oxford Enterprise Zone), which are likely to be at their most congested during the evening peak period.

In order to ensure a reliable core public transport service on the Didcot-Harwell corridor, it will be necessary to mitigate the current and forecast traffic congestion issues. This could be achieved either by providing priority measures at the congested locations, or by avoiding the congested locations. The measures proposed in Section 5 seek to provide public transport priority through or around the congested locations.

Significant improvements to the passenger waiting environment are also required, particularly at the Harwell Campus. This will ensure that the overall passenger experience is improved. Further detail is provided in Section 5.

5. Engineering and Operational Feasibility

5.1. Overview

This section provides outline proposals for packages of measures along each of the core alignments, along with indicative cost estimates. High and medium investment packages are presented. Lower levels of investment are not presented, as these are far less likely to provide the mode shift from private car which is required by the transport objectives established in Section 2 (Figure 2-1).

The cost estimates cover infrastructure implementation costs, as well as ongoing maintenance liabilities for any new infrastructure. Bus service operating costs are not provided as these will vary depending on how commercial bus operators decide to amend or recast their networks. The working assumption for this study is that bus services would be provided on a commercial basis along the core corridor, with passenger revenues meeting service operating costs. On this basis, neither public sector subsidies nor large private sector profits are included in the economic appraisal in Section 6.

5.2. Potential Infrastructure Measures

Table 5-1 shows the range of potential measures, with the locations shown in Figure 5-1. The core alignment selected and level of investment to be made determines which of these infrastructure measures are packaged together, as shown in Table 5-2.

Infrastructure costs have been estimated on a rate per kilometre basis for construction, including traffic management and preliminaries, site clearance, drainage, carriageway construction, lining and signing, ducting and lighting relocation. The costs presented also include allowances for design preparation, site supervision and a 30% risk budget. Where appropriate, allowances for traffic signal installation, utility diversions, and land purchase are also included. **These are indicative costs (not based on bills of quantities) which will need to be subject to further work should any decision be made to proceed with any of the measures.**

Maintenance costs over the full appraisal period (60 years) have been calculated on a percentage basis and cover periodic asset refurbishment and replacement, as well as general ongoing maintenance work.

Estimated maximum journey time savings for bus passengers resulting from each infrastructure measure are also presented in Table 5-1. Time savings are estimates only, compared to a ‘without intervention’ scenario in which bus services between Didcot and Harwell continue to operate with general traffic even after considerable housing and employment growth has been delivered. In this ‘without intervention’ scenario bus services would be expected to experience delays from greatly increased traffic congestion.

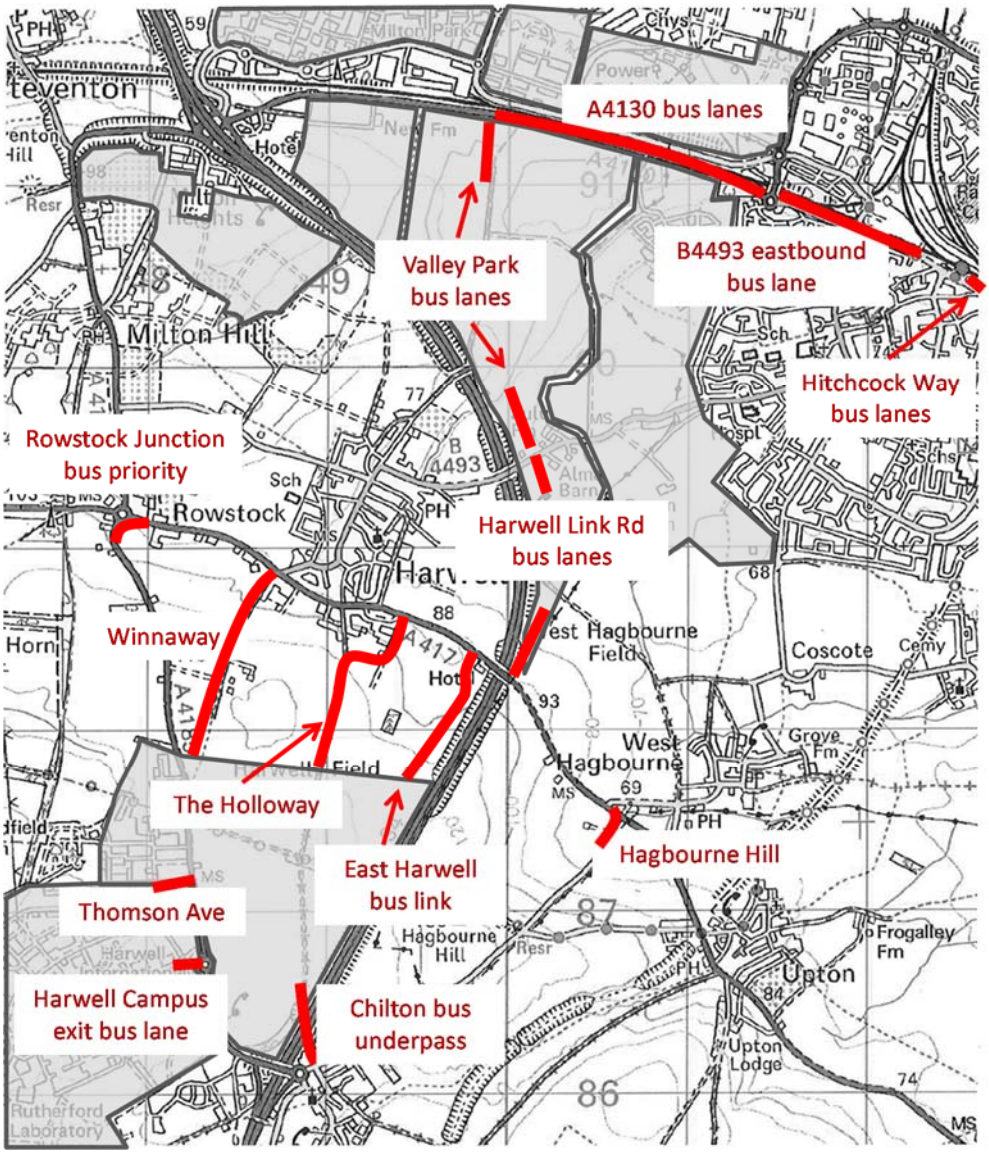
Table 5-1 Potential Infrastructure Measures

Problem Location (from section 4)	Measure	Description	Anticipated cost (2014 prices) incl land, prep, site supervision, risk	Allowance for maintenance over 60 years (2014 prices)	Expected User Benefits (maximum peak period time saving)
i	A4130 bus lanes – both directions	Additional eastbound and westbound bus lanes between Valley Park and Mendip Heights. A4130 widened by two lanes.	£3.4 million	£0.65 million	5 minutes
i	A4130 bus lanes – alternating (lower cost option)	Additional bus lanes provided, A4130 widened by one lane only with bus lane alternating sides to provide priority approaching junctions.	£1.8 million	£0.35 million	3 minutes
i	B4493 eastbound bus lane	Additional eastbound bus lane between Mendip Heights and All Saints Court (Station Road), terminated by signalised bus gate in advance of the substation pinch-point.	£0.8 million	£0.1 million	1 minute*
i / vii	Hitchcock Way eastbound bus lane	Eastbound bus lane between Cow Lane and Jubilee Way Roundabout, achieved through a combination of road widening and footway narrowing	£0.8 million	£0.15 million	1 minute*
i / vii	Hitchcock Way westbound bus lane	Westbound bus lane between High Street and Cow Lane achieved through road widening	£0.5 million	£0.1 million	1 minute*
iii / iv	Rowstock Junction bus priority	Assuming that the multi-stream south-east junction bypass is delivered as part of the Science Vale Highway Improvements Plan, amend design to provide one general traffic lane and one bus lane in each direction on the bypass.	£0.02 million	£0.03 million	1 minute
iii / iv	Winnaway sustainable transport corridor	Two-way bus link (1.2km) alongside new cycle path, connecting the A4185 / East Harwell Campus to the A417 at Harwell, avoiding Rowstock junction. Signalised junctions with selective vehicle detection at either end of bus link. Land purchase likely to be required.	£3.0 million	£0.4 million	3 minutes
iii / iv	The Holloway bus link	Two-way bus link (1.4km) connecting East Harwell Campus to the A417 at Harwell, avoiding Rowstock junction. Route via the central part of The Holloway and then along alignment of current field track to east of residential area. Signalised junction with selective vehicle detection at A417. Land purchase likely to be required.	£3.6 million	£0.9 million	3 minutes
v / vi	East Harwell bus link	Two-way bus link (1.3km) connecting East Harwell Campus to the A417 east of Harwell, running immediately to the west of the A34. Signalised junction with selective vehicle detection at A417. Land purchase required.	£3.3 million	£0.4 million	4 minutes
v	Hagbourne Hill northbound bus lane	Assuming the proposed roundabout is delivered through the Science Vale Highway Improvements Plan, amend design to include additional northbound bus lane and left bus-only filter lane onto A417.	£0.3 million	£0.075 million	1 minute*

Problem Location (from section 4)	**Measure**	**Description**	**Anticipated cost (2014 prices) incl land, prep, site supervision, risk**	**Allowance for maintenance over 60 years (2014 prices)**	**Expected User Benefits (maximum peak period time saving)**
vi	Chilton bus underpass	Further investigation required. Potential to reconstruct roadway through the underpass to allow single-deck buses to travel between Hagbourne Hill and the East Harwell Campus avoiding the Chilton Interchange. Would require signals for shuttle working.	Assume £1 million, but further investigation required	Assume £0.2 million	3 minutes
viii	Harwell Campus exit bus lane	Additional bus lane on the exit road to the A4185, achieved by road widening.	£1.1 million	£0.25 million	1.5 minutes*
viii	Harwell Campus Thomson Avenue bus only access	Converting the Thomson Avenue link between the expanded Harwell Campus and the A4185 to bus only in both directions. Signalised junction with selective vehicle detection at A4185.	£0.15 million	£0.025 million	1.5 minutes*
	Harwell Link Road bus lanes	Additional bus lanes approaching the two main junctions (southbound to the A417 and northbound to the B4493) along Section 1 of the proposed link road.	£0.4 million	£0.15 million	0.5 minutes
	Valley Park bus lanes	Additional bus lanes approaching the junctions at either end of the link road through the Valley Park development (northbound to the A4130 and southbound to the B4493).	£0.4 million	£0.15 million	1 minute
	New high specification bus stops	New 'light rail style' stop facilities along the corridor, where practical. Stops will include raised platforms for level boarding (where highway space permits), shelters with seating, real time information screens, lighting and CCTV.	£0.4 million (for corridor)	£0.4 million	No time saving, relates to service quality
	New medium specification bus stops	Enhanced bus stop facilities along the corridor. Stops will include new shelters with seating, real time information screens and lighting.	£0.2 million (for corridors)	£0.2 million	No time saving, relates to service quality

* indicates that this estimated time saving will only be achieved for passengers travelling in one direction.

Figure 5-1 Locations of potential infrastructure measures



5.3. Infrastructure Packages by Alignment

Table 5-2 demonstrates proposals for how the individual measures could be packaged together to form a core corridor, with total costs presented for high and medium levels of investment. In general terms, high investment packages will provide for the greatest journey time savings for passengers and a more noticeable improvement in service provision. These can be viewed as much more ambitious packages. Medium investment packages focus on on-line improvements, largely avoiding new bus only link roads unless there is no reasonable alternative (for example with Alignment B).

The medium investment packages have been subject to an iterative process to improve their value for money. This has involved removing the most costly elements as well as those elements that are comparatively costly given the anticipated benefits.

The indicative costs shown in Table 5-2 (in 2014 prices) have subsequently been adjusted in order to calculate the BCR estimates. Further explanation is provided in Section 6.

Table 5-2 Potential infrastructure packages by alignment

Alignment	A		B		C		D	
Measure	**High**	**Med**	**High**	**Med**	**High**	**Med**	**High**	**Med**
A4130 bus lanes – both directions	✓	-	✓	-	✓	-	✓	-
A4130 bus lanes – alternating (lower cost option)	-	✓	-	✓	-	✓	-	✓
B4493 eastbound bus lane	✓	✓	✓	✓	✓	✓	✓	✓
Hitchcock Way eastbound bus lane	✓	-	✓	-	✓	-	✓	-
Hitchcock Way westbound bus lane	✓	-	✓	-	✓	-	✓	-
Rowstock Junction bus priority	N/A	N/A	N/A	N/A	-	✓	-	✓
Winnaway sustainable transport corridor	N/A	N/A	N/A	N/A	N/A	N/A	✓	-
The Holloway bus link	N/A	N/A	N/A	N/A	✓	-	N/A	N/A
East Harwell bus link	N/A	N/A	✓	✓	N/A	N/A	N/A	N/A
Hagbourne Hill northbound bus lane	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A
Chilton bus underpass	✓	-	N/A	N/A	N/A	N/A	N/A	N/A
Harwell Campus exit bus lane	✓	-	✓	-	✓	-	✓	-
Harwell Campus Thomson Avenue bus only access	-	✓	-	✓	-	✓	-	✓
Harwell Link Road bus lanes	✓	-	✓	-	✓	-	N/A	N/A
Valley Park bus lanes	✓	✓	✓	✓	✓	✓	✓	✓
New high specification bus stops	✓	-	✓	-	✓	-	✓	-
New medium specification bus stops	-	✓	-	✓	-	✓	-	✓
Indicative cost £ million (2014 prices)	**£9.1m**	**£3.7m**	**£11.1m**	**£6.7m**	**£11.4m**	**£3.4m**	**£10.4m**	**£3.4m**
Maintenance allowance for 60 year appraisal period £ million (2014 prices)	£2.2m	£0.9m	£2.4m	£1.2m	£2.9m	£0.9m	£2.2m	£0.9m
Anticipated maximum peak period time saving under congested highway conditions	12 mins	6 mins	13 mins	9 mins	12 mins	6 mins	11 mins	6 mins

6. Indicative Benefits and Costs Assessment

6.1. Appraisal Method

This section sets out an indicative Benefit to Cost Ratio (BCR) for each potential infrastructure package, using a conventional approach to assessing transport economic benefits that is focused primarily on journey time savings. The BCR estimates give an indication of the value for money (in economic terms) of each package, over a 60-year appraisal period, by comparing the Present Value of Benefits (PVB) with the Present Value of Costs (PVC).

Other considerations, such as the social benefits and the wider environmental impacts, would need to be considered separately but are outside the scope of this study. Nevertheless, the BCR provides a good indication as to whether it is likely to be worthwhile progressing with a scheme. Recommendations for progressing a package of measures on the Didcot-Harwell corridor are made at the end of this section, in light of the BCR estimates.

The following key benefits have been monetised and incorporated into the BCR estimates, using standard economic parameters from WebTAG[11].

- Journey time savings for public transport users, compared to a conventional bus service travelling with general traffic, or compared to a journey being made by private car; and
- Estimated marginal decongestion and environmental benefits as a result of private car users switching to public transport.

Monetised benefits are then offset by the following costs:

- Infrastructure implementation costs, including design fees and other preparatory costs, land purchase, site supervision, and a quantified risk budget; and
- Ongoing maintenance and renewal costs over the full appraisal period.

In order to calculate the BCR, a number of adjustments are made to costs and benefits in line with the methods set out in WebTAG:

- Optimism Bias is applied to the costs to take account of the systematic tendency of scheme promoters to underestimate costs. A value of 44% has been applied to all implementation costs including the risk budget;
- Costs and benefits are factored to a common 2010 price base, which is currently the Department for Transport's preferred appraisal base year; and
- Costs and benefits are then also discounted back to 2010, using the HM Treasury recommended discounting procedure. This procedure reduces the importance of costs and benefits that are forecast for the later years of the appraisal period within the BCR calculation.

Due to the adjustments made to the costs, the PVC must not be confused with the scheme implementation and maintenance costs in current prices.

6.2. Appraisal Assumptions

A number of assumptions have been made in order to estimate the BCRs, as set out in Table 6-1. These assumptions would need to be investigated further and refined as necessary for any scheme that is progressed to the business case development stage:

[11] WebTAG is the Department for Transport's online transport appraisal guidance.

Table 6-1 Key appraisal assumptions

Parameter	Assumptions
Implementation and opening years	The core public transport corridor is upgraded and in operation by 2021, with construction starting two years before in 2019. Benefits will accrue from 2021 onwards.
Benefit annualisation	Benefits will be accrued in full on working weekdays (Mondays – Fridays) excluding bank holidays. Benefits will be reduced on Saturdays, with no benefits assumed for Sundays.
Different benefit levels for trips	Only 10% of public transport trips within the corridor would receive the full set of benefits from each package, with other trips receiving lower benefit levels. This is to account for trips that take place on only a short section of the corridor, or because they take place at times of day when there are little or no delays to general traffic.
Trip purpose proportions	Standard proportions for business, commuting and other trips have been taken from WebTAG. This assumption affects values of time.
Trip distances for car trips transferring to public transport	Average trip distance of 9km assumed; the distance between Valley Park and Harwell Campus via the A34 and Chilton Interchange. This assumption affects the marginal external benefits calculations.
Benefits to existing bus passengers	A basic figure has been obtained from a local bus operator, although further detail will be required for any scheme that is progressed to the business case development stage.
Cost inflation	In line with general UK background inflation, no real terms cost increases.
Bus service viability	Assumed that the bus service will be operated on a commercial basis, with no subsidy provided by the public sector.
Complementary highway measures	The Science Vale Highway Improvements Plan will be delivered as a separate set of measures, with public transport improvements adjusting those highway measures if required. The cost of Highway Improvements Plan measures are therefore not incorporated in the BCR estimates.

6.3. Indicative BCRs

For each package of measures, an indicative PVB, PVC and BCR is presented in Table 6-2.

Table 6-2 Indicative BCRs

Alignment & Package	Present Value of Benefits (PVB) estimate	Present Value of Costs (PVC) estimate	Indicative Benefit to Cost Ratio (BCR)	Current value for money category
A – High cost	£12.6 m	£11.0 m	1.1	Low
A – Medium cost	**£6.4 m**	**£4.4 m**	**1.5**	**Medium**
B – High cost	£13.3 m	£13.3 m	1.0	Low
B – Medium cost	£9.7 m	£7.9 m	1.2	Low
C – High cost	£12.5 m	£13.8 m	0.9	Poor
C – Medium cost	**£7.0 m**	**£4.1 m**	**1.7**	**Medium**
D – High cost	£11.4 m	£12.5 m	0.9	Poor
D – Medium cost	**£6.6 m**	**£4.1 m**	**1.6**	**Medium**

All costs are in 2010 prices, discounted to 2010.

Estimated BCRs for the high cost investment packages are consistently lower than for the medium level investment packages. This is because the additional costs involved are not likely to be offset by the additional benefits gained. BCRs for the high cost packages are all estimated to be close to 1.0, representing poor or low value for money. In contrast, the medium investment packages are currently estimated to have

BCRs between 1.2 and 1.7. Department for Transport advice is that BCRs of between 1.5 and 2.0 generally represent 'medium' value for money, while anything greater than 2.0 can be considered to represent 'high' value for money.

Notwithstanding the limitations of this study and the assumptions made, the most favourable solutions, in pure BCR terms, are the medium investment packages for alignment C (estimated BCR of 1.7), alignment D (estimated BCR of 1.6), and alignment A (estimated BCR of 1.5). **All three of these solutions appear to offer 'medium' value for money and could therefore form the starting point for further development work on the Didcot-Harwell corridor.**

The lowest performing packages are for alignment B as this would require a new offline bus only link to be constructed between the East Harwell Campus and the A417. In some respects, alignment A is the most suitable reduced cost alternative for alignment B anyway.

In considering whether or not a strong economic case can be developed for a package of measures on the Didcot-Harwell corridor, it is worth noting that **potential exists to improve the BCR**. An improved BCR might be achieved by obtaining more detailed information on existing bus flows in the area, in order to identify passengers on other bus services who would benefit from some of the proposed measures. Furthermore, more detailed considerations of the bus service reliability benefits for private sector operators, as well as any benefits that passengers might receive from increased service frequencies (and therefore reduced waiting times) could also be factored into future assessments.

If a more segregated bus priority corridor is desired to suit strategic policy aims, then efforts will almost certainly need to be focused on maximising passenger numbers. This might be achieved through influencing growth area designs to safeguard public transport alignments and to **deliver development layouts and densities that favour public transport use**.

6.4. Sensitivity Tests

The BCRs presented in Table 6-2 are based on the best available information at the time of preparing this report. They are also underpinned by a number of assumptions, as documented in Table 6-1. For these reasons, the BCRs have been re-estimated using passenger forecasts that are up to 100% higher and 50% lower than those used throughout this report.

The following key points have been identified through the sensitivity tests:

- If passenger numbers are 30% higher than forecast in this report then BCRs greater than 2.0 become much more achievable. For example, alignment C medium cost package would have a forecast BCR of 2.2, while alignment D medium cost package would have a forecast BCR of 2.1;
- If passenger numbers are double those forecast in this report (exceeding 3000 trips per day to/from the new growth areas) then BCRs greater than 3.0 will become more achievable. At this point the high investment packages (£10-11million) with bus-only links become more viable options with some BCRs greater than 2.0, representing high value for money. For example alignment A high cost package would then have a forecast BCR of 2.2; and
- If passenger numbers are 20% lower than forecast in this report then even the lower investment packages start to struggle to reach medium value for money. A maximum BCR of 1.4 is forecast under this scenario.

7. Conclusions and Recommendations

The Didcot-Harwell Public Transport Study has:

- Examined potential public transport options for addressing the future needs of the Didcot-Harwell area, with an emphasis on developing the 'Science Transit' core public transport route concept. This has involved identifying and appraising potential packages of measures on different alignments through the area;
- Investigated whether any of the public transport options could be developed into a favourable business case, in strategic and economic terms;
- Identified what the headline conclusions might be for the strategic and economic elements of the business case. The remainder of this section draws these conclusions together; and
- Made a recommendation as to which options might be worth pursuing further.

The study has demonstrated that potential exists to develop a business case for a modest (medium level) investment in a package of bus priority measures on the Didcot-Harwell bus corridor.

Strategic Case

The Science Vale area, and in particular the Didcot-Harwell corridor, is expected to suffer from increased traffic congestion, increasingly unreliable on-road public transport services, and increased journey times as housing and employment growth is delivered. Furthermore, the majority of the growth areas will be beyond a reasonable walking distance from Didcot town centre and the rail station.

In order to deal with the forecast transport problems, the number of trips made by private car will need to be reduced by delivering attractive public transport alternatives which ensure that residents are still able to access employment opportunities. Similarly locally-based businesses need to be able to access the labour market and their customers.

The transport solution for the Didcot-Harwell corridor must therefore provide for a reliable alternative to the private car, encourage mode shift on the corridor by connecting multiple trip generators and attractors and by connecting residential and employment growth areas. The solution will also need to be capable of evolving over time, allowing for extensions or alternative routes if this becomes necessary in the future. **A bus-based solution, focused on providing bus priority measures and improved passenger facilities is therefore considered to be appropriate**.

Economic Case

Delivering bus priority measures on the Didcot-Harwell Corridor is likely to provide 'medium' value for money, with BCRs achievable within the 1.5 to 2.0 range. This is on the assumption that the Science Vale Highway Improvements Plan is delivered as a separate programme of works in advance or alongside the public transport works.

Medium value for money looks to be most achievable for a scheme with an initial investment package of approximately £3.5 million (2014 prices), with on-going maintenance of new assets over the full appraisal period also factored in as an additional cost. This sort of level of investment is likely to give the right balance between user benefits and costs on the corridor.

It is likely to be challenging to deliver a more ambitious package of measures, such as a segregated bus priority corridor, which at the same time is also able to deliver high value for money (indicated by a BCR greater than 2.0). Nevertheless there are circumstances when this could occur.

If a more segregated bus priority corridor is desired then efforts will almost certainly need to be focused on maximising passenger numbers. Further patronage growth could potentially be achieved through influencing growth area designs to safeguard public transport alignments and to deliver development layouts and densities that favour public transport use.

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