



HM TREASURY

# Valuing infrastructure spend:

supplementary guidance  
to the Green Book

November 2011





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Any queries regarding this publication should be sent to us at: [public.enquiries@hm-treasury.gov.uk](mailto:public.enquiries@hm-treasury.gov.uk).

ISBN 978-1-84532-928-0  
PU1253

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# 1

## Introduction

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**1.1** This supplementary guidance on the assessment of infrastructure spending provides further advice on applying Green Book appraisal principles to programmes and projects across the economic infrastructure sectors of:

- energy;
- transport;
- water, waste water, flood risk and coastal erosion;
- solid waste management; and
- communications.

**1.2** This is not intended to provide comprehensive guidance on the project management of infrastructure investments. In addition, recognising that infrastructure projects take many years to develop and appraise, practical application of this guidance early after its introduction should be sensitive to the fact that many existing projects and programmes will already be a significant way through the policy appraisal and option selection process.

### Overview

**1.3** This guidance is intended to assist policy makers, analysts and all those who are concerned with appraising infrastructure policies and programmes. It covers four areas that will help to maximise the value from infrastructure policies, projects and programmes:

- 1 **Generating a range of infrastructure investment options** – at the outset, during strategic outline stage of project development, a long list of options should be generated and considered at a high level and a short list selected for more detailed analysis. The maintenance and smarter use of existing assets should be considered as a ‘do minimum’ option. Where this is insufficient, options should be considered for targeted action to tackle network stress points or develop networks on a small scale. Where appropriate, large scale transformational projects that are part of a clear long-term strategy can also be considered. Demand management can apply to any of these options and should be considered.
- 2 **Valuing the wider impacts of infrastructure** – the effects and costs of infrastructure investment have wider impacts that must be included in an appraisal to ensure that infrastructure investment is appropriately appraised. For example, improvements to a rail line will affect other transport links if travellers are diverted to alternative routes.
- 3 **Valuing the opportunities and risks of sharing infrastructure assets** – when appraising infrastructure, it is important to recognise that infrastructure networks are increasingly interdependent. This offers both opportunities to create value for example through sharing, but also increased risk as a failure in one infrastructure network may affect others.

- 4 **Valuing the risk of infrastructure failure** – the wider impact of infrastructure failure on the UK needs be taken into account in appraisal. Infrastructure provides the networks upon which the modern economy depends and the wider economic and other effects of network failures can be widespread and severe. It is therefore important to value investment spending to maintain infrastructure or increase its resilience appropriately.



# 2

## Generating a list of infrastructure options

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**2.1** As set out in the Green Book, the creation of options at the early stages of an appraisal involves preparing a list of the range of actions which Government could take to achieve its policy objectives.

**2.2** The Green Book requires all economic appraisals to include a 'do nothing' option or, where this is not possible, a 'do minimum' option. The UK is a mature economy with an extensive set of existing infrastructure networks. Maximising the potential of the assets which are already in place through maintenance can be an inexpensive option and will often provide the most cost-effective solution to infrastructure challenges. Minimal renewal and maintenance of existing assets would (in the absence of a decision to run down a network asset) be the equivalent of the 'do minimum' option, but there may be a range of renewal and maintenance options.

**2.3** The Green Book also sets out that use of existing programmes and projects should be included as options, especially when considering a major new programme. In the infrastructure sector, where maintenance investment needs to be supplemented or cannot meet policy objectives, targeted action to tackle stress points and develop networks should be considered. Small but targeted investments in existing infrastructure can have a large effect on overall network capacity, and can be highly cost effective in tackling issues like congestion.

**2.4** Transformational investment, or 'radical options' as described in the Green Book, should also be considered where appropriate to the policy objective, for example if small scale interventions are unlikely to meet future needs and where significant investment is needed as part of a long term strategy to enhance the performance and accessibility of infrastructure.

**2.5** After considering a full list of possible options, a shortlist of options may be created to keep the appraisal process manageable, though this should still cover a wide range of potential options, including use of existing networks. As the stages of an appraisal and project progress, the analysis of options must be refined to become more specific and accurate. The effort applied at each step should be proportionate to the importance or scale of the decision at hand. The strategic case, affordability, commercial viability and deliverability of the options must also be considered, in line with HM Treasury's 'Five Case Model' for business cases.<sup>1</sup>

### Infrastructure investment options

- **Maintenance and renewal:** the cheapest solution is often to make the best use of the extensive assets that are already in place through maintenance and demand management.
- **Targeted action to tackle network stress points and develop networks:** where maintenance needs to be supplemented, options should be considered to target new capital investment on pinch points to enhance resilience and capacity of the network overall and where new networks need to be developed. Small investments can often be highly cost effective in tackling issues like congestion.

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<sup>1</sup> *Public Sector Business Cases using the Five Case Model: a Toolkit*, HM Treasury

- **Transformational large scale capital projects:** where maintenance or small scale investment will not meet future need or policy objectives, significant investment in new or replacement infrastructure should be considered as part of a clear long term strategy.

## **Demand Management**

**2.6** The performance and public value of infrastructure assets often depends upon the way in which access to them is controlled. Alongside the investment options, therefore, policy makers should consider how the benefits of infrastructure may be enhanced through the use of demand management. All infrastructure is subject to a demand management regime, whether or not this is explicit, and better design of such processes can bring significant benefits through improved asset utilisation patterns.

**2.7** Demand management may involve measures that influence consumer behaviour in ways such as information provision or influencing how a consumer makes a choice, and where compatible with government policy, could also involve the inclusion or adjustment of price controls and access rationing. It may involve minor changes as part of maintenance and renewal (for instance, adjusting the information provided in road signs as they are replaced) or might require more significant capital investment (for instance, in providing the equipment needed for real-time information provision for road users).

**2.8** Demand management can apply to all infrastructure investment options, and should be considered, at the outset, when generating options for new programmes. This could be as a way of improving performance of the existing networks and/or of maximising the benefits of further infrastructure investment.

### **Box 2.A: An example road link**

There is severe overcrowding on the road link between City A and City B. The current two lane dual carriageway is ageing and does not have sufficient capacity especially at peak times causing delays and resulting in economic loss. A set of alternative options could be developed as follows:

#### **1. a) Do nothing / minimum – minimal maintenance**

The initial investment costs will be zero or very low, but costs will rise as usage increases leading to increased journey times, with increased congestion on the rest of the local road network and other transport networks.

#### **1. b) Minimal maintenance/no improvements with demand management**

Manage demand positively by encouraging passengers to use alternative forms of transport such as rail and cycling, or work from home and not travel. A very low cost option, which could help alleviate congestion and other externalities.

#### **2. Maintenance and renewal – minor whole route improvements**

The initial investment costs will be modest. There will be some improvements to the road and therefore some reduction in delays. However, the fundamental capacity constraints will still exist. Demand management by encouraging mode shift and alternatives to travel may help alleviate some but not all of these pressures.

#### **3. Target stress points – increase capacity at key junctions.**

The investment costs are now obviously larger, but the increased capacity at the junctions will help the flow of traffic and reduce delays. However delays on the road are not likely to be reduced significantly. Incorporating demand management in the form of regulating access to the main road may provide overall economic benefit, but local road users and communities may suffer time and severance disbenefits.

#### **4. a) Transformational, large scale project - build new off-line three lane inter-city motorway .**

The investment costs will now be very large but this investment could deliver large benefits through solving the problem of congestion and delays on the current route. This investment needs to should fit into a wider affordable strategy for the transport network in the area.

#### **4. b) Large scale project with demand management – enhance hard shoulders and introduce Managed Motorway features or lane widening.**

The Managed Motorway investment costs will be less than half conventional widening (which itself will be an order of magnitude less than the three lane motorway) yet the benefits will approach that of building to full motorway standard. Enhanced signing capacity and control centres jointly managed by local and strategic authorities would enable the local and strategic road networks to be balanced and managed to best overall effect, with ramp metering regulating flow for best congestion balance.



# 3

## Valuing the wider impacts of infrastructure

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**3.1** The wider costs and benefits of Infrastructure spending and investment including social and environmental effects may present challenges in measurement and valuation. For example, a new rail line may deliver direct benefits to rail commuters in terms of their ability to get from point A to point B more quickly, and experience a more pleasant and productive journey due to reduced over-crowding. Beyond this, though, there may be additional benefits. For example, a better train service may reduce congestion on the roads, which also implies reduced CO<sub>2</sub> emissions, improved air quality and less noise pollution. The new rail line may also have a positive effect on economic activity in deprived areas served, potentially bringing a combination of regeneration benefits and new employment opportunities.

### Including impacts in appraisal

**3.2** In line with the Green Book, all costs and benefits should be quantified and monetised as far as possible and included within the Social Cost Benefit Analysis. Annex 2 of the Green Book contains guidance on the valuation on non-market costs and benefits.

**3.3** Where it is not possible to put a monetary value on wider impacts then they should still be quantified in non-monetary units wherever possible, and should be the subject of a structured qualitative discussion. Chapter 5 of the Green Book contains guidance on considering non monetised costs and benefits, including Multi Criteria Decision Analysis.

### Wider impacts to consider for infrastructure projects and programmes

**3.4 Labour market participation**<sup>1</sup> – infrastructure can make it easier for people to travel to work, encouraging more people into the labour force and facilitating the creation of new jobs. For example, improved transport links facilitate getting to work in new places, broadband internet allows home-working and may encourage entrepreneurship by driving down the cost of running a business. Infrastructure can also have the reverse impact as slow, costly and unreliable infrastructure networks can drive people out of the labour force, discourage them from entering the Labour market, or make it harder to run a business.

**3.5 Resilience against economic shocks** – infrastructure plays a crucial part in the ability to cope with economic shocks caused by events such as extreme weather or terrorism. A wider impact of infrastructure investment may be increased resilience against network failure, providing some protection for against potential future economic shocks. This is discussed in more detail in the valuing risk section of this guidance. (Chapter 5)

**3.6 Environmental impacts**<sup>2</sup> – infrastructure projects could have environmental impacts both positive and negative.

**3.7 Linked network impacts** – an infrastructure project is likely to have an impact on the rest of a network and/or other networks and infrastructure assets. An appraisal should seek to estimate these impacts. For example the impact of a new light rail system could reduce the number of

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<sup>1</sup> Guidance on assessing the employment impacts of policies and projects is available in the Green Book (pp.52-54), and in supplementary guidance, 'Valuing Employment Impacts',

<sup>2</sup> Guidance on assessing environmental impacts is available from the Green Book website.

people using local roads or the benefits of a broadband service increase as a greater proportion of the population use the service.

**3.8 Regional and local impacts** – infrastructure can have a significant impact on regional economies. A well-planned major piece of infrastructure such as road link can deliver benefits to the local economy and, under the right circumstances, help facilitate greater economic activity. Other Major Infrastructure could have a more negative impact on the local region (but may be important to the national economy) such as a power plant that has an environmental impact that harms local tourism.

**3.9 Innovation** – infrastructure can facilitate innovative and growth creating economic activity. For example faster broadband connections not only allow existing businesses to operate more efficiently. They also facilitate new productive activity that would not previously have been possible or predicted. Although this area will always be difficult to quantify, an appraisal should estimate the potential for innovative benefits.

**3.10** Supplementary Green Book Guidance on '*Assessing the impacts of spatial interventions*' is available. This focuses on the impact of policy interventions on the '3Rs' – regeneration, renewal and regional development.

### **Additional value created by infrastructure development**

**3.11** Infrastructure development can be a major driver of, or even a necessity for major economic developments, both commercial and residential. Planning strategically creates an opportunity to add significant value in a particular place if infrastructure and other development work closely together.

#### **Box 3.A: Kings Cross Central**

King's Cross Central is a 67 acre site to the north of Kings Cross and St Pancras International stations in central London. Once completed it is expected to contain 3.4 million square feet of office space, 500,000 square feet of retail space and 2000 homes. The development of Kings Cross Central is expected to cost £2 billion of which £300 million is accounted for by its infrastructure development. The expected end value of the site is expected to be around £3.5 billion. The net benefit may be more difficult to estimate, but where transport is the constraint then transport interventions can play a key role in facilitating specific developments. Two infrastructure developments helped facilitate the Kings Cross Central development:

- Routing of the Channel Tunnel Rail Link - the decision was made to route through East London terminating at Kings Cross St Pancras Station. The approach of the line was to the North and the route was pushed as far north as possible into Kings Cross to allow maximum land space for the development of Kings Cross Central.
- Upgrade of Kings Cross Underground station – significant upgrade work was carried out to increase capacity and this was a key factor in facilitating planning permission for the development of King's Cross Central.

# 4 Valuing the opportunities and risks of sharing infrastructure assets

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**4.1** Infrastructure in the UK is a network of networks. A disturbance in one part of a network can affect other parts of the same network and other networks.

**4.2** Interdependencies offer both risks and opportunities. Increasing interdependence of networks increases risks because if one network fails then it will have consequences for other networks which may sometimes be more damaging than the original failure. Increasing interdependence of networks also offers increasing opportunities to save costs and add value. Identifying the risks and opportunities should be part of a full option valuation following the guidance in Chapter 5 of the Green Book on creating and short listing options.

## Sharing infrastructure assets

### Common infrastructure corridors for new infrastructure

**4.3** A significant proportion of the initial cost of building major infrastructure is attributable to site preparation work, for example, purchasing land, gaining planning permission to carry out major works, and preparation work (for example, digging up and shifting earth, demolition of buildings etc). When constructing new large scale infrastructure there may be significant opportunities<sup>1</sup> to achieve better Value for Money by sharing these costs across more than one project. In addition the ongoing maintenance costs could also be less with more than one type of infrastructure in one place. Including other works in an infrastructure corridor may push up the cost of an infrastructure project or programme and/or increase the marginal benefit of that project or programme (though this will not automatically be the case).

### Additional Risks

**4.4** Common corridors also come with additional risks:

- the complexities while seeking consents and during construction of including more than one form of infrastructure could add risks of increased delays.
- once built and operational any possible impact on the common corridor could disrupt several networks rather than one, increasing the negative impact of any single event.
- a failure in one of the networks could also impact on the other networks in a corridor. For example, if a water pipe in a common corridor was to break then not only would the water supply be affected but also the electricity and broadband networks which share the corridor; and
- the disruption consequences of maintenance work could be magnified.

**4.5** These risks can be mitigated by increasing the resilience of the corridor against any negative impacts. In some circumstances it may be more cost effective to increase resilience of one

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<sup>1</sup> Chapter 4 of the National Infrastructure Plan, available on the Treasury website.

common corridor rather than individual networks. See section on valuing the risk of infrastructure failure. (Chapter 5)

## Shared use of existing infrastructure

**4.6** Many existing infrastructure assets could also be used for additional infrastructure networks or systems. Using existing infrastructure rather than building entirely new networks could significantly lower the cost of delivering infrastructure. Having several forms of infrastructure in one place could also reduce the ongoing maintenance costs. In some circumstances it could be appropriate to use land around the UK's large infrastructure networks, such as the motorway network (Highways Agency) and the Rail network (Network Rail) to deliver additional infrastructure.

### Box 4.A: The Channel Tunnel Interconnector

A proposed 500MW electricity interconnector (ElecLink) may be built using the service tunnel in the Channel Tunnel increasing cross channel capacity by 25% to 2500MW, enough to supply approximately 350,000 homes. The 75km link will require an investment of £216 million. On the basis of industry norms it is expected that to deliver an interconnector of a similar length would cost around £350-£400 million. In addition ongoing maintenance costs would also be less.

## Additional risks

**4.7** As with common infrastructure corridors, housing more than one piece of infrastructure in the same asset could increase the impact if that infrastructure asset was to fail in some way though this can be mitigated by increasing the resilience of the asset. If an asset holds more than one infrastructure network it will become more important to increase the resilience of that asset. (Through using more durable materials, increasing security, creating additional capacity so that networks can be re-routed if needed.) In some circumstances, systems may interfere with each other and so reduce standards of performance. When looking at unused land around existing networks, an appraisal of the potential costs and benefits should ensure it takes into account the non market values of publicly owned land such as environmental benefits.

## Summary

**4.8** When considering interdependencies, benefits are most easily realised when there is a long term strategy for infrastructure and spatial development in place. Not all infrastructure projects will be planned as part of a long term, broader strategy. However, it is still important that the feasibility and appropriateness of delivering other shared infrastructure alongside is considered at an early stage of the project development cycle, otherwise such potential benefits will not be achievable without subsequent revisions in project scope. Considering the scope for combining projects importantly requires a policy appraiser to work across organisational (i.e. departmental) boundaries in order to identify opportunities to add value.

**4.9** When conducting a policy appraisal, policy makers should ensure to consider all of the risks and opportunities. If sharing infrastructure assets is not deemed to be feasible or appropriate, this should be explicitly stated when reporting the options that have been considered.



# 5

## Valuing the risk of infrastructure failure

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**5.1** The economy and society are reliant on infrastructure. A failure of infrastructure can result in large scale disruption and loss of output.

**5.2** Infrastructure failure can occur due to risks posed by exogenous factors such as the weather, or it can occur due to investment decisions – for example, lack of maintenance, or lack of strategic planning which causes networks to become overloaded. There are different types of failures, all of which will have different probabilities and impacts. An assessment of an infrastructure failure should consider:

- the severity of the event that may have caused the failure – a very severe winter storm will have a bigger impact (but is less probable than) a lighter, more regular snow shower;
- the depth of the failure – the impact on a road network will vary depending on whether it causes delays or a complete closure; and
- the duration – the impact of an electricity blackout will vary depending on whether it is short, where the impact will be small (although this may depend on the time of day) or lasts a few days or even weeks.

**5.3** The risk of infrastructure failure must be considered in the appraisal of infrastructure projects.

- when evaluating the benefits of spending on existing infrastructure, (maintenance spend or targeted action), it is important to value the resultant reduced risk of infrastructure failure. The benefits of the expenditure may otherwise be undervalued; and
- when evaluating the benefits of new infrastructure, it is important to assess the impacts if the infrastructure fails, otherwise the benefits of the project may be over-valued.

**5.4** For both old and new projects, infrastructure can be adapted to mitigate against risks. This could be achieved by a change of design, use of different (perhaps more costly) materials, or through the creation of additional network capacity. Where risks to an infrastructure project have been identified, the appraisal should consider the costs and benefits of relevant resilience measures.

**5.5** The risk associated with infrastructure failure is measured by looking at the probability of failure and the impact of that failure on society. The benefits of additional resilience are measured by how much that additional resilience decreases the expected impact of failure, by reducing either its probability of occurrence or impact. Any expected variation in the impact or probability over the course of the appraisal period should be taken into account. Where there is uncertainty, a range should be considered.

**5.6** When assessing the probability and impact of risks, policy makers should follow the guidance in Annex 4 of the Green Book on risk and uncertainty, including where appropriate guidance on Monte Carlo analysis.

## Probability of infrastructure failure

**5.7** The probability of an infrastructure failure will affect the benefit of increasing resilience against that failure. In some cases, investment to protect against a damaging but highly unlikely event may not be appropriate where a lower impact but much more likely event would make an investment worthwhile.

**5.8** Further details on policy relating to infrastructure failure can be found in the Infrastructure and Corporate Resilience Programme<sup>1</sup> and the CP09 climate change projections.<sup>2</sup> Investment in upfront resilience measures should be considered alongside investment in better response-recovery measures.

## Impact of an infrastructure failure

**5.9** The impact of a failure of infrastructure will depend partly on the economic and social value of the assets that could be put at risk. This value will be determined by both the economic value of the assets at risk (i.e. a flood could cause permanent damage to buildings) and/or the loss of output that occurs (i.e. an electricity blackout would halt most economic activity), as well as the wider social costs of large scale infrastructure failure, such as re-housing or medical costs.

**Table 5.A: Table**

Type of impact	Example
Immediate impact	Networks are severely disrupted or fail completely causing damage to property and risk to members of the public.
Cascade (intra-systemic)	A failure in one part of a network has a significant impact on the rest of the network. For example, a failure in an electricity substation affects other parts of the electricity network.
Displacement effect (inter-systemic)	A failure in one system affects another infrastructure system, such as a power failure affecting the transport network.
Indirect productivity impacts	Loss of productivity as workers cannot get to work, manufacturing is disrupted, retailers cannot open as normal. For example, a failure in the communications networks affecting the ability of people to work efficiently or summon emergency assistance.
Correlated failures	An extreme event could be correlated with further extreme events. A storm could disrupt infrastructure by causing high winds and flooding. But the storm may then have a secondary impact after the original event, such as causing a landslide or disrupting water supplies.

## Delayed or transferred economic output

**5.10** There is a tendency to measure the costs of infrastructure failure caused by issues such as severe weather in terms of lost economic output. But this output may not always be lost completely, but rather delayed to a different time or transferred to a different form of output. For example, a day of reduced productivity as a result of bad weather disrupting the ability of people to get to work will have a negative economic impact in terms of lost output for that day. But this output loss may be partly made up for during the course of the following month or work may be conducted at home rather than in the office.

<sup>1</sup> [www.cabinetoffice.gov.uk/infrastructure-resilience](http://www.cabinetoffice.gov.uk/infrastructure-resilience)

<sup>2</sup> [ukclimateprojections.defra.gov.uk](http://ukclimateprojections.defra.gov.uk)

**5.11** The possibility of delayed or transferred output must be considered when calculating the impact of infrastructure failure, otherwise the economic impact of infrastructure failure could be overestimated.

**Box 5.A: Example – a severe winter storm**

A severe winter storm takes a large part of the transport network in a town out of action for a day, preventing people from getting in to work. Lost productivity of this kind contributes to the case for increasing resilience of the town's transport network against winter weather. However it may be the case that much of the business that would have been conducted that day is instead delayed to another day (when the weather is less severe and the network is fully operational) and/or many people will instead work from home that day, therefore transferring economic activity from the workplace to home.

When these two factors are taken into account the economic loss from that one day is lessened. This may therefore reduce the case for strengthening the town transport network against winter weather. If the town only suffers from one or two days of winter per year then the overall impact may not be sufficient to warrant the investment necessary to make the transport infrastructure more resilient.

**Climate change adaptation**

**5.12** Climate change could potentially have a large impact on the UK's national infrastructure, raising the likelihood of unpredictable and extreme weather and strengthening the need for infrastructure to be more resilient. When appraising infrastructure investment decisions, it is important to take into account the effects that climate change could have on infrastructure resilience. Some of the risks related to climate change reflect the potential occurrence of events that have not been frequent in recent years, meaning that care should be taken in using past data to infer probabilities and risks over the long time horizons relevant for infrastructure investments.

**5.13** The Department for the Environment Food and Rural Affairs has produced specific guidance on adapting to the effects of climate change on key infrastructure, which policy makers should follow in an infrastructure appraisal.<sup>3</sup>

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<sup>3</sup> Green Book Supplementary Guidance: Considering Climate Risks in Option Appraisal (2011)





# Useful resources for infrastructure appraisal

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## Sector-specific appraisal guidance

Transport (DfT): <http://www.dft.gov.uk/webtag/>

Flood risk and coastal erosion (Defra/EA)

<http://www.defra.gov.uk/environment/flooding/information-for-practitioners/appraisal-guidance-scrutiny/>

Regeneration and Regions:

<http://www.berr.gov.uk/files/file45733.pdf>; and

<http://www.communities.gov.uk/documents/corporate/pdf/146865.pdf>

Resilience (Cabinet Office): <http://www.cabinetoffice.gov.uk/infrastructure-resilience>

## Environmental impacts and risk

EIA guidance (CLG)

<http://www.communities.gov.uk/publications/planningandbuilding/environmentalimpactassessmet>

DECC carbon valuation

<http://www.decc.gov.uk/en/content/cms/emissions/valuation/valuation.aspx>

Climate risks Green Book supplementary guidance (DEFRA)

<http://archive.defra.gov.uk/environment/climate/documents/adaptation-guidance.pdf>

## Finance and planning

PPP/PFI guidance: [www.hm-treasury.gov.uk/ppp\\_guidance\\_index.htm](http://www.hm-treasury.gov.uk/ppp_guidance_index.htm)





### **HM Treasury contacts**

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If you require this information in another language, format or have general enquiries about HM Treasury and its work, contact:

Correspondence Team  
HM Treasury  
1 Horse Guards Road  
London  
SW1A 2HQ

Tel: 020 7270 5000

Fax: 020 7270 4861

E-mail: [public.enquiries@hm-treasury.gov.uk](mailto:public.enquiries@hm-treasury.gov.uk)

ISBN 978-1-84532-928-0



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