111207 Assessment of Landscape Impacts for High Speed 2.

NOTE: This analysis of landscape impacts for HS2 was undertaken upon the route consulted upon in 2011. However, the Secretary of State subsequently made a small number of amendments to the line of route in 2011, and then in January 2012 announced addition mitigation with the inclusion of additional tunnelling particularly around the Chilterns Area of Outstanding Natural Beauty. These changes are likely to lower the landscape impact of HS2. Therefore, in respect of the subsequent route changes, this analysis provides a conservative upper end estimate of landscape impacts.

Introduction.

DfT WebTAG guidance outlines the Department's approach to appraising landscape impacts associated with transport schemes. The assessment forms part of the Value for Money assessment. The Guidance advises that the current methodology for appraising landscape in quantitative terms is not sufficiently robust to be included within the Department's core Benefit Cost Ratio (BCR) (see Webtag unit 3.5.4). Webtag unit 3.3.7 advises that landscape impacts are assessed qualitatively using a 7-point-scale (ranging from strongly adverse to strongly beneficial) whereby the scheme is assessed against a set of qualitative criteria.

However, where a scheme is judged to have a significant impact on landscape and therefore on the economic case of the scheme, a quantitative analysis of landscape is to be undertaken to provide an indication of the magnitude of landscape impact. The Landscape valuation can be incorporated into the Core BCR to assess whether the BCR is sensitive to the inclusion of this analysis. The quantitative assessment of landscape impacts is based upon the methodology outlined by the Department for Communities and Local Government[1] (DCLG) in the document "Valuing the external benefits of undeveloped land: main document". This quantitative analysis is summarised within this document. However, it should be noted at the outset that the quantitative analysis is most frequently applied to Highways schemes which are on a much smaller scale than the HS2 scheme.

Up until recently, the quantitative analysis of landscape impacts involves using a pencil and ruler on an Ordinance Survey map, and outlining different land types around the scheme route. This is a crude method of measuring landscape. The landscape analysis for the High Speed 2 (HS2) uses a different **application** of the (same) methodology that has previously been applied to Highways schemes. In particular, the HS2 analysis represents a first attempt to partially automate the methodology with the use of GIS mapping software.

The objective of this paper is to summarise the DCLG methodology, outline the historic application of the analysis, and outline how the analysis has been applied for HS2. The paper also provides the results of the analysis with sensitivity analysis. Finally, discussion is provided on the pros and cons of adopting a partially automated GIS mapping approach.

[1] Formerly Office of the Deputy Prime Minister

The rest of this paper is structured as follows:

- Methodological Approach for Analysing Landscape Impacts.
- Historical Application of Methodology.
- Application of Methodology for HS2.
- DCLG Methodology results
- 'Central' Scenario results
- Comparison with previous HS2 Ltd results
- Caveats and limitations.
- Pros and Cons of GIS approach.
- Conclusion.

Methodological Approach for Analysing Landscape Impacts.

The Department has adopted the methodological approach as outlined in the DCLG document entitled: "Valuing the external benefits of undeveloped land: main document".

The methodology requires mapping the proposed route (road or rail line – henceforth 'rail line') on Ordinance Survey maps with the analyst defining where along the route the proposal is on-line (widening an existing line along a corridor) or off-line (creating a new line). The next stage is to outline the 'footprint' of the route which is defined as the 500-meter buffer (loci) around the rail line.

The scheme footprint is then partitioned into one of seven different land types as defined in the DCLG report (and outlined below). The land type polygons must tessellate, that is to say their must be no gaps or overlaps between different land type polygons within the scheme footprint.

The next stage is to assess whether there are any mitigating factors[2] within the footprint of the scheme, this may result either because the local landscape is already degraded (to capture multiple mitigation factors, for HS2 these factors were entitled 'in footprint' mitigation), or the scheme design specifically incorporates mitigating infrastructure (entitled 'at line' mitigation). A full list of mitigation factors is provided below. 'In footprint' mitigating includes passing through a built up area or current road, and 'on line' mitigation may include tunnelling, cutting, retained walls. As mentioned above it is important to distinguish whether the scheme is on-line of off-line. If a scheme is on-line (ie. road widening) then the scheme is highly mitigated because the current line has already degraded the landscape to a large extent.

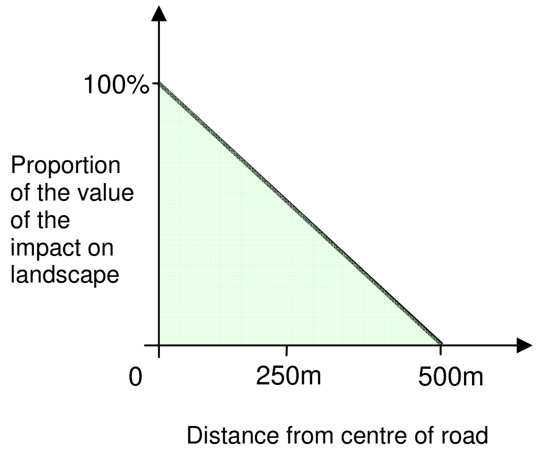
The methodology entails scoring each area within the footprint a mitigation factor alpha 'α' between 1 and 0 (inclusive) which reflects the extent of landscape mitigation. Therefore the value '1-α' reflects the factor by which areas of land type must be multiplied by to account for mitigation, this is the 'mitigation adjusted landscape factor'. Where an area is mitigated both 'at line' and 'in footprint', the 'mitigation adjusted landscape factor' is the product of the 2 factors resulting from as outlined below:

[2] There is limited guidance in the DCLG paper informing how to apply mitigation, therefore it is appropriate to provide broad sensitivity analysis to capture feasible alternative mitigation levels.

$1\text{-}\alpha_{\text{(land type)}} = [1\text{-}\alpha_{\text{(at line)}}] * [1\text{-}\alpha_{\text{(in footprint)}}]$

The landscape is valued at a diminishing rate the further away within the 500 meter buffer the land is from the line of route. At the location of the route line the value of landscape degradation is 100%, this decreases in a linear fashion to the location 500 meters away from the line where the degradation to landscape becomes equal to 0%. This is illustrated below which shows the declining value of landscape impacts the further away from the line (note, the illustration only reflects one side of the proposed scheme).

Figure 1



The equation below outlines the method of calculating landscape damage (in decimal form). This assumes a linear road/rail line where the landscape either side is 'homogonous' (ie the land to the west and east of the line is constant and equal on both sides.) and mitigation is also constant either side of the line.

$[(500 - D) / 500] = 1 – (D / 500)$

Here 'D' defines the distance (in meters) away from the line of route. The assumptions of the 500 meter cut-off point, and the linearity of the decline distance function reflect best-practice within the DCLG guidance. It could be argues that employing a greater cut-off distance would enable the analyst to capture a greater footprint, and therefore capture landscape impacts on a greater land area. It could be argues that a smaller footprint should be used. Further, it could be argued that the effect of distance is non-linear, and that an exponential (decay) function more accurately reflects the affect of distance. A decaying function (where weight placed on land declines at a declining rate with distance) may emphasis even higher weight that people place on land within the close vicinity of the route, than further away.

The equation below outlines how adjustments for mitigation and distance come together to derive the final landscape value for the proposed scheme;

$V_{s,i} (£) = length_s * value_i * (1- \alpha_s) * 50$

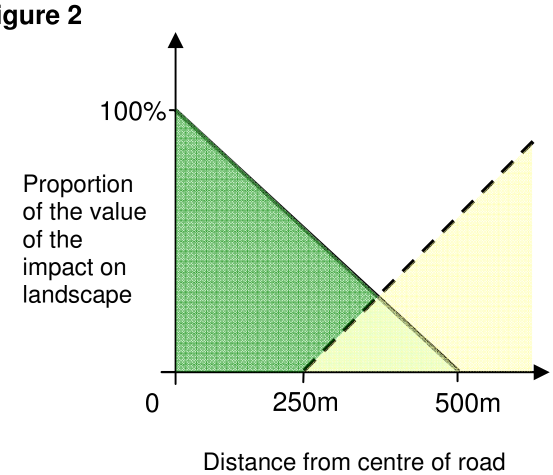
Where:

- $V_{s,i}$ reflects total landscape value (per hectare),
- **length$_s$ (KM)** reflects the length of the scheme,
- **value$_i$ (£/ha)** reflects the value of the land type, and
- **(1- α_s)** reflects the impact of mitigation
- **50(ha/KM)** reflects the 50 hectares valued per KM (accounting for distance from the line).

The value of 50 in the final bullet-point is explained in this paragraph. A Hectare (ha) is an area 100m by 100m (or $100m^2$). For a 1 km linear stretch of road/rail line, the foot print will stretch 500m in each direction giving a total buffer width of 1km. Therefore the buffer is a 1km by 1km square, which is equivalent to 100 hectares of land, of which 50 hectares are located each side of the line. On the basis that landscape is assessed in a linear diminishing fashion (with respect to distance) from a weight of 100% at the line, to 0% 500m away, this means that for each side of the line only half the landscape is values which equates to 25 ha each side of the line, or a total of 50 for both sides of the line.

A problem arises when assessing the extent of mitigation resulting from other roads, rail lines or built up areas which impact upon the footprint. For example if a road is already located 750 meters away from the new road, the footprint of the old road encroaches on the footprint of the new road as illustrated below. In principle, this should be captured as reflecting 12.5% (one-eight) mitigation which is equal to the proportion of the dark green triangle covered by the yellow triangle. However, the section below outlines the practical limitations in perfectly applying mitigation in this fashion, and summarises how mitigation has been applied for the HS2 scheme.

Figure 2



Further, when the land is not homogenous (ie the land type changes across the 500 meter span of the footprint) the land closer to the line should be weight more highly than land further away as outlined by the declining weight function. For example, if land type ‘A’ is within 250m of the line, and land type ‘B’ is between 250m and 500m away, then ‘A’ should be weighed at 75% and B weight at 25%, this reflects the proportional area below the curve.

The values of the different land types are outlined in the table below which is extracted directly from the original DCLG report. A major limitation of the analysis is that these land types have not been explicitly defined against objective criteria (such as population density). This necessitates subjective judgement on part of the analyst as to which land areas on a map constitutes the land type classifications. This process can be aided with the use of aerial photography and following using making partial use of definitions within the ordinance survey map key; however the analysis should include sensitivity analysis to account for uncertainty around these judgements.

Table 1: DDCLG summary table – land types and non-market benefits

Land type	£ /ha /yr (2001)	Present value	
		r = 3.5% p=3%	6% p=3%
Urban Core Public space (City park)	£54,000	£10,800,000	£1,800,000
Urban Fringe ('greenbelt')	£889	£177,800	£29,600
Urban Fringe forested land	£2,700	£540,000	£90,000
Rural forested land (amenity)	£6,626	£1,325,200	£220,800
Agricultural land (extensive)	£3,150	£630,000	£105,000
Agricultural land (intensive)	£103	£20,600	£3,400
Natural and semi-natural land (Wetlands)	£6,616	£1,323,200	£220,500

Historical Application of Methodology.

The classification of land types and the estimation of mitigation necessarily require a subjective judgement. This has historically been undertaken with the use of Ordinance Survey mapping. The analysis has previously been undertaken by producing a 500 meter buffer around the proposed scheme on a paper Ordinance Survey map which with the use of a ruler and pencil. This is inaccurate as this approach does not easily allow for the fact that the HS2 route is not linear (i.e. it bends), and it is difficult to fully capture the effect of distance of the land from the line of route with a ruler.

The land types were marked out (partitioned) on the paper Ordinance Survey maps with any mitigating factors (on-line widening, tunnelling, cutting) outlined on the map to permit mitigation weighting. Where the line was not homogenous, a crude estimate of the distance of each land type was outlined on the map to permit distance weighting. The data on land area, land type, mitigation and distance were aggregated and incorporated into a spreadsheet and the analysis of the central scenario was undertaken with sensitivity analysis.

Application of Methodology for HS2.

The analysis for the HS2 used ArcGIS software. Within ArcGIS layers were loaded for the route (provided by HS2 Ltd), Raster Ordinance Survey mapping and aerial photography. The 500 meter buffer (loci) was generated around the route. The route was disaggregated into 525 separate sections to reflect changes in the combinations of west side / east side mitigation along the route including the following ten attributes:

- At grade
- Cut
- Fill
- Green tunnel
- Land bridge
- On line widening
- Partially retained cut
- Retained
- Tunnel
- Viaduct

These assumption definitions are crude, for example they do not specify the height or depth of the infrastructure.

Mitigation was also highlighted for within the footprint of the scheme where there was mitigation provided by current:

- Built up areas.
- Existing A roads / motorways.
- Existing railway lines.

The 7 land types were manually incorporated into the footprint by outlining polygons into the GIS software where these areas overlay the 7 land types in the Ordinance Survey maps; this process was aided by the use of aerial photographs. The analysis of 'rural forested' and 'Natural and semi-natural land' were assessed using definitions from the Ordinance Survey map keys. However, owing to the limited definition of the different land types a judgement was required for the analyst to define where one land type ends and another begins. This was particularly difficult to distinguish 'Agriculture Intensive' and 'Agriculture Extensive'. For this reason a sensitivity scenario was incorporated into the analysis by adding the classification 'intensive/extensive' where it was not obvious which land type a given area should be classified as – this is outlined in the results and sensitivities section below.

As a more systematic approach to analyse the impact of distance from the line of route the GIS approach included a 250m by 250m grid[3] covering the entire route of

[3] The smaller the grid squares become the more accurate the final analysis. However there is diminishing returns to using smaller grids, while the number of calculations increases at an increasing

the scheme. While each land type was included to reflect the natural shape of the land type areas, all mitigation impacts were incorporated into the grid system. Each grid square was given a mitigation score for mitigation factors associated with either the scheme design (‘at the line’), or factors already within the present scheme footprint (‘footprint’). For mitigation ‘at the line’ all grid squares were mitigated from the line to the buffer, in some cases the mitigation was provided only on either the West or East side of the line. For mitigation in the ‘footprint’ (ie an A road) mitigation was only provided for the grid squared covered by the mitigating factor.

Table 2 below outlines the mitigation factors used for the HS2 scheme. Again, the caveat is that these are based on subjective judgement, and the guidance does not define mitigation factors to use. Sensitivity analysis is provided in the results section of the paper.

Table 2: Mitigation impacts and mitigation factors

Mitigation impact	Mitigation factor (α)
footprint	
Urban area partially degraded	0.5
Urban area degraded	1
A road [or motorway]	0.2
Built up area partially degraded	0.4
Current rail line in place	0.6
At the line	
At grade	0
Cut	0.5
Fill	0
Green tunnel	1
Land bridge	0
On line widening	0
Partially retained cut	0.3
Retained	0.3
Tunnel [long – more than 500m]	1
Tunnel [short – less than 500m]	0.5
viaduct	0

The strict application for the mitigation rule outlined above (ie applying a diminishing mitigation function as outlined in figure 2) is technically problematic to apply in proactive as it requires fully. A close approximation of the methodology was facilitated by highlighting within the footprint which grid squared were covered by the mitigation factors (eg an A road). These grids squares were discounted at the mitigation factor outline above. The distance between the grid centroid and the scheme line captures some of the impact of the interaction of mitigation and distance.

rate as squares become smaller. A decision proportionality based decision was required to determine an appropriate size of grid square.

The sensitivity section below outlines how the sensitive the final results are to changes in assumptions relating to the weight given to different mitigation impacts.

Where a grid square was homogenous (contained a single land type) the distance between the centre of the square and the rail line was calculated to reflect the diminishing value of landscape impact with distance. This reflects the 'D' value outlined above in the distance weighting section of the methodology. The weight given to each grid square (necessarily between 1 and 0 inclusive) to reflect distance was equal to;

$[(500 - D) / 500] = 1 – (D / 500)$

A complication arises where a grid square covers two or more land types. The GIS analysis calculated the "geographic centroid[4]" of the land type area within each grid, and calculated the distance between the centroid point and the line and calculated which was weighted to reflect the proportion for the grid square covered by each land type.

The analysis was transferred to Microsoft Excel outlining with the use of unique ID numbers to reflect the land type(s) within each grid, the distance from the line, and the level of mitigation. This combined with the value of land types outlined in the section above enabled the aggregation of mitigation and distance weighted landscape degradation valuation for the whole HS2 scheme, as well as sensitivity analysis to be undertaken.

DDCLG Methodology results

A 'base' scenario analysis was undertaken based on the strict application of the DCLG guidance. This analysis is based upon the following set of assumptions:

- Impacts valued in 2011 base year prices.
- Landscape impacts assumed to come into effect in year '0' (2011).
- Impacts discounted into perpetuity timeframe.
- Discount rate assumed constant at 3.5%.
- Income uplift rate assumed constant at 3.0%[5].
- Mitigation applied as outline in table 2 above.

However, these assumptions pre-dated HMT Green Book guidance and latest WebTAG guidance. Therefore, DCLG guidance may not be compliant with Green Book guidance primarily because of discounting assumptions:

- Green Book assumes declining discount rate (see table £) where as central analysis from DCLG assumes constant (exponential) discount of 3.5% with an uplift of 3.0% per annum.

[4] The geometric 'balance point'.
[5] DCLG guidance uses 3 scenarios based on a 2.5% annual GDP growth, and multiplication factors derived from income elasticities of 1, 1.2, 1.4. Thus the income uplift values 'p' respectively are 2.5, 3.0, and 3.5, with 3.0 assumed the core figure.

- WebTAG assumes 60 year appraisal for all impacts of capital schemes. DCLG guidance assumes landscape should be assessed into perpetuity as it is argued that landscape is degraded indefinitely.
- Furthermore, the application of mitigation values are not explicitly defined in the DCLG paper, therefore these are based on the judgement of the analyst. The results section.

Table 3 below outlines HMT Greenbook discount rates.

Table 3: Greenbook discount rates						
Period of years	0-30	31-75	76-125	126-200	201-300	301+
Discount rate	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%

For these reasons, the valuation for the 'base' scenario is calculated as outlined above to inform a series of sensitivities to provide an order of magnitude indication of the sensitivity of results to underlying assumptions (all sensitivities 'pivot' off these results). Finally, a 'central' scenario is undertaken which is based upon the most appropriate set of assumptions. The full 'central' scenario assumptions, and rationale for selecting them, are outlined later within this section.

The present value of costs in the 'base' scenario (perpetuity discounting, discount rate 'r' = 3.5%, income uplift 'p' = 0.30%, impacts incurred from year '0' (2011)) is £1.96 billion (£1,955,604,585) assessed in 2001 prices, which equates to £2.56 billion (£2,555,113,623) in 2011 prices using the GDP deflator.

The first sensitivity undertaken relates to uncertainty around defining intensive and extensive agricultural land within the GIS software. Some land was highlighted specifically to reflect uncertainty at classifying this land (in the 'central' scenario this was defined as intensive). This was undertaken to reflect that extensive agriculture is valued 30 times greater than intensive agriculture. In the central scenario this land was all assumed intensive, however, in the sensitivity where this is values as extensive the total costs increase by 10 percent as outlined below in table 4.

Table 4: land classification sensitivity			
Classification	2001 price	2011 price	Ratio to 'base-case'
Intensive	£1,955,604,585	£2,555,113,623	1
Extensive	£2,152,275,926	£2,812,076,419	1.101

A second sensitivity changed the 'effective discount rate' defined as the discount rate minus income uplift (r-p). The figures provided in table 5 in 2001 prices but the ratio relative to the central case is consistent for 2011 prices.

Table 5: effective discount rate sensitivity (2011 prices)		
Scenario	Present value	Ratio to 'base case'
'Central' (r-p=0.5%)	£1,955,604,585	1.000
Central, but with (r-p=1.0%)	£977,802,293	0.500
Central, but with (r-p=1.5%)	£651,868,195	0.333
Central, but with (r-p=2.0%)	£488,901,146	0.250

	£391,120,917	ratio
Central, but with (r-p=0%)	£325,934,098	0.167
Central, but with (r-p=1.0%)	£977,802,293	0.500

The next sensitivity entails applying a 60 year appraisal period as advised by WebTAG for transport schemes (though the assumption of perpetuity for landscape has been validated by WebTAG). These scenarios assume Green Book declining discount rate with varying income uplift (p). The final scenario (p=1.7%) is of particular relevance as this figure has been assumed by HS2 Ltd as art of their analysis.

Table 6: effective discount rate sensitivity (2001 prices)	
r = green book declining p = 0% 60 years	£259,187,382
r = green book declining p = 0.5% 60 years	£285,747,513
r = green book declining p = 1% 60 years	£318,838,241
r = green book declining p = 1.5% 60 years	£358,412,458
r = green book declining p = 2% 60 years	£406,048,439
r = green book declining p = 2.5% 60 years	£463,759,442
r = green book declining p = 3% 60 years	£534,123,973
r = green book declining p = 1.7% 60 years	£376,397,675

The next sensitivity changes the level of mitigation of each individual mitigation factor individually. Again these are in 2001 prices, but the ratio provide indication of order of magnitude of changes and these are relevant for 2011 prices.

Table 7: mitigation sensitivity (2001 prices)					
footprint	Mitigation in central analysis	no mitigation present value	full mitigation present value	no mitigation ratio to base case	full mitigation ratio to base case
Urban area partially degraded	0.5	£2,414,360,688	£1,496,848,482	1.234585307	0.765415
Urban area degraded	1	£6,722,047,841	-	3.437324647	-
A road	0.2	£2,007,808,528	£1,746,788,815	1.026694529	0.893222
Built up area partially degraded	0.4	£2,031,822,510	£1,841,277,698	1.038974098	0.941539
Current rail line in place	0.6	£1,963,187,791	£1,950,549,115	1.003877678	0.997415
no land mitigation	-	-	-	-	-
on line widening	0.9	£2,050,766,691	£1,945,031,018	1.048661221	0.994593
At the line	mitigation	no mitigation present value	full mitigation present value	no mitigation ratio	full mitigation ratio
At grade	0	-	-	-	-
Fill	0	-	-	-	-
Land bridge	0	-	-	-	-
On line widening	0.9	£4,060,314,994	£1,721,747,873	2.076245385	0.880417
retained	0.3	£2,063,732,330	£1,703,306,513	1.055291211	0.870987

long tunnel	1	-	-	-	-
short tunnel	0.5	£1,980,748,854	£1,930,460,316	1.012857542	0.987142
viaduct	0	-	-	-	-
no track mitigation	0	-	-	-	-
cutting	0.5	£2,603,338,435	£1,307,870,736	1.331219232	0.668781

The analysis above assumes the landscape degradation comes into effect in 'year 0' of the scheme. The base year of the analysis 2011, construction starts in 2018, with the proposed scheme opening date is 2026. The scenario below applies income uplift of 3.0% and discount rate of 3.5% into perpetuity. This analysis accounts for the fact that the impact on landscape is deferred from the base year.

Table 8: landscape impact year sensitivity (perpetuity)			
Impacts discounted to:	2001 prices	2011 prices	Ratio to 'base case'
Base year (2011)	£1,955,604,585	£2,555,113,623	1
start construction (2018)	£1,537,087,527	£2,008,296,211	0.79
open year (2026)	£1,167,282,031	£1,525,123,351	0.60

For the central scenario below it is deemed appropriate to discount to 2011 prices with landscape damage assumed to start in 2018 when the scheme opens. 2011 is the price year other HS2 costs and benefits have been reported in, and it is inappropriate to assume that landscape impacts will be felt before 2018, and that impacts will be felt to a sufficient extent between 2011-2018 to warrant assuming costs are incurred from 2018.

The next scenario assumes Green Book discount rates with income uplift of 0.0% per annum appraised over 60 years.

Table 9: landscape impact year sensitivity (60 years)		
Impacts discounted to:	2001 prices	2011 prices
Base year (2011)	£257,897,892	£336,958,924
start construction (2018)	£196,017,156	£256,108,064
open year (2026)	£141,338,772	£184,667,505

No sensitivity was undertaken to assess whether changes to landscape in Areas of Outstanding Natural Beauty or Sites of Special Scientific Interest impact on the present value of costs.

From this sensitivity it can be concluded that the results of this analysis are highly sensitive to the assumptions made. In particular the time frame of appraisal (perpetuity vs. 60 years), the income uplift factor, and the mitigation weights given to some of the mitigation factors can alter the magnitude of the present value of landscape costs substantially.

<u>'Central' Scenario</u>

The ‘central’ scenario was based on the following set of assumptions. The rationale for choosing each of these assumptions is also outlined:

- Impacts valued in 2011 base year prices. 2001 prices were selected to be consistent with the price base year that other impacts are being assessed in for the HS2 proposal
- Landscape impacts assumed to come into effect in 2018. 2018 reflects that construction on the scheme begins in 2018 and there is no damage in the interim. It was deemed that sufficient landscape impact would be incurred during construction to warrant 2018 over 2026 when HS2 is assumed to open.
- Impacts discounted into perpetuity timeframe. This reflects DDCLG guidance that if it is prohibitive or impossible to undo damage to landscape the landscape impact will be felt into perpetuity even though other elements of the HS2 appraisal (eg revenues) are assumed over a 60 finite timeframe.
- Discount rate assumed constant at 3.5%.
- Income uplift rate assumed constant at real annual GDP for each year multiplied by an elasticity of 1.2. This is the central scenario outlined in the DDCLG to reflect that demand for landscape benefits increases with time.
- Mitigation applied as outline in table 2 above. In the absence of formal guidance on how to apply mitigation for rail schemes where mitigation has been incorporated within the design (eg tunnelling, cutting) a judgement was needed to incorporate mitigation into the analysis. An decision was made to use the mitigation factors in section 2 with sensitivities provided.

The ‘central’ scenario of present value landscape costs is £960 million (£957,391,315) in 2011 prices using the income elasticity factor 1.2. The other 2 ‘sensitivity’ scenarios are outlined in table 10 below:

Table 10: ‘central’ scenario values (2001 prices top, 2011 prices bottom)

Income elasticity factor = 1.0	Income elasticity factor = 1.2	Income elasticity factor = 1.4
£610,631,307	£732,757,568	£854,883,829
£797,826,096	£957,391,315	£1,116,956,534

Subsequent to completion of the original analysis new downgraded GDP growth forecasts were published by the Office of Budgetary Responsibility. These figures were downgraded by 0.2% per annum between 2011 and 2018[6]. This affects the PV costs is a downward direction as lower GDP in the future is assumed to lower demand for landscape. Inserting the updated figures into the analysis with a 1.2 elasticity factor lowers PV costs from £957 million to £840 million (12.2% decline). However, the original figure is reported as the central scenario as a conservative upper estimate.

<u>Comparison with previous HS2 Ltd results</u>

[6] A complexity with the new numbers was that previous estimated were based on CPI inflationGDP deflator, whereas new figures were based on RPI deflator. An OBR agreed adjustment was made to the GDP stream to account for the switch to CPI.

HS2 Ltd has previously undertaken a crude assessment of landscape for the proposed HS2 scheme. Based on highly conservative assumptions they derived a figure of £4.4billion reflects a large discrepancy between the analysis undertaken within this analysis (£ billion).

The HS2 analysis was undertaken to provide an upper estimate of the order of magnitude of landscape impacts. Unlike the analysis in this paper, their analysis did not incorporate mitigating factors, and was based on DCLG GDP growth (2.5% per annum). These numbers are not directly comparable because they are based on different assumptions, but have been recorded to highlight the inherent uncertainty when undertaking landscape analysis.

Caveats and limitations.

There remain a number of limitations and caveats associated with the underlying methodology and application as outlined below:

1. The analysis includes only landscape impacts which need to be clearly distinguished from noise and townscape impacts. The built up areas in the urban centres (ie. London and Birmingham) were fully mitigated because the area is already degraded, though there may be separate impacts for townscape and noise.

2. Even with the use of GIS, at present the methodology still requires subjective assessment of land types. The methodology would be improved with assessments of landscape based upon objective criteria such as population density which could be applied across numerous schemes.

3. There remains no formal guidance on how to weight different mitigation impacts (such as green tunnels). The sensitivity analysis inform that the some results are highly sensitive to these assumptions.

Pros and Cons of GIS approach.

Table 11 below outlines the pros and cons of the GIS approach relative to the conventional paper and pencil approach.

Table 11: Pros and Cons of GIS approach	
Pros	Cons
Reproducibility	Requires specialist mapping skill
Largely objective	Computationally intensive.
Possibility to fully automate whole analysis with development of full UK wide land type database.	

Conclusion.

This paper has summarised the Department's methodology for undertaking quantitative analysis of landscape impacts for transport schemes. The application of this methodology has been explained in relation to the HS2 scheme (London to West Midlands) as well as outline of the key sensitivities. The analysis provides a central value of landscape impacts in the order of £1 billion in 2011 prices), but this is highly sensitive to the underlying analytical assumptions. In addition, a number of caveats have been applied to highlight where these assumptions are based on less robust evidence. Though the specific impacts that landscape could have on the HS2 BCR has not been outlined, the central figure and its uncertainty range indicate that landscape potentially could have a noteworthy impact on the BCR and therefore economic case.