# London’s Environmental Infrastructure Needs: A Strategic Study

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**London is a large, complex and diverse city. Its growth and success as a major modern capital is both driven by and supported by investment in its people and places.**

The Draft Replacement London Plan makes clear that London's physical infrastructure must support the needs of a growing city. Its services must meet the highest and most modern standards to help us use the city's resources as efficiently and sustainably as possible.

Climate change focuses our attention on the way we interact with our environment and use its resources. Managing flood risk, reducing the amount of waste we produce, and learning to use water sustainably will help maintain and improve environmental standards and quality of life of London. Improving our urban design and providing high quality green spaces will also help to make London a more attractive place to live and work.

We estimate that the additional investment in environmental infrastructure needed to support new housing up to 2031 could be in the region of £3 billion. It is important to put the scale of this into perspective – it constitutes less than 0.1 per cent of London's annual economic output over the same time period.

This report illustrates how using water more efficiently and reducing waste arisings could help to ensure we manage resources sustainably and protect London's environment over the longer term. Demand management measures could also help to reduce the costs of additional environmental infrastructure in London by about a third.

In this report we present evidence on these issues in relation to housing growth. We want to inform the debate about how new homes are planned and delivered. We believe careful planning and work across the different infrastructure areas and delivery mechanisms is key to make sure London has the infrastructure it needs to support sustainable economic growth.

We have worked with a range of external partners to develop this study. We are committed to working in partnership to develop and inform our evidence base on London's environmental needs.

Howard Davidson
Environment Agency, Director - Thames Region

# Acknowledgements

Colleagues from across the Environment Agency and partner organisations including Natural England, the Greater London Authority, Thames Water, the Homes and Communities Agency and the London Development Agency have helped to shape this report and its recommendations.

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# 1 Executive summary

London is supported by a network of environmental infrastructure that sustains our quality of life and protects the environment. As London grows, the necessary environmental infrastructure needs to be in place to support new homes. It will also be essential to reduce the environmental impact of new housing development.

This study highlights the **scale of the challenge** between now and 2031. It aims to show how much additional infrastructure will be needed to support new housing growth, in terms of costs and capacity. The study looks at five areas of environmental infrastructure: flood risk management; green infrastructure; waste; water quality and sewage treatment; and water resources.

In simple terms, if Londoners carry on using resources at current levels, the environmental infrastructure needed for new housing could cost an **additional £140 million** a year. This would be ten per cent more than is being spent now. By 2031, the extra costs would add up to around £3 billion.

But these additional costs are not fixed. **Changing the way resources are used** and being careful about where and how new homes are built, could mean that less investment will be requirement in additional capacity.

Our findings suggest that reducing demand for waste and water resources infrastructure could cut **the additional spending** required by around 30 per cent – or around £44 million per year (almost £1 billion up to 2031). The additional costs would then be some £90 million a year. Up to 2031 these would total £2.1 billion. However, there would be costs for managing demand. These need to be identified and set against the potential cost savings.

We have already identified London as being in an area of **'serious water stress'** and the highest level of investment will be for clean water supply. This study estimates that, over the lifetime of the Draft Replacement London Plan, an additional £1.3 billion could need to be invested to supply clean water to new homes. Reducing Londoners' water consumption to an average of 130 litres per person per day could cut that figure by around £550 million.

Additional investment will be required to **improve and extend** wastewater infrastructure across London. We have estimated that around £605 million will need to be invested to provide sufficient sewage treatment capacity to support housing growth. In addition there will also be wider costs associated with the capacity of the sewer network and future treatment standards which are not identified within this study.

The importance of the **location and design of new homes** is illustrated by our findings for flood risk management. Redevelopment offers a crucial opportunity to reduce flood risk through better layout and design of sites at risk. The framework set out in Planning Policy Statement 25 (PPS25) provides a clear route for ensuring that new development is located and designed to be safe.

In some cases, **fiscal incentives** are helping to shape the delivery of environmental services. Our results for waste show that reducing levels of household waste and diverting it from landfill could reduce future spending by around £415 million up 2031. These are just the savings from new housing. There would be even bigger reductions if existing households create less waste and send less to landfill.

Green infrastructure offers **multi-functional benefits** to those who live and work in London, as well as to the capital's many visitors. This report argues that the same approach needs to be taken for green infrastructure as for other key environmental

services: it must be prioritised, planned and delivered. This is essential if we are to maximise the benefits from green infrastructure, and build links with services for flood alleviation or water services.

By showing how the long-term costs change in different circumstances, we also hope to contribute to discussions about the way that new housing and infrastructure are planned, delivered and paid for in London.

To support growing communities, environmental infrastructure requires **strategic, long-term planning and sustained investment.** We suggest that planning mechanisms could take better account of linkages between infrastructure areas. They could also make more of the opportunities that new developments offer for the improvement and extension of existing services.

The cost and capacity figures in this report are indicative. The study is not a definitive planning tool. Rather it should be used in conjunction with other evidence to make informed decisions about housing growth and environmental infrastructure provision.

# 2 Introduction

London is one of the world's largest and most advanced cities, home to more than seven million people. The city has the largest concentration of people in England and Wales, with nearly 14 per cent of the population living on just over one per cent of the land.

A network of environmental infrastructure underpins the homes, jobs and services that these people need to survive. This network is critical to their quality of life. Without adequate environmental infrastructure, London would not be able to support such a large population.

Yet this infrastructure is under increasing pressure from a range of different sources. The city has ambitious targets for new homes, and these will put greater demands on essential environmental services. At the same time, much of London's environmental infrastructure is ageing, and will need investment to maintain it. Construction and commercial and industrial activity will also contribute significantly to the pressures on environmental infrastructure, including London's waste services, land and water supply.

To accommodate continued growth without damaging the environment or compromising people's quality of life, we need to plan well into the future. This study explores how housing growth will affect environmental infrastructure in London between now and 2031. Focussing on impacts from new homes, it identifies constraints on capacity and estimates the additional costs of providing and maintaining environmental infrastructure to support forecast housing growth.

## 2.1 Who and what is the study for?

The Environment Agency is a regulator, operator and adviser. Our brief is to protect and improve the environment. We work closely with planners and developers because their decisions affect matters for which we have statutory responsibility, and directly shape and change the wider environment in which we all live.

This study will help everyone involved in the planning and delivery of new housing to understand the scale of future infrastructure needs. It looks at how to manage future demand by choosing different locations for new homes and by improving housing design. For example this study identifies real benefits from initiatives that encourage the more efficient use of resources in both new and existing homes.

The study is not intended as a prescriptive plan for the provision of additional environmental infrastructure. In many cases, there will be a need for site-specific assessments of infrastructure capacity. Instead, this study identifies the scale of future needs under different housing and demand scenarios. In this way it complements existing planning mechanisms.

The study also aims to raise the profile of environmental infrastructure to that of traditional forms of infrastructure such as roads and energy. By explaining the scale of London's investment needs, we hope to encourage the development of environmental infrastructure planning within local infrastructure plans. Further information about the scope and nature of our findings is set out in later sections.

## 2.2 Our approach to this study

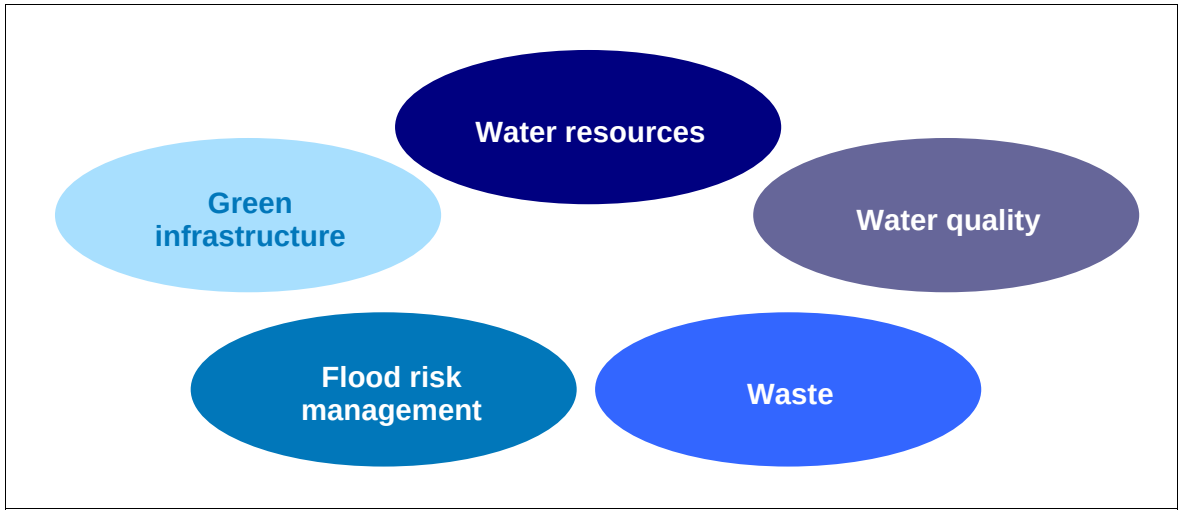
The Environment Agency is at the forefront of work to ensure that new and existing developments have a reduced environmental impact and that they are supported by well-planned environmental infrastructure. As communities grow, it is vital that plans are in place to manage the increased demand from new homes and related development.

Our 2007 report *Hidden Infrastructure*[1] identified four key principles:

| | | | |
|---|---|---|---|
| **Getting the location of new housing right** | **Planning for environmental infrastructure for the longer term** | **Reducing demand on environmental services** | **Securing funding at an early stage** |

This study looks at environmental infrastructure under five headings. These are shown in Figure 2.1.

**Figure 2.1 The five areas of environmental infrastructure**

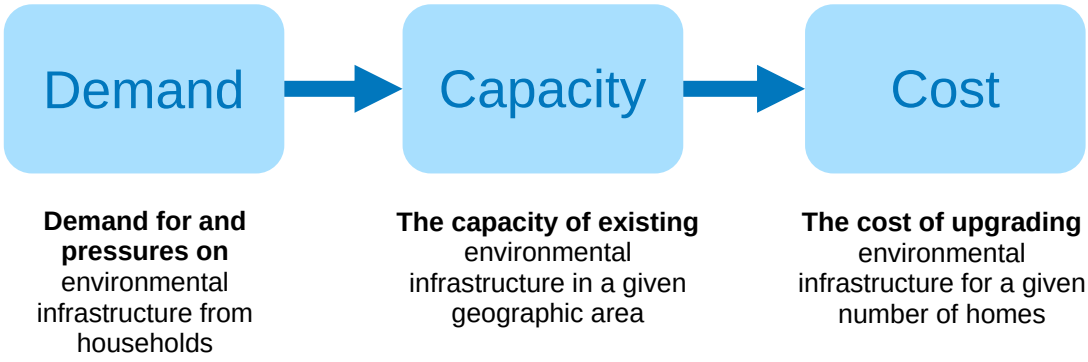



This study does not attempt to provide a detailed plan or strategy for environmental infrastructure. Rather than try to predict exactly what will happen in the future, it tests a number of different hypothetical scenarios. These allow us to make comparisons between different areas of environmental infrastructure, and between different ways of managing London's future environmental infrastructure needs.

This study looks at what is needed in three stages. These are shown in Figure 2.2.

[1] *Hidden Infrastructure: The pressure on environmental infrastructure,* Environment Agency 2007. http://publications.environment-agency.gov.uk/pdf/GEHO0307BMCD-E-E.pdf

**Figure 2.2 Our approach to assessing environmental infrastructure needs**




## Demand

This study looks at the impact of different levels of demand. The scenarios we have used compare different levels of housing and population growth, from now until 2031.

New homes and the number of people living in them have a huge impact on environmental infrastructure needs. In this study, we have calculated population using a fixed occupancy rate, so that more new homes mean a higher population.

The growth scenarios we have used throughout the report are set out in Table 1.1.

**Table 2.1 The three main growth scenarios**

| Growth scenario | Number of new homes per year | Number of new homes to 2031 | Associated population rise |
|---|---|---|---|
| Zero growth | 0 | 0 | 0 |
| Draft Replacement London Plan | 33,400 | 734,800 | 1,310,000 |
| NHPAU[2] upper limit | 44,700 | 983,400 | 1,865,000 |

Demand also depends on the amount of resources that each person consumes. This study looks at a range of different demand scenarios. We compare different levels of resource consumption, and different ways of managing environmental infrastructure. These demand-management scenarios include different:

- levels of water consumption per person;
- levels of waste generated;
- locations of new housing in relation to areas at risk of flooding.

We explain these scenarios in detail in later chapters. Where possible, we have based our approach on targets from the Draft Replacement London Plan[3].

[2] The National Housing Policy Advice Unit (NHPAU) assesses London's capacity for new homes. It has estimated London's upper bound for housing growth at 44,700 homes a year. For more information on the National Housing and Planning Advice Unit, see http://www.communities.gov.uk/nhpau/

[3] The Draft Replacement London Plan is the Mayor of London's long term spatial plan for developing London. For more information, see www.london.gov.uk/shaping-london/

## Capacity

The ability of existing environmental infrastructure to accommodate growing demand varies across London. This study identifies present capacity and highlights how this might need to be expanded to cope with increased demand. Key information sources include: the water companies' Water Resource Management Plans and June Returns; the Environment Agency's National Flood Risk Assessment; waste permitting information; and the Generalised Land Use Database.

## Costs

This study estimates the capacities of different types of environmental infrastructure required to meet demand from new homes. Where demand is predicted to exceed capacity, there will be costs for additional infrastructure. We have also included costs for operating and maintaining new infrastructure over the period of the study. In the section on waste, we have also looked at market costs for waste management.

There is already considerable investment in London's environmental infrastructure every year. This study focuses on the extra investment which will be needed in the years up to 2031 to support housing growth.

We also identify some future pressures which are unrelated to housing growth. These are made clear in the results for our zero-growth scenario:

- The cost of managing the household waste from existing homes is likely to rise between 2010 and 2015 due to scheduled increases in landfill tax.
- Some of the water companies serving London will need to invest in water resources infrastructure even without population growth. This investment will be necessary to overcome existing deficits and address the effects of climate change.
- We consider the scale of investment needed for a 5% increase in green infrastructure in Inner London.

The costs in this report relate to the estimated *expenditure* for providing new infrastructure, rather than to economic costs. If we don't plan and invest in infrastructure, there would be considerable environmental costs.

## Data sources

This study has brought together data from a wide range of sources. Many of the figures presented in this report are based on detailed calculations which have drawn on a range of background data. Wherever possible, we have used data that is in the public domain. However, the quality of data varies between areas of environmental infrastructure. Some aspects of this study have benefited from better data than others.

For more detailed information on the methodology used in this study, or on the data sources available, please refer to the accompanying report, *A Methodology for Evaluating Environmental Infrastructure Needs* and the *London Study Technical Annex.*

## Data level

This study can be used to inform and guide more detailed studies of environmental infrastructure at a local level. It is not intended to replace local studies and it does not have the necessary level of detail to do so. The results and analysis provided in this report and in the Technical Annex can be used as benchmarks or guides for other studies. However they should not be used as sources of raw data.

### Climate change

Climate change will have a major impact on the capacity of London's environmental infrastructure. In the future, sea level rises and climatic changes could affect patterns of flood risk and the availability of water. They may also lead to tougher standards for the performance and design of environmental infrastructure.

Last year Government published the latest UK Climate Change Projections (UKCP09). These provide climate projections for each decade through the century for three emissions scenarios (low, medium and high). These projections are not yet incorporated in the data sources we have used for this study – although information on water resources and water quality was informed by the previous set of climate projections. Our findings should therefore be considered alongside other evidence on the future impacts of climate change.

## 2.3 What the results mean

The results from this study show the scale of investment required to support new housing. Using a unit cost approach derived for each area of infrastructure, we have developed estimates for each of the three housing growth scenarios.

Infrastructure is planned and provided for in a number of ways. Consequently, planning mechanisms vary across the five areas that we have looked at:

- For water resources, there are dedicated planning mechanisms, including statutory Water Resource Management Plans and Ofwat's periodic Price Reviews. These ensure that additional demand from new housing is catered for.
- Similarly, for water quality, a five-year investment plan is required via the Asset Management Plan process.
- To manage household waste, London boroughs often agree long-term contracts to ensure that future waste needs are met.
- For green infrastructure and flood risk management, the role of developers will be important. Although the Environment Agency plans to maintain and improve existing flood defences, we will not be able to fund the protection required for all new housing. To protect new homes from flooding, we will need to take a partnership approach, sharing the financial costs and gains.

The costs that we have identified in this study need to be understood in the context of existing planning processes. The relationship between the costs and existing plans is set out in Table 1.2.

**Table 2.2 How our results fit in with existing planning mechanisms**

| Area | What our results show |
|---|---|
| Flood risk management | • We have identified the scale of costs for infrastructure to defend new properties.<br>• These additional costs could fall to a range of partners, including London boroughs and developers.<br>• We have not included the planned spend by the Environment Agency which is associated with maintaining and improving existing defences. |
| Green infrastructure | • We have identified the scale of costs associated with |

| Area | What our results show |
|---|---|
| | maintaining or improving levels of green infrastructure as housing volume increases.<br>• These costs could fall to a range of partners, including London boroughs and developers. |
| Waste | • We have identified the scale of future costs to collect and dispose of household waste from new development.<br>• These additional costs would fall to London boroughs.<br>• A wider range of partners may be involved in measures to reduce demand. |
| Water quality | • We have identified a scale of costs associated with improving the treatment capacity of sewage treatment works to handle effluent from new households.<br>• Costs for the growth scenarios planned by water companies will be incorporated in investment plans. Our results show how these costs could change with different growth levels. |
| Water resources | • We have used information from Water Resource Management Plans to identify a scale of costs associated with providing water to new homes.<br>• Costs for the growth scenarios planned by water companies will be incorporated in Water Resource Management Plans and paid for by water companies. Our results show how these costs could change with different levels of housing growth.<br>• A wider range of partners may also be involved in measures to reduce demand. |

Housing growth places additional pressures on environmental infrastructure. However, it also provides us with an opportunity to reconsider how infrastructure is managed. To take advantage of this opportunity, both the demands on environmental infrastructure, and the ways in which infrastructure is provided need to be considered.

## 2.4 How we developed this study

This study was guided by a steering group made up of technical experts in the five areas of environmental infrastructure. These experts came from across the Environment Agency. We consulted with external partners throughout the development of our findings. Those we worked with included representatives from the Greater London Authority, the London Development Agency, the Homes and Communities Agency, Thames Water and Natural England.

# 3 Key results

## 3.1 The costs of meeting London's environmental infrastructure needs

This section summarises our findings on what housing growth will mean for London's environmental infrastructure over the next 22 years. More detailed information on each of the five areas is presented in later chapters.

More than £1.4 billion a year is currently spent on environmental infrastructure to support existing communities across London[4]. With no change to this level of spending, London would be on course to spend more than £30 billion by 2031.

This report focuses on the additional investment necessary to support planned housing growth. It looks to draw out the strategic implications for the way that new housing is planned and delivered. If there is no change in the way in which services are used, London could need to spend an additional £140 million a year on environmental infrastructure. This would be a ten per cent increase on the amount already spent to support existing communities. The total additional spend by 2031 could be around £3 billion.

Table 3.1 sets out a breakdown of these results. It sets out the scale of the additional investment needed to provide sufficient environmental infrastructure for London's new households up to 2031. The figures are based on 33,400 new homes a year, as projected in the Draft Replacement London Plan.

**Table 3.1 Costs of meeting environmental infrastructure needs arising from new housing**

| Area of environmental infrastructure | Total additional cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|
| Flood risk management | 270 | 12 |
| Green infrastructure | 175 | 8 |
| Waste | 730 | 33 |
| Water quality and sewage treatment infrastructure | 605 | 28 |
| Water resources | 1,290 | 59 |
| **Total** | **3,070** | **140** |

[4] This figure has been calculated from plans for the different types of environmental infrastructure.

Notes:

- These results only take account of environmental infrastructure costs directly associated with new housing growth.
- They assume that London builds 33,400 new homes a year and that there are no extra interventions to manage demand for environmental infrastructure.
- Flood risk – in accordance with our nationally developed methodology, we have estimated costs for building defences to protect new homes. However, in London, the most sustainable approach to manage flood risk from rivers is through appropriate location, layout and design of development rather than creating new defences.
- Water quality – this study only captures costs related to wastewater treatment infrastructure. The full costs associated with water quality are likely to be much higher.
- Green infrastructure – the results for green infrastructure include the cost of achieving a 5% increase in green infrastructure in Inner London boroughs by 2031. This aspiration is set out in the Draft Replacement London Plan.
- Waste – the figure used here does not include any future costs for existing communities.
- Water resources – the figure used here does not include any future costs for existing communities.

Water resources will require the most significant investment to support housing growth. This study estimates that an extra £1.3 billion of spending will be needed to supply clean water to new homes. Some £605 million could be needed for wastewater treatment infrastructure. In reality, the costs of managing water quality are expected to be even higher. There are a number of other costs associated with the sewer network and future treatment standards which we were not able to capture owing to data constraints.

Waste is also likely to require high levels of investment. The additional costs associated with new housing could be more than £730 million. This study also identifies significant pressures from existing communities (not included in Table 3.1). Total additional spending on household waste could be more than £2 billion. Much of this is due to the impact of the landfill tax, which is likely to provide an incentive to manage waste by other means.

London already has comprehensive defences in place to deal with tidal flood risk. Recognising that the preferred way forward in London is to avoid building new defences to protect new property at risk from fluvial flooding, it is very difficult to assign a cost for flood risk management infrastructure. However, using a methodology we developed nationally we have estimated an approach to defending new homes based on capital defences. Under this approach the estimated investment in flood risk management infrastructure to protect new housing from fluvial flooding is around £270 million.

In many cases costs can be managed through the correct application of PPS25 and early discussions on the design of new developments. The most sustainable way of accommodating new housing growth in relation to flood risk is to locate new development in the areas of lowest risk. In London, some sites currently at risk of flooding will be redeveloped. By improving the layout and design of these redeveloped sites, there is a crucial opportunity to reduce risks and avoid the need to construct new defences that will require future maintenance. There will be additional costs to manage the risk of surface water flooding, but identifying the impact of this risk on new housing was beyond the scope of this study.

Finally we have estimated that we could need to invest around £175 million in green infrastructure to increase provision and to offset land that could be lost through new development. Importantly, these costs could be offset by potential cost savings in other infrastructure areas, where green infrastructure provides essential flood alleviation or water services.

## 3.2 The costs of meeting London's environmental infrastructure needs if demand can be managed effectively

Table 3.1 showed what would happen if there were no interventions to manage demand for environmental infrastructure. However strategic planning and partnership working can reduce the impact of new housing on existing environmental infrastructure. Careful consideration needs to be given to where homes are built and to measures that manage demand.

Table 3.2 sets out the effect on costs if demand for waste and water resources infrastructure is reduced. These reductions in demand are based on targets set out in the Draft Replacement London Plan and Defra's Future Water Strategy.

We have not included the costs of interventions to manage or reduce demand. These results show the effect of reduced demand on the infrastructure investment required to support housing growth of 33,400 new homes a year.

The figures show that London could reduce the additional spending on environmental infrastructure to around £90 million a year up to 2031. This represents a total extra cost of £2.1 billion up to 2031. This is about 30 per cent lower than the cost if there are no interventions to manage demand.

**Table 3.2 Costs of meeting environmental infrastructure needs arising from new housing – under demand-management scenarios**

| Area of environmental infrastructure | Total additional cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* | Saving from demand reduction to 2031 *(£ millions)* |
|---|---|---|---|
| Flood risk management | 270 | 12 | - |
| Green infrastructure | 175 | 8 | - |
| Waste | 315 | 14 | 415 |
| Water quality and sewage treatment infrastructure | 605 | 28 | - |
| Water resources | 740 | 34 | 550 |
| **Total** | **2,105** | **96** | **965** |

Notes:

- These results assume that London builds 33,400 new homes a year.
- Flood risk – in accordance with our nationally developed methodology, we have estimated costs for building defences to protect new homes. However, in London, the most sustainable approach to managing the flood risk from rivers is the appropriate location, layout and design of new homes and redevelopments.
- Water quality – this study only captures costs related to wastewater treatment infrastructure. The full costs associated with water quality are likely to be much higher.
- Green infrastructure – the results for green infrastructure include the cost of achieving a 5% increase in green infrastructure in Inner London boroughs by 2031. This aspiration is set out in the Draft Replacement London Plan.
- Waste – the figure used here does not include any future costs for existing communities.
- Water resources – the figure used here does not include any future costs for existing communities

The demand-management scenarios applied here are:

- Waste – the amount of waste produced per person falls by 20% by 2031. London recycles or composts 60% of its waste by 2031, and sends zero waste to landfill. These aspirations are set out in the Draft Replacement London Plan and the Mayor's Draft Municipal Waste Management Strategy.
- Water resources – the average amount of water consumed per person falls to 130 litres per person per day by 2031. This aspiration is set out in Defra's Future Water Strategy.

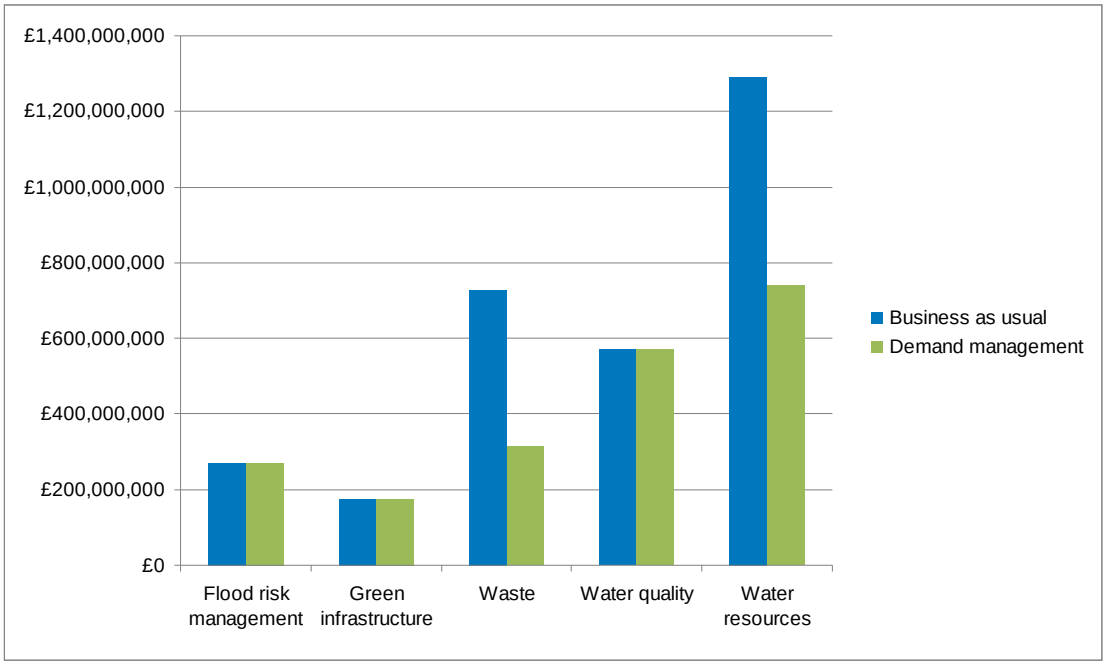
These results suggest that reducing demand for waste and water resources infrastructure could reduce future investment needs by an estimated £44 million a year (almost £1 billion up to 2031) compared to the costs shown in Table 3.1. If we look only at resource use from new homes, the cost savings from managing household waste more sustainably could be about £415 million to 2031, while for water resources the cost savings could be up to £550 million. However, the results do not include any costs for managing demand, and these need to be considered against these potential cost savings.

It may also be possible to manage the demand for flood risk management and green infrastructure more effectively – by changing the location of new homes, and by making more effective use of available land. These possibilities are explored in later chapters.

Costs for water quality and sewage treatment infrastructure could also be lower under a demand-management scenario, as the volume of effluent requiring transfer and treatment will be lower. However total costs will also be influenced by the standards of treatment required. These results include a small increase in treatment standards, to maintain the load discharged from sewage treatment works at current levels. This costs an additional £120 million up to 2031.

Figure 3.1 compares the costs of environmental infrastructure under the business as usual scenario with those under a scenario where demand is managed.

### Figure 3.1 Comparing 'business as usual' with demand management




Figures 3.2 and 3.3 divide the total estimated environmental infrastructure costs set out in Table 3.1 by numbers of new homes to give an average cost. Figure 3.2 does not include costs for fluvial flood risk management, as this only applies to new homes in areas at risk of flooding from rivers.

### Figure 3.2 Estimated average costs of environmental infrastructure per new home

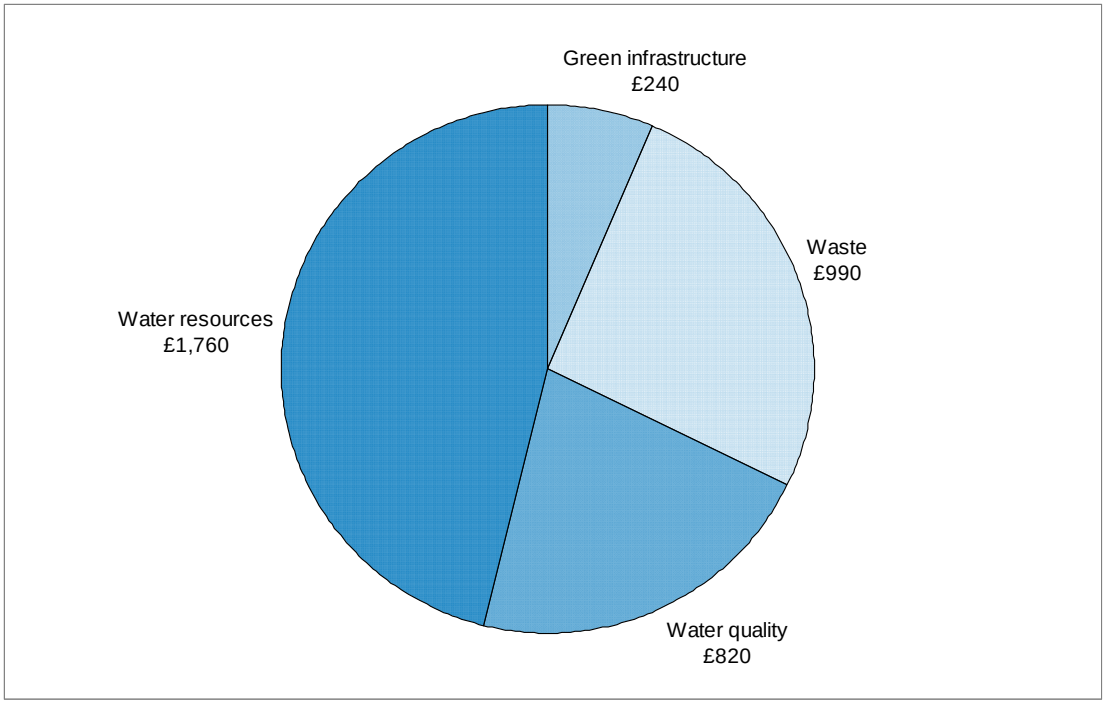
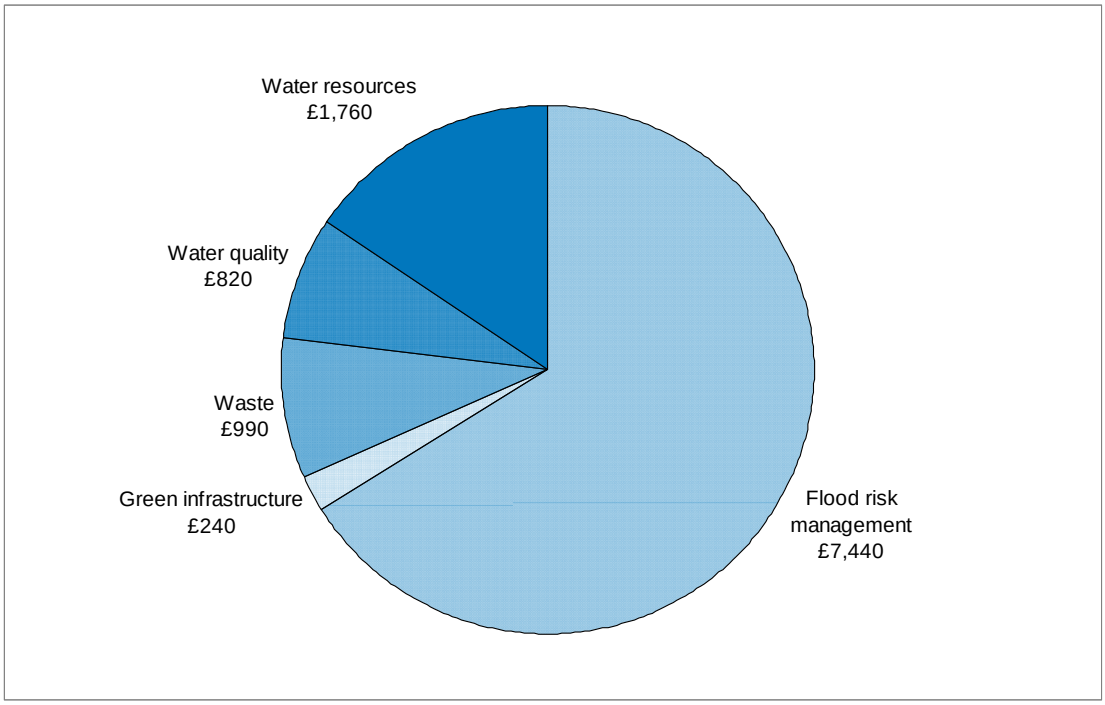



Figure 3.3 shows estimated average costs for environmental infrastructure per new home built in an area at risk of fluvial flooding. It is important to note that these are average costs presented as costs for each new home in order to outline the scale of the challenge for each infrastructure area. The actual costs for each home will depend on their location and circumstances. For flood risk, for example, costs will vary greatly

depending upon the most sustainable solution in each case. In most cases, it is more sustainable to reduce risk through development's layout and design rather than create new defences.

**Figure 3.3 Estimated average costs for a new home in an area at risk of flooding from a river**



# 4 Flood risk management

## 4.1 Overview

Flooding is a major threat to communities. It puts lives at risk, and can destroy our infrastructure, disrupt communities and cause a huge amount of damage to our homes and businesses. The risk of flooding will continue to grow in the future. Climate change is causing variations in rainfall patterns, and population growth is placing ever greater demands on land. To protect our homes and communities, careful planning is necessary to identify and manage flood risks.

Our homes are at risk from several different types of flooding, depending on where they are built. We have a good understanding of how fluvial and tidal flooding can threaten our homes, but we also need to be aware of threats from surface water, coastal erosion and other sources. It is vital that new homes are built in appropriate places. They must also be designed carefully to avoid increasing the risk of flooding, keep people safe and minimise the damage from flooding.

The Environment Agency's role in England is to take a strategic overview of flooding from rivers, the sea, surface water and groundwater. An enhanced oversight role is planned for Wales. We manage flood risk from rivers and the sea. We also provide guidance to local authorities to lead the local management of coastal erosion and flooding from surface water, small watercourses and ground water. Additionally, we provide information to other organisations, such as utility companies and insurers.

This section explores the scale of the challenges involved in managing the risk of flooding to new homes in London.

## 4.2 Our approach

It is very difficult to assign a cost for flood risk management infrastructure, given the importance of site-specific details and location in determining costs. This study uses a methodology developed nationally to estimate the potential costs of managing flooding to new homes using capital defences.

Our methodology uses the National Flood risk Assessment (NaFRA)[5] to determine the number of new homes in London that could be at risk of fluvial or tidal flooding[6] without investment in additional flood defences. The methodology identifies the number of new homes that will have more than a one per cent annual probability of flooding[7]. It then estimates how much it could cost to provide additional flood protection to each of these homes, in order to reduce the annual probability of flooding to less than one per cent[8].

[5] NaFRA is an Environment Agency tool. It assesses the probability of flooding for all areas of the UK which fall within Flood Map Zones 2 or 3. It puts these areas into Low, Moderate and Significant Risk Categories. These calculations take into account the protection provided by existing defences. See http://www.environment-agency.gov.uk/research/library/publications/108660.aspx for more details.

[6] We cannot accurately predict the number of new homes that will be built in areas of flood risk, as we do not know the exact locations of all new homes. Our methodology allows the user to test different scenarios for the location of new homes.

[7] Probability of flooding is expressed as a percentage and/or an annual chance. A one per cent annual probability of flooding – a 1 in 100 chance of flooding at that location in any given year – is the relative frequency of occurrence of that event, out of all possible events. It does not mean that a site will flood once every 100 years.

[8] This is the required minimum standard of protection from fluvial flooding, as outlined in Planning Policy Statement 25.

Costs for reducing flood risk are based on building capital flood defence schemes, such as walls or embankments. They also include estimated costs for compensatory storage, to recognise that schemes should not increase flood risk in other areas[9].

However avoiding future flood damages and reducing risk to new homes through appropriate location, layout and design will be preferable to the approach modelled through this methodology. Steering development away from flood risk areas, or ensuring it is safe and resilient to floods is far more sustainable and cost beneficial than constructing new defences which require on-going maintenance, replacement and upgrading.

During 2008/09 our role in advising local planning authorities across England and Wales ensured that over 700,000 new homes would be located in the right locations and designed to keep people safe during a flood. This has resulted in over £400 million of flood damages avoided in any given year.

Our methodology only considers new homes, and does not take account of existing homes in areas of flood risk, or the Environment Agency's ongoing investment to maintain existing defences. We have identified where new houses could be built in areas with greater than a 1 per cent risk of flooding. The flood risk costs associated with areas which are already protected to above a 1 in 100 year standard are not considered, whether new houses were built there or not.[10]

We have not looked at managing flood risk from surface water in this study. This is because of the current lack of suitable data on the risks of surface water flooding to new homes.

At this stage we have not been able to look at changes in the annual probability of flooding associated with the latest climate change projections. We hope to be able to do this in the near future as NaFRA data is updated to take account of the latest climate change projections.

For more information on our approach, please see the flood and coastal risk management section in our accompanying report, *A Methodology for Evaluating Environmental Infrastructure Needs.*

## 4.3 What are the flood risks affecting London?

### 4.3.1 Tidal flooding

London's greatest flood risk challenge comes from the River Thames. Much of London's flood management efforts and resources are allocated to protecting the city from tidal flooding. As a result, London benefits from a very high degree of protection against tidal flooding: it has less than a 0.1 per cent chance of tidal flooding in any given year.

The Thames Estuary 2100 (TE2100)[11] plan sets out the actions for ensuring that London remains protected from tidal flooding for the next century. Over the next ten years, the Environment Agency expects to spend about £300 million[12] on maintaining and replacing the tidal defences along the Thames estuary. This spending would take

[9] This is in line with recommendations in Planning Policy Statement 25.
[10] For more information on the derivation of costs and the number of new homes which could be built in areas with a risk greater than 1% per annum please see the Technical Annex to this report.
[11] For more information on TE 2100, see http://environment-agency.gov.uk/research/library/consultations/106100.aspx
[12] Derived from the TE2100 report (see link above).

place even without new housing development. We have not therefore added any of these costs to the protection of new housing. Any new housing should be located and designed to be safe and sustainable, as well as not relying on the public purse to upgrade or build new defences in the future. That said, new developments and riparian owners may have to contribute towards the cost of tidal defences in the future.

### 4.3.2 Fluvial flooding

London is protected to a very high standard against tidal flooding from the Thames estuary. But there are many smaller rivers and tributaries which are prone to flooding. As the country's most heavily developed and densely populated area, London is under increasing pressure to develop or redevelop areas that are at risk of flooding.

More than 30,000 homes in London are already at significant risk of flooding[13]. If London is to grow as planned over the next 20 years, it is likely that new homes will be built in areas of similar flood risk. This will pose a further challenge to managing flood risks in the city. However it is also a crucial opportunity to reduce the risks through developments that have new layout and designs which will keep people safe and reduce flood risk to the surrounding communities.

### 4.3.3 Surface water flooding

Surface water also poses flood risks for London. It occurs when heavy rainfall overwhelms the drainage capacity of the local area. It is difficult to predict and pinpoint, much more so than river or coastal flooding. The city is largely covered by impermeable surfaces which do not let rainfall seep away. The situation has been made worse by infill development that increases the amount of impermeable area. Such development is referred to as 'urban creep'.

This report does not cover the cost of methods of dealing with rainfall. These include Sustainable Drainage Systems (SuDS)[14] and other methods that deal with surface water at source. In the future these are likely to play a greater part in addressing urban creep and dealing with the risks of flooding from surface water.

The threat posed to London by surface water flooding is not as well understood as the risks of fluvial or tidal flooding. At this stage, there are indicative maps that show where surface water flooding could occur. The Drain London forum[15] has been established to improve our understanding of the risk posed to London by surface water flooding.

### 4.3.4 Flood risk management policy

The location of new homes will have a major impact on future flood risks. PPS25[16] states that new development should not take place in areas of flood risk, unless there are no alternative sites available in areas at little or no risk of flooding. However, the amount of land available for development in London is limited. Building in areas of flood risk may be the most viable option.

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[13] Defined as having a greater than 1 in 75 chance of flooding each year by the National Flood risk Assessment (NaFRA).

[14] For more information on Sustainable Drainage Systems, see http://www.environment-agency.gov.uk/business/sectors/36998.aspx

[15] For more information on Drain London, see http://www.london.gov.uk/priorities/environment/water-management/rainwater-drainage

[16] For more information on PPS25 see: http://www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/planningpolicystatements/planningpolicystatements/pps25/

PPS25 requires any development in an area of flood risk to take account of flooding from all sources, now and in the future, and put in place adequate measures to ensure that the development is safe and does not increase flood risk elsewhere. This covers redevelopments as well as new developments, providing an opportunity to reduce flood risk through site layout, housing design, incorporation of sustainable drainage and the construction of new or improved flood defences.

### 4.3.5 Climate change

The latest UK climate science (UKCP09) confirms that rising sea levels and more severe and frequent rainstorms will greatly increase the risk of significant flooding and coastal erosion.

Our *Long Term Investment Strategy for England*[17] sets out our investment options to manage flood risk over the next 25 years. We will need to steadily increase investment in building, improving and maintaining defences. This will be necessary if we are to maintain current levels of protection in the face of climate change.

Our Catchment Flood Management Plans will play an important role in assessing future flood risk and in shaping our response over the next 50 to 100 years. TE2100 sets out a strategic flood risk plan for the Thames estuary until the end of the century. Research from this project was used to develop UKCP09 projections for rises in sea level.

[17] For more information on the *Long Term Investment Strategy*, see: http://www.environment-agency.gov.uk/research/library/publications/108673.aspx

**What methods are available for managing flood risks?**

London covers a large urban area and has only limited stocks of undeveloped open land. Because of this, fluvial flood risk has to be managed through a complex and interconnected system. Water either has to be accommodated in the floodplain or diverted elsewhere (to minimise the impact on people and property).

It is rarely appropriate just to build new walls or other hard flood defences around housing developments. This approach can also create problems for other areas by raising water levels or creating new flood routes. New raised flood defences may result in the loss of existing floodplain and require compensatory storage[17]. This avoids creating problems further downstream.

Further, it is not always either possible or feasible to protect homes through hard or capital defences. Views and access to rivers can also be obstructed when new flood defences are built and may not be the type of flood protection measures that the community want.

Planning Policy Statement 25 (PPS25) provides the most effective strategy for managing flood risks for new homes in London. Careful planning and design can significantly reduce the risk of flooding. The correct application of the Sequential and Exception Tests ensures that new homes are only located in flood risk areas where:

- it is safe to do so; and
- all lower risk sites have already been discounted.

Where site constraints mean that some new homes may have to be sited within areas at risk of flooding without benefiting from defences, the homes should be designed so that they remain dry during a flood or where the damage and disruption during a flood is minimised. Safe access to and from the development is also important and a requirement of PPS25.

PPS25 and the associated best practice guide set out a hierarchy of options for minimising flood risks through housing design. If the planning process is followed correctly, there may be no need for hard or capital defences. However, flood risk issues and the likely costs need to be properly thought through at the very beginning of the planning process.

## 4.4 What are London's future flood risk management needs?

### 4.4.1 The number of new homes requiring additional flood risk management interventions

Just how many new homes will require additional flooding protection depends on how many new homes are built, and where they are built. Table 4.1 shows the effects of different housing growth scenarios. The results assume that new housing will be evenly distributed across the area of each London borough. Details of housing allocations for London boroughs are set out in the Draft Replacement London Plan.

**Table 4.1 New homes requiring additional fluvial flood protection**

| New homes per year | Number of new homes requiring additional protection each year | Total number of new homes requiring additional protection by 2031 |
|---|---|---|
| 0 | 0 | 0 |
| 33,400 | 1,650 | 36,300 (5% of total 734,800) |
| 44,700 | 2,200 | 48,500 (5% of total 983,400) |

Notes:

- These figures reflect the number of new homes which would have a greater than 1% annual probability of fluvial flooding, unless there is some form of flood risk management intervention.
- These figures are based on an even distribution of new homes throughout each London borough. This means that the proportion of new homes in areas of flood risk is equal to the proportion of land which is at risk of flooding. For example, it is assumed that a London borough with 10% of its land area at risk of flooding would allocate 10% of its new homes to areas at risk of flooding.

### What do these results show?

- Around five per cent of London's new homes would require some form of flood risk management intervention, if housing growth is evenly distributed within each London borough.
- This equates to 1,650 new homes requiring flood risk management intervention out of the Draft Replacement London Plan target of 33,400 new homes a year.
- Housing growth of 44,700 new homes a year would mean 2,200 new homes per year needing flood risk management intervention – a total of 48,500 by 2031.

### What do these results mean?

The potential requirements for protecting new homes vary between different London boroughs. This is because some have higher levels of flood risk than others, and because different boroughs have different housing growth targets.

Nearly 60 per cent of the new homes identified as being at risk in Table 4.1 will be concentrated in five east London boroughs: Tower Hamlets; Barking and Dagenham; Greenwich; Newham; and Havering.

Two London boroughs, Camden and Islington, have no rivers. Here there will be no new homes requiring additional fluvial flood protection. Like all boroughs, they may still be at risk from surface water flooding and new homes will need to have sustainable drainage.

While we have assumed an even distribution of housing in each borough, the actual allocation of new housing sites will impact on the proportion of new housing within the fluvial or tidal floodplain. If new homes can be built in areas that are not at risk from flooding, fewer homes will require flood risk management interventions.

However, London has little land available for development. Developing in flood risk areas may sometimes be the only viable option. Indeed, redevelopment of sites already at risk offers an opportunity to reduce risks and will be encouraged in some places.

Housing development may also provide an opportunity to improve the management of flood risks for *existing* homes. If new homes built in flood risk areas are designed appropriately, they may reduce flood risk not just on the development site itself but also on other sites within the floodplain.

### 4.4.2 The cost of providing additional protection

Table 4.2 shows how much it might cost to provide additional fluvial flood protection for new homes through capital flood defence schemes[18].

**Table 4.2 Costs of protecting all new homes with capital flood defences**

| New homes per year | Total cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|
| 0 | 0 | 0 |
| 33,400 | 270 | 12.4 |
| 44,700 | 365 | 16.6 |

Notes:

- These figures refer to the cost of managing flood risk to new homes which would have a greater than 1% annual probability of fluvial flooding, unless additional protection from flooding is provided.
- These figures are based on an even distribution of new homes throughout each London borough. This means that the proportion of new homes in areas of flood risk is equal to the proportion of land which is at risk of flooding. For example, it is assumed that a London borough with 10% of its land area at risk of flooding would allocate 10% of its new homes to areas at risk of flooding.
- The costs include both the cost of defending new homes, and the cost of compensatory storage to offset any impacts on flood risk elsewhere.

#### What do these results show?

- The Draft Replacement London Plan has a target of 33,400 new homes a year. The cost of protecting these new homes through capital flood defence schemes is likely to be more than £12 million a year. The total cost by 2031 could be around £270 million.
- If there are 44,700 new homes a year, the additional protection for new homes could cost more than £16 million a year – a total of £365 million by 2031.
- For the level of housing growth set out in the Draft Replacement London Plan, the cost of additional fluvial flood protection for each new home built in an area of flood risk is approximately £7,500.

#### What do these results mean?

By 2031, London could have at least 36,000 new homes with a greater than one per cent annual probability of flooding. It is vital that any new development in London adequately addresses these potential flood risks.

[18] Capital flood defence schemes include walls, embankments and barrages, or any other scheme which keeps flood water away from an area of land. The cost of compensatory storage is also taken into account. Avoidance, resistance and resilience measures are not included.

Table 4.2 shows the scale of investment that could be required in capital flood defence schemes. But in many cases these costs could be reduced or avoided through the rigorous application of PPS25. This requires that flood risk be taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk.

It will not always be feasible to protect all new homes through capital flood defences. London's flood risk protection system is complex. Capital defences are not always possible or wanted by the local communities since they can obstruct views and access to the river and riverside. There is often simply not enough space or the cost of land is prohibitively high.

The importance of addressing flood risk is emphasised by the potential costs of damage caused by flooding. The summer 2007 floods affected some 48,000 homes. The estimated cost to the UK economy was £3.2 billion (of which £1.2 billion fell to households) [19]. If floods of a similar scale and intensity hit London, the costs are likely to be much higher. London has a far greater concentration of buildings and infrastructure. The economic disruption would also be much worse.

## 4.5 Managing London's flood risk management needs

### 4.5.1 Changing the proportion of new homes in flood risk areas

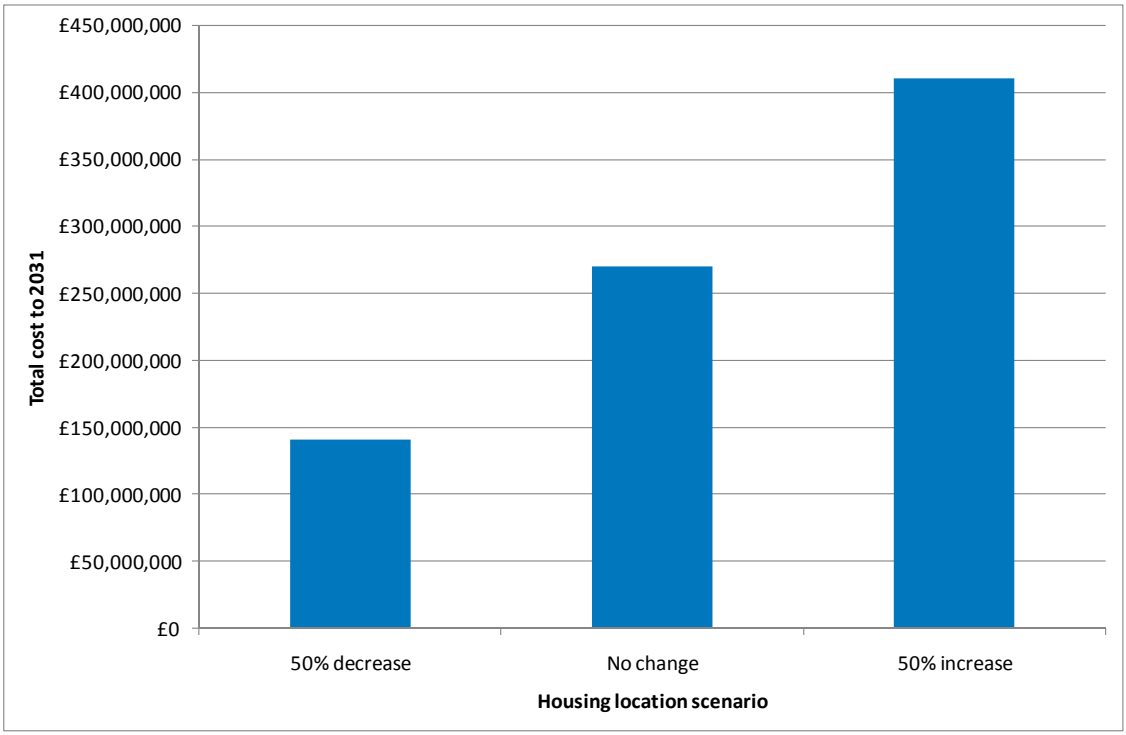
Table 4.2 highlighted the costs of building new homes in areas of fluvial flood risk if new housing were distributed evenly across each borough. Figure 4.1 shows what happens if we change the proportion of new homes built in at-risk areas.

There are three scenarios:

1. 50% decrease – development is diverted away from flood risk areas. Only half as many homes are built in flood risk areas.
2. No change – new homes are assumed to be evenly distributed within each borough. The proportion of new homes in flood risk areas is the same as the proportion of land in each borough which is at flood risk. (This scenario is the one used in Tables 4.1 and 4.2.)
3. 50% increase – more new homes are diverted into flood risk areas.

[19] For more information on these costs, see the Environment Agency's report into the costs of the summer 2007 floods at http://publications.environment-agency.gov.uk/pdf/SCHO1109BRJA-e-e.pdf

### Figure 4.1 The impact of changing the location of new homes




Notes:

- These figures reflect the number of new homes which would have a greater than 1% chance of fluvial flooding each year, unless additional protection from flooding is provided;
- The 'change in proportion' scenarios relate to the even distribution of homes used in Tables 4.1 and 4.2.
- These figures are based on the Draft Replacement London Plan target of 33,400 new homes each year.
- The costs include both the cost of defending new homes, and the cost of compensatory storage to offset any impacts on flood risk elsewhere.

## What do these results show?

- Reducing the proportion of new homes built in flood risk areas would reduce the costs of providing some form of risk reduction (for example increased resilience or flood defences).
- Using an approach based on costs for capital defences, building half as many homes in flood risk areas could reduce the estimated annual cost to £6.2 million – a total of £140 million by 2031.
- If the proportion of new homes built in flood risk areas increases by 50 per cent, the estimated annual cost rises to £18.6 million – and to a total of £410 million by 2031.

## What do these results mean?

The more homes built in areas of flood risk, the more investment would be needed on fluvial flood protection. Depending on the location of new homes, the total annual cost for protecting new homes in London could be in the range of £6.2 million to £18.6 million.

However, it is important to look at these figures in a wider context. There may be benefits to building in areas of flood risk. Carried out properly, redevelopment can be

an opportunity to reduce flood risk for existing homes and to provide other financial and environmental benefits to the surrounding area. In some boroughs, sites at risk of flooding may also be the only viable places for new development.

## 4.6 Key findings and implications

### 4.6.1 Key findings

If housing growth of 33,400 new homes a year is achieved up to 2031, London could need some form of flood risk intervention for 36,300 new homes. The final figure will depend on exactly where the new homes are built.

If capital defence schemes were used to protect new homes from flooding, it could cost more than £7,500 for each new home in London built in an area of existing fluvial flood risk. This equates to a total cost of around £270 million by 2031.

Although the Environment Agency plans to maintain and improve existing flood defences, we will not be able to fund the protection required for all new housing. These costs will need to be met through the range of partners involved in the development process.

The most sustainable way of accommodating new housing growth is to locate new development in the areas of lowest risk. In London, many sites currently at risk of flooding will be redeveloped. By improving the layout and design of these redeveloped sites, there is a crucial opportunity to reduce risks and avoid the need to construct new defences that will require future maintenance.

The framework set out in Planning Policy Statement 25 (PPS25) provides a clear route for ensuring that new development is located and designed to be safe. If new development must be located in the floodplain, it should also aim to reduce flood risk to the surrounding community and provide investment for maintaining or upgrading any existing flood defences that it will depend on.

### 4.6.2 Implications

#### Ongoing investment in existing defences

We have estimated a scale of costs for protecting new homes built in areas of flood risk. In addition to this there is substantial planned investment to maintain, operate and improve existing defences, as well as to adapt to climate change. Foremost is the planned spend of around £300 million over the next ten years to maintain and replace the tidal defences along the Thames estuary.

#### Strategic planning essential for managing flood risk

Proper application of PPS25, and planning for flood risk at an early stage will reduce the costs of future flood risk management. This underlines the importance of the strategic planning process: new homes must be built in the right places using the right layout and design.

#### Early liaison on development design

When planning new developments, flood risks need to be taken into account at an early stage with careful consideration of the location, layout and design of new housing

sites. Developers should discuss options with the local planning authority and the Environment Agency before they send in their planning application.

### Ensure developers contribute appropriately

Developers should meet any costs for flood defences for new developments, either by directly funding defences, or by contributing to a wider flood risk management fund. Funding mechanisms available to the London boroughs include section 106 agreements[20] and local levy or tariff schemes.

### Consider all sources of flooding

London is already protected from tidal flooding. This report only looks at the cost of hard defences and capital schemes to protect new homes from fluvial flooding. However it is important to consider the flood risk from all sources, including surface water. This will ensure that new homes have the best possible protection from flooding.

### Consider links to green infrastructure

Rivers, canals and green spaces are all part of a city's green infrastructure. London has the opportunity to link its flood risk management to that wider infrastructure. This would enable flood risk management to bring other benefits, such as biodiversity, recreation space and climate change adaptation. Making the best use of flood plains, wetlands, river restorations and Sustainable Drainage Systems will also enhance the character and sustainability of the city.

### Other costs associated with flooding

The costs of managing flood risk go beyond capital schemes for flood defences. For example, if there are more homes in the flood plain there will be further demands placed on flood forecasting, warning and the emergency services. It will also extend the resources involved in emergency planning.

[20] For more information on planning obligations/S106 see: http://www.communities.gov.uk/planningandbuilding/planning/planningpolicyimplementation/planningobligations/modelplanningobligation/

# 5 Green infrastructure

## 5.1 Overview

Green infrastructure greatly affects the quality of life in our cities. Networks of green space and water help us to respond to climate change, manage flood risk, protect wildlife and habitats, and improve water and air quality. Such networks also encourage recreation and improve our health and sense of well-being.

Green infrastructure is distinct from the other areas of infrastructure discussed in this report in that it can provide a variety of services. It can play an important role in supporting other forms of infrastructure, including water management and flood risk. It is therefore a valuable part of any city's infrastructure.

A number of different organisations are involved in planning and managing green infrastructure. The Environment Agency focuses on the benefits it can bring for flood risk management, climate change adaptation, water based recreation, biodiversity, water resources and water quality.

**What is green infrastructure?**

Green infrastructure is about more than open space. It is a network of features – all of which, in their different ways, support the sustainability of our towns and cities. Green infrastructure provides many economic, social and environmental benefits and services.

One example would be the green corridors around our rivers. These help to protect homes from flooding. But they can also provide habitats for wildlife, absorb water, provide space for recreation and help to improve air quality.

Similarly, a park's primary function may be to provide space for recreation and amenity. However, it can also promote biodiversity and conservation. It may help with surface water runoff. It can be a corridor for sustainable transport, helping to mitigate climate change. Equally, it provides a space that brings communities together and promotes health and wellbeing.

Examples of green infrastructure include:

- parks and gardens;
- playing fields and allotments;
- towpaths and wildlife corridors;
- beaches;
- watercourses;
- wetlands and flood storage areas;
- woodlands;
- grasslands;
- green roofs and walls.

## 5.2 Our approach

Our methodology works out how much additional green infrastructure would be needed to meet a target level of provision for each London borough. The amount is expressed in hectares. We do not set out the type of green infrastructure required or where it should go. Our aim is to provide a broad framework for assessing the scale of what is needed.

We have based our targets on maintaining and improving the existing amount of natural space in each borough. We try to establish what is needed:

- to replace green infrastructure lost through housing development;
- to increase levels gradually over time.

Our work should broadly reflect the ambitions of existing local strategies.

The methodology looks at the effects of housing development on green infrastructure. It is self-evident that building on undeveloped green spaces reduces local levels of green infrastructure. This loss needs to be offset by creating new green infrastructure. This could be new green open space, or could be provided by retrofitting existing homes with green roofs or Sustainable Drainage Systems.

There is limited information available on the overall costs of green infrastructure, and different types of green infrastructure have different costs. Our approach has focused on the overall provision of infrastructure. We have not taken account of land costs.

For more information on our approach, please refer to the green infrastructure section of the accompanying report, *A Methodology for Evaluating Environmental Infrastructure Needs.*

**Does brownfield land count as green infrastructure?**

The London Plan expects 96 per cent of all new housing growth to take place on brownfield land (*London Strategic Housing Land Availability and Housing Capacity Study*, Greater London Authority, 2009*)*

As defined in PPS3, land which has blended into its 'natural surroundings' cannot be classified as brownfield. However, brownfield sites often act as green infrastructure – aiding biodiversity, soaking up surface and flood waters and linking other sites*.* Some sites will be used for recreation.

The London Development Agency estimates that 90 per cent of London's brownfield land is currently built on. For the purpose of this study, we have assumed that the remaining 10 per cent acts as green infrastructure.

## 5.3 What is the current state of green infrastructure in London?

At present, 63 per cent of London is covered by green space, gardens or water[21]. However, much of this space is located in Outer London and within the greenbelt[22].

[21] Derived from the Generalised Land Use Database. See www.communities.gov.uk/publications/planningandbuilding/generalisedlanduse for more information.

London is the UK's most heavily developed area. Much of the city is covered by buildings, roads and paved areas. The best possible use needs to be made of land that is available for green infrastructure.

Many places have little in the way of open green space. In many Inner London boroughs[23], the proportion of green space is less than 20 per cent. The boroughs with the lowest proportions of green space include Hammersmith and Fulham, Kensington and Chelsea, Islington, Lambeth and Tower Hamlets. However, this does not mean that they cannot have a network of green infrastructure which provides a wide range of benefits.

Much of the existing resource is fragmented, and not linked in to a wider network. Several plans and strategies aim to improve the situation. The Draft Replacement London Plan seeks to increase the amount of surface area greened in central London by at least five per cent by 2030. The Mayor has also set out a plan to enhance up to 1,000 hectares of green infrastructure by 2012.

Local and regional government in London has acknowledged the importance of creating networks of green infrastructure. There is a commitment to developing the 'All London Green Grid'. This would create unbroken networks of green infrastructure, through the city and along strategic corridors, such as rivers and key transport routes.

The Quaggy River flood alleviation scheme[24] is a good example of the many benefits that green infrastructure can bring to communities. The scheme developed open spaces along a two-mile stretch of the Quaggy River that was prone to flooding. The clever design reduced flood risk for local people, as well providing space for recreation and biodiversity.

[22] 22% of London's land is greenbelt, according to *Greener London*, the Mayor's State of the Environment Report (2007).

23 The Inner London boroughs include Camden, Greenwich, Hackney, Hammersmith and Fulham, Islington, Kensington and Chelsea, Lambeth, Lewisham, Southwark, Tower Hamlets, Wandsworth, Westminster and the City of London.

[24] For more information on the Quaggy scheme, see: www.cabe.org.uk/case-studies/quaggy-river

**What is the value of green infrastructure?**

Green infrastructure is different from other types of environmental infrastructure because it can perform so many different functions. It therefore brings many different kinds of benefits, not all of which can be valued in monetary terms. However those benefits on which we can place a monetary value do support the case for investment in green infrastructure.

Some benefits can be valued at a site-specific level, while others can only be valued across a whole network.

At a site-specific level, the value of green infrastructure varies greatly – depending on its function, location, and how it is used. Research suggests that, in the right place, high-quality urban green infrastructure can lead to direct benefits of between £40,000 and £100,000 per hectare a year. It may also provide a one-off boost of between £250,000 and £750,000 to nearby property prices. However, some of the benefits included in this, such as flood risk management, will not apply to all green infrastructure sites.

London's wider network of green infrastructure brings more general benefits. These include reducing the pressure on wastewater infrastructure, enabling sustainable transport, and promoting economic growth. These benefits could be worth tens of millions of pounds a year.

When we compare these benefits with the costs identified in this report, green infrastructure seems to offer excellent value for money. Over the 22 years to 2031, a hectare of green infrastructure could bring benefits of up to £2 million.

These figures were derived from:

- the Environment Agency's report into the costs of the summer 2007 floods: see http://publications.environment-agency.gov.uk/pdf/SCHO1109BRJA-e-e.pdf;
- the Office for National Statistics' 2009 report into Family Spending: seehttp://www.statistics.gov.uk/downloads/theme_social/Family-Spending-2008/FamilySpending2009.pdf;
- figures reported by Dr. William Bird in his 2004 paper *Natural Fit*: see http://www.rspb.org.uk/Images/natural_fit_full_version_tcm9-133055.pdf;
- research commissioned by the Royal Institute of Chartered Surveyors: see http://www.rics.org/site/download_feed.aspx?fileID=5728&fileExtension=PDF;
- the GLA paper *Valuing Greeness*: See http://www.london.gov.uk/mayor/economic_unit/docs/valuing_greenness_report.pdf.

## 5.4 What are London's future green infrastructure needs?

### 5.4.1 How much extra green infrastructure is needed?

In this study we look at the amount of new green infrastructure that could be required to offset losses from new housing development and also to increase existing levels of provision. The Draft Replacement London Plan sets out the Mayor's ambition to increase the amount of surface area greened in the Central Activity Zone[25] by at least five per cent by 2030. In this study we have extended our focus to look at the amount of green infrastructure required to achieve a five per cent increase in greening across

[25] The Central Activity Zone covers London's geographic, economic and administrative core including the City of London and parts of the City of Westminster and London Boroughs of Camden, Islington, Hackney, Tower Hamlets, Southwark, Lambeth, Wandsworth and Kensington and Chelsea.

the whole of Inner London[26] , as well as to prevent any net loss of open space in Outer London. These results are set out in Table 5.1.

**Table 5.1 Extra green infrastructure required to maintain existing levels and to increase provision by 5 per cent in Inner London**

| New homes per year | Total amount of extra green infrastructure needed by 2031 *(hectares)* | Extra green infrastructure needed each year *(hectares)* |
|---|---|---|
| 0 | 570 | 25.9 |
| 33,400 | 970 | 44.1 |
| 44,700 | 1,105 | 50.2 |

Notes:

- The amounts given here show how much extra green infrastructure is needed to offset all losses from housing development and achieve a 5% greening for Inner London boroughs. It does not include the 1,000 hectares that the Mayor of London wants to see enhanced.
- We have estimated that 13.6% of new homes in London will be built on land currently acting as green infrastructure. This is based on the London Development Agency's Brownfield Land database[27].

### What do these results show?

- To increase green infrastructure in the Inner London boroughs by five per cent by 2031, an additional 5.7 $km^2$ of green infrastructure would need to be provided – equivalent to 950 football pitches.
- If 33,400 new homes are built a year until 2031, the amount required would increase by 4 $km^2$ to 9.7 $km^2$. This is an area three times the size of Hyde Park.
- If 44,700 new homes are built a year until 2031, this would require 11 $km^2$ of new green infrastructure across London by 2031.

### What do these results mean?

These results suggest that the Inner London boroughs would need to plan for and invest in nearly 6 $km^2$ of new green infrastructure if they were to achieve a five per cent increase by 2031.

Housing growth will deplete the current stock of green infrastructure. This provision will need to be replaced. However, new housing development will provide an opportunity for creating new green infrastructure – through garden space, communal areas and the inclusion of Sustainable Drainage Systems.

We should endeavour to improve the green infrastructure in place already. There may be opportunities to introduce elements of green infrastructure into existing developments, where these are subject to redevelopment, refurbishment, conversion or change of use.

[26] In this study Inner London covers the City of London, City of Westminster and London Boroughs of Camden, Islington, Hackney, Tower Hamlets, Southwark, Lambeth, Wandsworth and Kensington and Chelsea, Greenwich, Lewisham and Hammersmith and Fulham.
[27] See www.londonbrownfieldsites.org/Content/home.aspx for more information.

This study only looks at quantities of green infrastructure. Housing growth may also compromise the quality or integrity of existing green infrastructure, as increased population puts additional pressure on existing resources.

### 5.4.2 How much will the extra green infrastructure cost?

Table 5.2 sets out the estimated costs of a five per cent increase in green infrastructure in Inner London boroughs, and of offsetting any losses from housing development. It does not include the costs associated with enhancing the existing provision.

**Table 5.2 Additional costs for providing green infrastructure under different housing growth scenarios**

| New homes per year | Total additional cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|
| 0 | 100 | 4.6 |
| 33,400 | 175 | 7.9 |
| 44,700 | 200 | 9.0 |

Notes:

- The costs indicate how much extra green infrastructure would be needed to offset all losses from housing development and achieve a 5% greening for Inner London boroughs.
- We have estimated that 13.6% of new homes in London will be built on land acting as green infrastructure. This is based on the London Development Agency's Brownfield Land database.
- These cost figures reflect the costs of creating and maintaining high-quality green infrastructure at ground level. It includes hard and soft landscaping, topsoil, trees and associated infrastructure. The costs do not include land values.

#### What do these results show?

- With zero housing growth, around £4.5 million a year could be needed to achieve a five per cent increase in green infrastructure across Inner London by 2031. This adds up to a total of £100 million by 2031.
- Offsetting losses from 33,400 new homes and still achieving a five per cent increase in green infrastructure could require an annual investment of almost £8 million – a total of £175 million by 2031.
- If 44,700 new homes are built a year, the annual outlay could increase further – to £9 million. This would add up to £200 million by 2031.

#### What do these results mean?

To offset losses from housing growth and achieve a five per cent increase in green infrastructure in Inner London by 2031 there would need to be substantial investment in green infrastructure.

However, this investment can be justified by the multi-functional benefits additional green infrastructure will provide. Well-planned green infrastructure may reduce costs in other areas such as water quality and flood risk management.

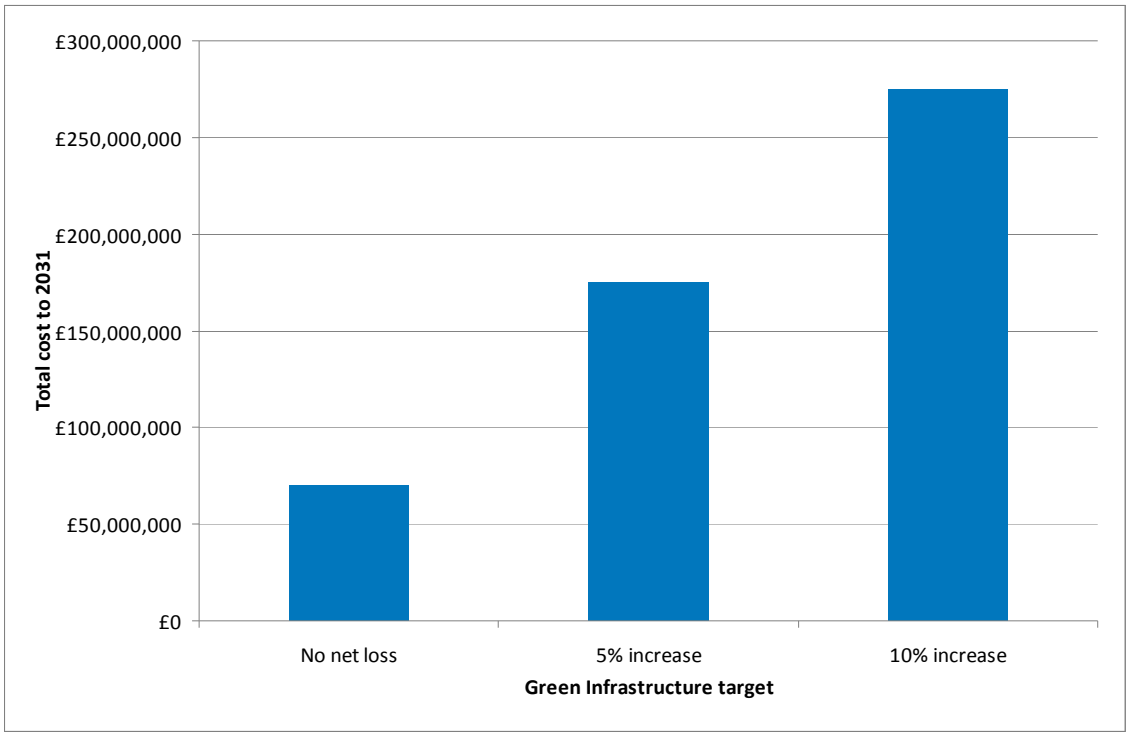
The investment described in this study only relates to creating new green infrastructure. Additional investment will be needed to meet the Mayor's target of enhancing 1,000 hectares of green infrastructure by 2012.

## 5.5 Managing London's green infrastructure needs

### 5.5.1 Other targets for green infrastructure

Section 5.4 looked at what would be needed to increase provision by five per cent in Inner London boroughs by 2031. Figure 5.1 compares these results with those for other possible targets.

**Figure 5.1 Costs of different green infrastructure standards**




Notes:

- These figures reflect a scenario where the Draft Replacement London Plan target of 33,400 new homes per year is met;
- These cost figures reflect the costs of creating and maintaining high-quality green infrastructure at ground level, including hard and soft landscaping, topsoil, trees and associated infrastructure. The costs do not include land values.

**What do these results show?**

- We could need nearly 4 $km^2$ of additional green infrastructure just to cancel out the effects of housing growth. This could cost a total of £70 million by 2031 – an average of £3.2 million a year.
- A more ambitious target would be a ten per cent net increase of provision within Inner London boroughs. This could cost a total of £275 million by 2031 – an average of £12.5 million a year. This is an increase of £100 million over the five per cent target considered in Table 5.1.

### What do these results mean?

Even if the funding is available, it may not be feasible to allocate this much extra land to green infrastructure. The boroughs in Inner London are heavily developed and open space is in short supply.

It will be important to consider the use of green roofs and green corridors along roads and other developed areas. Incorporating these features into new development will allow more effective use of available land.

It will also be important to improve existing resources, so that they can bring as many benefits as possible to the community and the environment.

## 5.6 Key findings and implications

### 5.6.1 Our key findings

To offset losses from new housing development at the level set out in the Draft Replacement London Plan, around 4 $km^2$ of new green infrastructure could need to be provided in London by 2031. This equates to almost three Hyde Parks and could cost around £70 million.

A five per cent increase in the area of green infrastructure in Inner London boroughs by 2031 would require an additional 5.7 $km^2$ of new green infrastructure.

Meeting this level of provision could cost around £175 million by 2031. These costs could be met by the range of partners involved in the development process, including London boroughs and developers. They could also be offset by potential cost savings in other infrastructure areas, for example where green infrastructure provides essential flood alleviation or water services.

### 5.6.2 Implications

#### Plan green infrastructure alongside other environmental services

Green infrastructure is an essential feature of our cities. It is especially important in London because of the high density of people and buildings. It needs to be planned for alongside other types of infrastructure and considered at the earliest stage of the planning process.

#### Make sure green infrastructure brings as many benefits as possible

Green infrastructure can be helpful in many different ways. For example it can help to manage flood risks and aid London's water management. This could reduce costs for other areas of environmental infrastructure. The strategic planning process should aim to maximise the links between green infrastructure and these other areas.

#### Plan the wider network

Green infrastructure works best as part of a wider network, facilitated by long-term strategic planning. Initiatives such as the 'All London Green Grid' will provide the

framework for this planning in the future. Ideally, these networks should extend beyond London and into neighbouring authorities.

### Make the best use of available land

Land is a scarce commodity in London. However available land could be used more effectively by:

- improving the quality and range of functions performed by green infrastructure;
- using smaller pockets of land for green infrastructure;
- incorporating green infrastructure into new and existing developments – for example, by the use of green roofs or living walls.

### Ensure developers contribute appropriately

New housing developments could provide much of the green infrastructure that this study has discussed. New developments may contain features of green infrastructure, such as gardens, landscaping, green roofs and Sustainable Drainage Systems. Equally, developers may help to fund public green infrastructure through mechanisms such as section 106 agreements and local levy schemes.

# 6 Waste

## 6.1 Overview

London's population currently produces almost three million tonnes of household waste a year[28]. This equates to almost one tonne for every home in London – enough waste to completely cover Regent's Park every year. This waste needs to be collected, transported and disposed of. As London's population grows, the logistics of waste management will become ever more challenging.

London's waste should be managed to minimise the amount sent to landfill – wherever possible, we should reduce, re-use and recycle (or recover) our waste[29]. To do this, we need a network of waste infrastructure that not only collects all of the waste generated, but which streams that waste for re-use, recycling or energy generation.

Household waste is only a part of the picture. It makes up only about 14 per cent of the total waste generated in London a year[30]. There are also some 19 million tonnes of other types of waste, including commercial and industrial waste and other streams of municipal waste.

The Environment Agency regulates a wide range of businesses and organisations that either use resources and produce waste, or which manage waste. We regulate operations at waste management sites, oversee international movements of waste, and run registration schemes for manufacturers. Our role also includes administering schemes for the landfill of biodegradable waste by London boroughs.

The next twenty years will see significant housing growth in London. This will put increasing pressures on waste infrastructure. There will also be future pressures associated with managing household waste from existing communities. Foremost is the impact of the landfill tax, which is providing an effective incentive to divert waste from landfill.

This section considers the scale of this challenge and how it might be managed. We also explore what would happen with different approaches to managing waste.

## 6.2 Our approach

This study looks at the management of household waste in two separate ways:

- *A market approach* – here all waste is managed through private sector contracts. Waste authorities pay by the tonne for the waste they produce, and there are no geographic limits on where waste can be disposed of.
- *Internal capacity approach* – this is designed to look at self-sufficiency. How much extra infrastructure would be needed for London to manage its household waste within its borders?

The study uses these two approaches in tandem, so that we can see the waste infrastructure needs for different policy goals.

[28] This data is derived from WasteDataFlow, a database held by Defra. This collates information on waste streams for all local authorities in England and Wales. See www.wastedataflow.org for further information.
[29] For more information see: www.defra.gov.uk/environment/waste/topics/documents/waste-hierarchy.pdf
[30] This data is from the Draft Replacement London Plan. This is available at www.london.gov.uk/shaping-london/london-plan/docs/london-plan.pdf

For both approaches, we have modelled the amount of household waste generated per person, and broken this waste down into four streams:

- recycling;
- composting;
- landfill;
- energy from waste.

We have then looked at different scenarios, in which we vary the amount of waste generated per person, the proportion recycled and the proportion sent to landfill. This allows us to test the implications of different approaches to managing household waste.

For more information on our approach, please refer to the waste section in the accompanying report, *A Methodology for Evaluating Environmental Infrastructure Needs.*

## 6.3 How does London manage its waste?

London's household waste is managed through Collection and Disposal Authorities. All London boroughs are Collection Authorities. However, twenty-two boroughs come together under four Statutory Disposal Authorities. The remaining boroughs are Unitary Authorities. They are responsible for both the collection and disposal of waste in their area.

It costs about £450 million a year to manage the three million tonnes of waste that are generated by London's households[31]. At present, London exports 44 per cent of its waste outside its boundaries[32]. Of the three million tonnes of waste collected from households each year, around half is sent to landfill. In the past, it has been most cost effective to transport much of the waste to relatively cheap landfill sites outside London.

It is neither environmentally sustainable nor financially viable for London to continue to send so much household waste to landfill. The Draft Replacement London Plan calls for London to send no household waste to landfill by 2031, and for 60 per cent of all municipal waste[33] to be recycled or composted[34].

In recent years recycling and composting rates have improved – 29 per cent of all household waste is now either recycled or composted.

At the same time, the Mayor has recognised that London should aim to become more self-sufficient and deal with more of its household waste within its own borders. This would require significant investment in waste infrastructure, backed up by careful planning. However, the long-term benefits may be large. Not only would it reduce transportation costs, but it would also end the capital's reliance on capacity in other regions. This capacity is likely to come under increasing pressure in the future.

[31] This data is reported by the Greater London Authority in the Mayor's *Draft Municipal Waste Strategy* (January 2010). See www.london.gov.uk/mayor/environment/waste/docs/draft-mun-waste-strategy-jan2010.pdf for further details.
[32] From the Draft Replacement London Plan. See www.london.gov.uk/shaping-london/ for more information.
[33] Municipal waste is defined as household waste plus some commercial waste from small businesses.
[34] This aspiration is quoted in *The Mayor's vision for London's waste,* published in January 2010. For more information, see www.london.gov.uk/mayor/environment/waste/docs/vision-jan2010.pdf

## 6.4 What are London's future infrastructure needs for household waste?

### 6.4.1 The total amount of waste generated by households

Table 6.1 sets out how much waste London's households will generate in the future. The study assumes that the amount of household waste generated per person is fixed at current levels – an average of about 370 kg per person.

**Table 6.1 Estimated household waste generated per year up to 2031**

| | ('000s tonnes of household waste) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Housing growth per year** | **2010** | **2013** | **2016** | **2019** | **2022** | **2025** | **2028** | **2031** |
| **0** | 2,780 | 2,780 | 2,780 | 2,780 | 2,780 | 2,780 | 2,780 | 2,780 |
| **33,400** | 2,810 | 2,870 | 2,930 | 2,990 | 3,050 | 3,120 | 3,200 | 3,280 |
| **44,700** | 2,820 | 2,910 | 2,990 | 3,090 | 3,180 | 3,270 | 3,370 | 3,480 |

Notes:

- The amount of household waste generated per person is fixed at current levels.
- This includes waste collected from households only.

#### What do these results show?

- If London meets its target of 33,400 new homes a year, the total amount of household waste will rise by 16.5 per cent by 2031.
- Household waste would increase by 24 per cent if there were 44,700 new homes built a year.

#### What do these results mean?

As expected, these results demonstrate that the total amount of household waste generated increases as housing growth increases. The target figures for housing growth are 33,400 new homes a year up to 2031. Unless individuals reduce the amount of waste they produce, London will need to handle an extra 500 thousand tonnes of waste by 2031.

### 6.4.2 The additional cost of managing household waste

Table 6.2 sets out the *additional* costs of managing London's household waste. It uses a market-led approach, where all waste authorities pay private sector contractors for each tonne of waste they manage. These costs are additional to the amounts they spend currently on waste management.

### Table 6.2 Additional costs of managing household waste using a market approach

| Housing growth per year | Total additional cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|
| **0** | 1,330 | 60 |
| **33,400** | 2,060 | 94 |
| **44,700** | 2,370 | 108 |

Notes:

- The additional cost is the increase in expenditure over what was spent in 2009.
- These costs reflect the cost of collecting waste from households, and paying a market rate for each tonne of waste disposed of. The costs are subject to changes in market rates.

### What do these results show?

- Even with zero housing growth, London is likely to face an increase in its household disposal costs of around £1.3 billion to 2031. These costs assume that Londoners continue to generate waste at the same rate they do now and that local authorities manage that waste in the same way. The cost increase is largely driven by increases in landfill tax up to 2015.
- Housing growth of 33,400 new homes a year would raise costs by a further £730 million, giving a total additional cost of £2.06 billion. This £730 million figure is reported as the key cost for waste in Table 3.1.

**The impact of landfill tax on London**

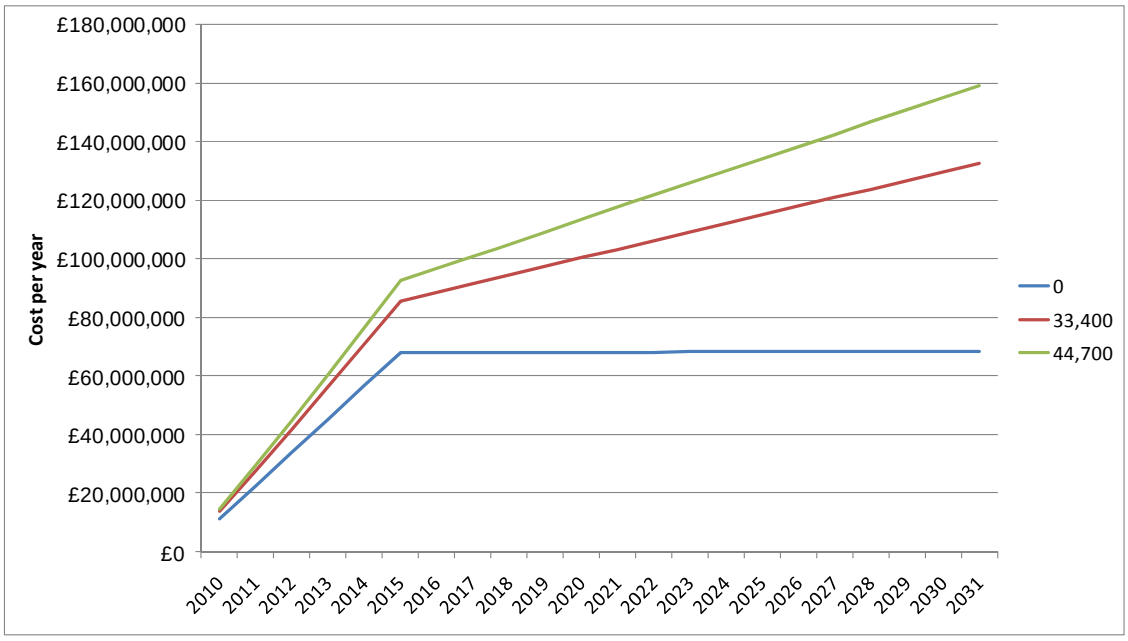
Landfill tax currently stands at £40 per tonne for biodegradable waste. This is due to rise to £80 per tonne by 2014/2015.

Landfill tax is one of the most important factors in the increasing costs shown in Table 6.2. It gives waste authorities a financial incentive to divert as much waste as possible from landfill.

Landfill tax could rise further after 2014/2015. However, for the purposes of this study, we have kept it at a constant level from 2014/2015 onwards.

Figure 6.1 shows how the cumulative costs identified in Table 6.2 will change year on year up to 2031.

**Figure 6.1 Additional cost of household waste management up to 2031**




### What do these results show?

- The additional costs of managing household waste are likely to rise sharply up to 2015, as the landfill tax rises to £80 a tonne.
- Housing growth is likely to steadily increase the total costs of household waste management after 2015.

### What do these results mean?

Increases in landfill tax will cause a sharp increase in the total cost of managing household waste up to 2015. However, housing growth will cause steady and continued increases after 2015. Without change to the way household waste is managed, the waste authorities could face a major financial challenge to accommodate this growth.

## 6.5 Managing London's household waste infrastructure needs

### 6.5.1 The impact of increasing recycling and reducing landfill

The Draft Replacement London Plan has set a target for 60 per cent of all household waste to be recycled or composted by 2031. Zero waste is to be sent to landfill, and the remaining 40 per cent of household waste is to be used to create energy. Table 6.3 compares the costs of managing London's household waste under this policy with the costs under current waste management strategies. However, it does not include any reduction in the amount of waste generated per person.

**Table 6.3 The effect of managing household waste in a different way**

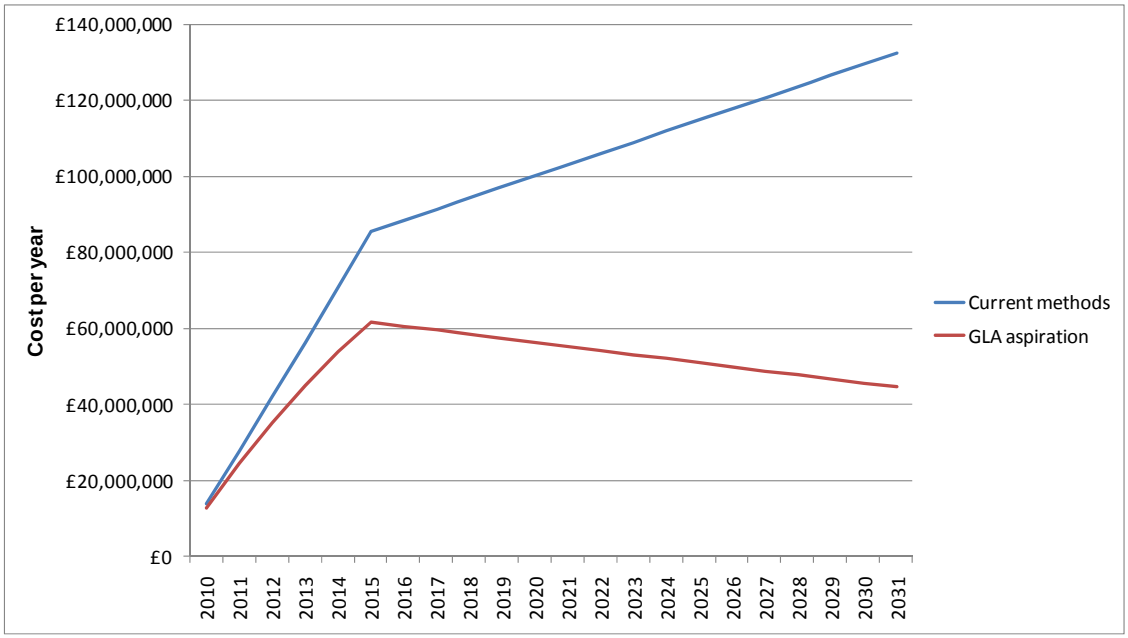
| Waste management policy | % of household waste recycled or composted by 2031 | % of household waste sent to landfill by 2031 | Total additional cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|---|---|
| Current | 29% | 51% | 2,060 | 94 |
| GLA aspiration | 60% | 0% | 1,070 | 49 |

Notes:

- The total additional cost is the increase in expenditure over what was spent in 2009.
- These costs are for housing growth of 33,400 new homes a year.
- These costs reflect the cost of collecting waste from households, and paying a market rate for each tonne of waste disposed of. The costs are subject to changes in market rates.
- There is no reduction in the amount of waste generated per person under either of these scenarios.
- The change to 60% recycling, 40% energy from waste and 0% landfill will not happen overnight. These figures assume a steady, gradual change between now and 2031.
- These costs do not take account of any spending required to make these changes happen. There may be investment needed, especially in waste collection and the sorting processes.

Figure 5.2 illustrates how we expect these costs to change over time.

**Figure 6.2 Impact of changing waste streams year on year**




## What do these results show?

- After 2013, the additional annual cost of managing household waste starts to decline, even though there is more waste being generated by households. This is thanks to increased recycling and composting.
- By recycling more household waste, and reducing the amount of waste sent to landfill, London could reduce the additional costs for managing household

waste by almost £1 billion up to 2031. This amounts to an average reduction of £45 million a year – around 10 per cent of London's current total spending on municipal waste.

### What do these results mean?

These results support the waste management approach set out the Draft Replacement London Plan. This is to re-orientate London's waste management processes towards recycling, composting and energy from waste, and away from landfill. Not only will sustainable waste processes benefit London's environment, they will also make financial sense.

The Greater London Authority has already identified that it is now cheaper to recycle household waste than to send it to landfill[35]. This is due to rises in landfill tax. The difference will become even more marked over the next three years, as landfill tax will continue to rise until 2015. This should provide a strong incentive for waste authorities to divert their household waste away from landfill.

By 2031, the cost savings from adopting more efficient household waste management processes could be more than £85 million.

## 6.5.2 The impact of reducing waste generation

It may also be possible to reduce the amount of household waste generated per person. The Mayor's *Draft Municipal Waste Management Strategy* calls for a 20 per cent reduction in the amount of household waste produced per person by 2031. Table 6.4 sets out the impacts of such a reduction, as well as the effects of an intermediate ten per cent cut.

**Table 6.4 The effect of reducing the generation of household waste**

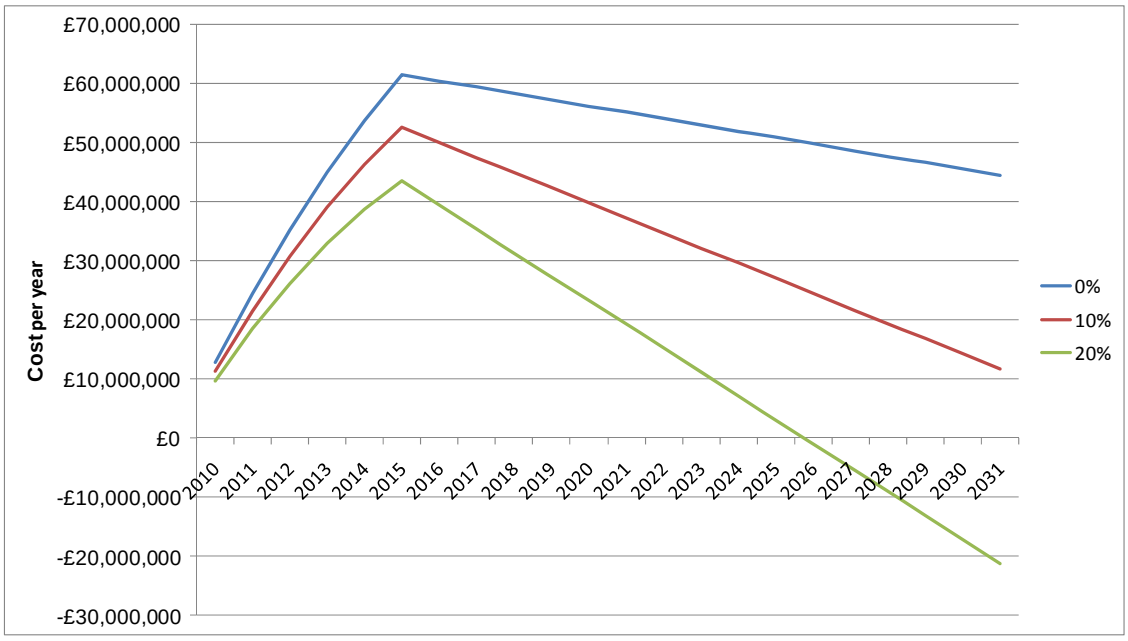
| Reduction in household waste generation rate | Total additional cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|
| 0% | 1,070 | 49 |
| 10% | 690 | 31 |
| 20% | 315 | 14 |

Notes:

- The additional cost is the increase in expenditure over spending in 2009.
- These costs assume 33,400 new homes are built a year. Also, they reflect the Greater London Authority's target of achieving 60% recycling and 0% landfill by 2031.
- These costs cover collecting waste from households, and paying a market rate for each tonne of waste disposed of. The costs are subject to changes in market rates;
- The change to sending 60% of household waste for recycling and nothing to landfill will not happen overnight. These figures assume a steady, gradual change between now and 2031.
- These costs do not take account of any spending required to reduce the rate of household waste generation. There may be investment required to achieve this.

[35] This is cited on page 9 of the Mayor's *Municipal Waste Strategy*. For more details, see www.london.gov.uk/mayor/environment/waste/docs/draft-mun-waste-strategy-jan2010.pdf

**Figure 6.3 Impact of reducing household waste generation rate year by year**




## What do these results show?

- Reducing the amount of household waste generated per person by 20 per cent, could reduce the additional costs of household waste management by more than £750 million.
- If London reduces the amount of waste generated per person by 20 per cent, as well as diverting waste from landfill, the additional cost of managing waste from new homes could be reduced to £315 million. This is the headline figure reported in Table 3.2.
- Over the next two decades the additional costs of household waste management could fall below 2009 levels, even with 33,400 new homes a year.

## What do these results mean?

In the long term, a reduction in household waste generation, combined with increased recycling and less waste being sent to landfill, could significantly reduce the costs of household waste management.

However, there will be costs associated with behavioural change and the interventions necessary to increase recycling and reduce the amount of waste produced per person. These costs have not been included in our figures.

Future savings could be redeployed to initiatives for managing demand and changing behaviour. These would help to reduce costs in the long term.

**How can London achieve its waste reduction and recycling targets?**

**Resource efficiency**

Residents and businesses should be encouraged to reduce the amount of material they use, especially materials which cannot be re-used or recycled. This might involve reducing packaging or reducing food waste or encouraging people to re-use materials, rather than throw them away.

**Influencing behaviour**

People's behaviour plays a big part in waste management. Household recycling and composting relies on residents to sort their waste. Behaviour also influences the amount of waste that people throw away.

**Offering incentives**

Price incentives can be a good way of encouraging people and organisations to manage their waste more effectively. Price incentives such as landfill tax are already influencing waste authorities.

**Improving collection techniques**

How we collect household waste largely dictates how we can dispose of it. If we improve our separation of waste into the different waste streams, this could improve recycling rates. London's waste authorities would also receive more money from selling recycled material for re-use in another form.

**Investing in technologies to divert waste from landfill**

There are also a number of technological options that allow us to make use of resources that would otherwise be sent to landfill. These options include: Mechanical Biological Treatments; Mechanical Heat Treatments; and advanced Energy from Waste treatments.

**Designing new homes to encourage recycling**

New homes should be designed with spaces allocated for recycling. In blocks of flats and other large buildings, this might include communal spaces for recycling, or chutes which take waste directly from living areas into separate containers.

**Synchronising waste streams**

Much of the waste produced by small businesses is similar to that produced by households. Managing waste from different sources through the same processes should reduce costs – so this should be done wherever possible.

## 6.6 How can London manage more of its own waste?

The Draft Replacement London Plan states that London should become more self-sufficient in managing its waste over the next two decades. At present, London manages 56 per cent of its own waste. It exports the remaining waste to other parts of the country, paying fees to use waste facilities there. If London is to manage more of its waste within its own boundaries, the local waste authorities will need to invest in new facilities[36], and plan this process strategically. Table 6.5 sets out the extra capacity that

[36] This investment will not necessarily have to be made by the public sector. New waste facilities may be built and funded by private sector companies.

London would need in order to manage all its household waste itself by 2031. These results have been derived using this study's Internal Capacity Approach[37].

### Table 6.5 Cumulative extra capacity required for London to be 100% self-sufficient by 2031

| | ('000s tonnes of extra capacity per year required for household waste) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Housing growth per year** | **2010** | **2013** | **2016** | **2019** | **2022** | **2025** | **2028** | **2031** |
| 0 | 140 | 170 | 210 | 290 | 390 | 500 | 620 | 770 |
| 33,400 | 145 | 200 | 300 | 460 | 635 | 820 | 1,025 | 1,250 |
| 44,700 | 145 | 210 | 340 | 520 | 720 | 930 | 1,160 | 1,410 |

Notes:

- The amount of waste managed within London is assumed to increase in a linear fashion, from 56% in 2009 to 100% in 2031.
- These figures assume that London meets its targets of sending 60% of household waste for recycling and 0% to landfill, and reducing waste generation per person by 20%.
- These figures do not include requirements for non-household waste streams. Other waste streams are assumed to remain constant over time.

Table 6.6 shows the level of investment required in infrastructure if London is to manage all its household waste itself by 2031.

### Table 6.6 Investment required for London to be 100% self-sufficient by 2031

| **Housing growth per year** | **Total additional cost to 2031** *(£ millions)* | **Average annual cost** *(£ millions)* |
|---|---|---|
| 0 | 220 | 10.0 |
| 33,400 | 360 | 16.3 |
| 44,700 | 400 | 18.4 |

Notes:

- These figures do not relate to market costs of the gate fees paid to dispose of waste. They do not reflect the amount London will have to spend on waste (the figures in Tables 5.2 to 5.4 give a better indication of this). They represent the extra capital and operational spending on waste infrastructure that would be required to provide enough capacity for London to manage all of its household waste within its own borders. These figures cannot be compared with the figures given under the Market Approach in Tables 5.2 to 5.4.
- The amount of waste managed within London is assumed to increase in a linear fashion, from 56% in 2009 to 100% in 2031.
- These figures assume that London meets its targets of sending 60% of household waste for recycling and 0% to landfill, and reducing waste generation per person by 20%.
- These figures do not include requirements for non-household waste streams. Other waste streams are assumed to remain constant over time.

## What do these results show?

- With target growth in housing, London would need to create approximately 1.25 million tonnes of extra capacity within its own borders in order to manage all its

[37] For more information on the Internal Capacity Approach, see section 6.1, or refer to *A Methodology for Evaluating Environmental Infrastructure Needs.*

own waste by 2031. This extra capacity is split between facilities for recycling, composting and energy from waste.

- About £360 million would have to be invested in waste facilities. This investment could be made in a variety of ways, including through contracts with private sector waste companies.

### What do these results mean?

These results highlight the level of future investment needed to manage all household waste within the London area. Further investment could be required to manage all commercial and industrial waste within London's boundaries.

The investment in new waste facilities within London may not necessarily be an extra cost – it may replace investment that would otherwise be needed in other parts of the country.

It may be harder to provide these waste facilities in London than it would be in less heavily developed areas. It will be a challenge to convert existing waste facilities to new technologies, and to provide enough land for new waste facilities. These difficulties may significantly increase the costs presented here.

If London's local authorities are to manage these challenges effectively, both strategic and local planning frameworks will need to tackle the provision of new waste facilities.

## 6.7 Key findings and implications

### 6.7.1 Our key findings

Without a major shift in the way London manages its waste, the additional costs of managing waste from new housing could be more than £730 million by 2031. A big part of this increase is directly attributable to increases in landfill tax. Costs for managing all of London's household waste could rise by £2 billion between now and 2031.

The additional costs associated with new housing could be reduced by around £415 million up to 2031 by reducing the amount of household waste each person generates by 20%, and by diverting all household waste away from landfill. Across new and existing homes future investment needs could be reduced by £1.75 billion.

These additional costs for managing London's household waste will fall to London boroughs. However, there will be costs associated with behavioural change and the interventions necessary to increase recycling and reduce the amount of waste produced per person. These costs have not been included in our figures, but could fall to a wider range of partners.

It would not be easy for London to become largely waste self-sufficient by 2031, but this could bring a number of financial and environmental benefits. In order to manage household waste within its own boundaries, London could require an extra 1.25 million tonnes of waste management capacity by 2031. This would require an estimated £360 million of investment.

### 6.7.2 Implications

#### Manage waste in accordance with the waste hierarchy

London could reduce additional costs for household waste management by reducing the amount of waste produced, increasing recycling, and ensuring energy recovery from waste. These principles, commonly referred to as the 'waste hierarchy', also apply to the management of commercial, industrial and construction waste. This was beyond the scope of this study.

#### Reduce the amount of waste each person produces

If a modest reduction in the amount of waste produced per person is achieved, the costs of population growth could be offset for many years to come. The Mayor's Municipal Waste Strategy calls for a 20 per cent reduction in the amount of waste produced per person. This would save London money each year. Measures that would contribute towards this target include reducing packaging, promoting the re-use of waste, and influencing people's attitudes to waste.

#### Co-ordinate collection to allow for sustainable waste disposal

The way household waste is collected has a major bearing on waste management. If waste is to be managed efficiently and sustainably, the London waste authorities will need to work towards greater consistency in collection. They will also need to learn from best practice elsewhere, paying attention to the needs of different types of housing.

#### Carefully consider the challenges of waste self-sufficiency

It would be a significant logistical and technological challenge to manage all of London's household waste within its own borders by 2031. However, the costs are not prohibitive given the overall spending on household waste. Creating infrastructure that meets London's needs and its ambitious vision for self-sufficient waste management could also have long-term environmental benefits.

#### Reflect waste infrastructure needs in the planning system

If waste is to be managed efficiently, the right infrastructure needs to be in the right places. It can be hard to find appropriate locations for waste facilities and to obtain planning permission. London's long-term planning system should reflect the need for appropriate waste infrastructure, including recycling and energy from waste facilities.

# 7 Water quality and sewage treatment infrastructure

## 7.1 Overview

London's watercourses perform a wide range of functions, from providing space for recreation and biodiversity, to supplying some of the water we use in our homes. Poor water quality in our rivers and lakes can damage our health, make them unusable for recreation or wildlife, and threaten the quality of our drinking water.

The European Union's Water Framework Directive (WFD)[38] sets out wide-ranging requirements and standards for the UK's watercourses. The directive requires Member States to aim for good ecological status[39] in all surface water bodies by 2015. This deadline may be extended up to 2027, or less stringent objectives set, but only if certain conditions are met.

The Environment Agency is responsible for managing water quality to safeguard the water environment. Our role is to protect and enhance this environment and to ensure the sustainable use of water. We therefore monitor water quality, regulate effluents, and control pollution.

This study focuses on sewage treatment infrastructure. Over the next twenty years housing growth will place an extra burden on this infrastructure. In this study we try to assess the scale of the investment that will be needed to:

- maintain sufficient treatment capacity;
- prevent the additional flows of treated effluent from reducing water quality.

## 7.2 Our approach

Household activity can affect water quality in a variety of ways. This study focuses solely on the wastewater treatment infrastructure required to support households. We have not looked at other household impacts on water quality, such as contributions to storm sewage, misconnections and surface water run-off.

There are three key criteria:

- Treatment capacity – the capacity of sewage treatment works to treat the effluent and wastewater produced by households. If treatment capacity is insufficient, some household effluent will not be treated.
- Hydraulic capacity – the capacity of sewage treatment works to handle the volume of wastewater discharged by households.
- Environmental capacity – the capacity of sewage treatment works to treat effluent to a standard that maintains certain water quality standards.

[38] See www.environment-agency.gov.uk/research/planning/33362.aspx for an introduction to the Water Framework Directive.
[39] Good ecological status means that human activity is only causing a slight change in the biological quality of surface water bodies. The benchmark is the quality that would be expected in undisturbed conditions.

Our approach focuses on the capacity of sewage treatment works to treat more household effluent. We have also included a limited interpretation of environmental capacity.

Treatment capacity can be expressed in terms of population[40] because the amount of load generated per person is roughly constant. One population equivalent is roughly the amount of load produced by one person.

This study looks at the relationship between load and the capacity until 2031. We estimate the costs of meeting any shortfalls in capacity. We also look at the impact of changing consent levels for sewage treatment works. This could be done to avoid deterioration in water quality.

There is only limited data available on hydraulic capacity. For this reason we have not taken into account the impact of housing growth on hydraulic capacity: either on the sewer network or on the sewage treatment works. Nor does the study look at sludge treatment.

The Water Framework Directive will require many of London's sewage treatment works to treat household effluent to a higher standard than they do at present. This may involve a substantial cost. Our study does not include the costs of meeting higher water quality standards.

For more information on our approach, please refer to the waste section in the accompanying report, *A Methodology for Evaluating Environmental Infrastructure Needs.*

[40] One population equivalent is the biodegradable load (matter) in wastewater having a five-day biochemical oxygen demand (BOD) of 60 g oxygen per day, as defined in the Urban Waste Water Treatment Directive (91/271/EEC). Population equivalent doesn't necessarily reflect the actual population of a community, as a proportion of the total load may be from commercial or industrial trade effluent.

**What are the main pressures on water quality?**

There are two main pressures on water quality: diffuse pollution and point source pollution.

**1. Diffuse pollution**

Diffuse pollution originates from large areas of land and can arise from a number of sources. Pollutants from a range of small sources can be washed into a watercourse, either through groundwater or surface water. Sources of diffuse pollution include:

- **urban impermeable surfaces** – rainfall on impermeable surfaces can collect a number of pollutants from the ground, before flowing into a watercourse;
- **agricultural land** – chemicals from agricultural processes are collected by rainwater and washed into watercourses.

**2. Point source pollution**

Point source pollution comes from a single, defined source. Wastewater from households is a major part of point source pollution. It can affect water quality in a number of ways. Major sources of point source pollution include:

- **misconnections** – if new homes have foul effluent connected to surface water sewers, raw effluent can drain directly into watercourses;
- **storm sewer overflow** – heavy rainfall can cause sewers to overflow, causing sewage to discharge into watercourses;
- **trade effluent** – this needs to be treated or mitigated in order to ensure that it isn't discharged directly into watercourses;
- **household effluent** – this needs to be treated so that most pollutants are removed before it is discharged into watercourses.

## 7.3 How does London manage water quality?

London faces a number of challenges if it is to maintain and improve its water quality over the coming decades. Housing growth, diffuse pollution and climate change will all increase the pressure on London's watercourses.

Of London's 47 river water bodies, only one currently achieves good ecological status. Sixteen have poor ecological status. Thirty-eight have been heavily modified and are expected to achieve good ecological potential by 2027. The nine unmodified rivers are expected to achieve good ecological status by 2027. The upper and middle sections of the Thames Estuary currently achieve moderate ecological status. London's 16 lakes generally have a higher standard of water quality, with ten achieving good ecological status[41].

Eight sewage treatment works treat London's wastewater. These are operated by Thames Water. Some of these works, including Crossness, Beckton, Deephams and Mogden, are among the largest in the country. They deal with large volumes of wastewater each day.

[41] *London State of the Environment Report 2010*. This is available at www.environment-agency.gov.uk/research/library/publications/34083.aspx

Much of London has a combined drainage system. This allows surface water to mix with wastewater. Even moderate rainfall can overwhelm London's sewerage network, leading to discharges of storm sewage. This can have a severe impact on water quality.

The UK Government tasked Thames Water with delivering the London Tideway Tunnels. This £2.2 billion programme will limit pollution from storm overflows and fulfil the requirements of the Urban Waste Water Treatment Directive.

The London Tideway Tunnels will feature two tunnels: the Thames Tunnel and the Lea Tunnel. These will store and transfer storm sewage to Beckton for treatment.

There are also plans for significant investment at Beckton, Crossness, Modgen, Riverside, Long Reach and Deephams sewage treatment works. This will upgrade hydraulic capacity and/or treatment capacity. These improvements are designed to accommodate housing and population growth up to 2021.

## 7.4 What are London's future wastewater infrastructure needs?

### 7.4.1 Extra treatment capacity will be required at sewage treatment works

As part of its Final Business Plan for 2010 to 2015, Thames Water has scheduled the expansion of six of its sewage treatment works. This should accommodate population growth up to 2021. Table 7.1 looks at what else may be needed under different housing and population growth scenarios.

**Table 7.1 Extra treatment capacity required at London's sewage treatment works**

| | Extra treatment capacity required in population equivalent ('000s) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Housing growth per year** | **2010** | **2013** | **2016** | **2019** | **2022** | **2025** | **2028** | **2031** |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33,400 | 0 | 0 | 10 | 24 | 90 | 300 | 510 | 740 |
| 44,700 | 0 | 0 | 24 | 220 | 555 | 865 | 1,170 | 1,500 |

Notes:

- These figures take into account the capacity increases at the Tideway sewage treatment works and Deephams. These are planned by Thames Water up to 2021. They will ensure that Tideway sewage treatment works and Deephams will have sufficient capacity to accommodate Thames Water's forecast population growth up to 2021.
- The capacity deficits are expressed in population equivalent terms, where one population equivalent is roughly the amount of load produced per person per day.
- The zero growth scenario assumes that there is no existing deficit in treatment capacity for London's eight sewage treatment works – so that no further capacity is required if there is no population increase.

### What do these results show?

- To support housing growth of 33,400 new homes a year, Thames Water will need to increase its sewage treatment capacity by around 740,000 population equivalents by 2031. This is over and above the capacity increases it already has planned as part of its AMP5[42] investment plan.
- Increased housing growth of 44,700 new homes a year will require an increase in capacity of 1.5 million population equivalents.

### What do these results mean?

Planned investments into the Thames Tideway sewage treatment works and Deephams mean that London should require little extra capacity to address population growth up to 2021.

Some of London's smaller treatment works, away from the Thames Tideway, may require some extra capacity before 2021. The Environment Agency is working with Thames Water to ensure this is provided. The Tideway treatment works should be able to accommodate growth without any extra capacity.

Any deficits in treatment capacity after 2021 will be planned for by Thames Water under regulation from Ofwat[43] and the Environment Agency.

## 7.4.2 The costs of increasing treatment capacity at sewage treatment works to accommodate growth

Table 7.2 shows the likely costs of providing the extra treatment capacity identified in Table 7.1. It assumes that there is no change in the standard of treatment required at each sewage treatment works.

**Table 7.2 Costs of providing extra treatment capacity at sewage treatment works to accommodate housing growth**

| New homes per year | Total cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|
| 0 | 0 | 0 |
| 33,400 | 215 | 9.8 |
| 44,700 | 380 | 17.3 |

Notes:

- These costs include the capital and operational costs for increasing treatment capacity. They do not include costs for increasing hydraulic capacity, or any costs associated with the sewer network.
- These costs assume that there is no change in the consent level at any sewage treatment works.
- These are additional to the costs of Thames Water's proposed works during AMP5 at the Thames Tideway and Deephams sewage treatment works.

[42] The Asset Management Plans (AMPs) are the water company investment plans. Each AMP covers a five-year period, and each water company produces a Final Business Plan for each of these periods. AMP5 covers the years from 2010 to 2015. For more information on the processes involved in AMP periods, or for specific details of water company investment plans, visit www.ofwat.gov.uk.

[43] Ofwat (The Water Services Regulation Authority) is the economic regulator of the water and sewerage sectors in England and Wales.

### What do these results show?

- If there is housing growth of 33,400 new homes a year, Thames Water may have to invest an extra £215 million in treatment capacity at its sewage treatment works between now and 2031.
- If there is housing growth of 44,700 new homes a year, Thames Water may have to invest an extra £380 million in treatment capacity at its sewage treatment works.
- These costs are additional to Thames Water's planned spend in AMP5. Under AMP5, £270 million will be invested at six of its sewage treatment works. Add this investment to the figures in Table 6.3 when considering the full costs up to 2031[44].

Thames Water's detailed planning mechanisms should identify and address these investment needs. These planning mechanisms are regulated by Ofwat, and influenced by the Environment Agency.

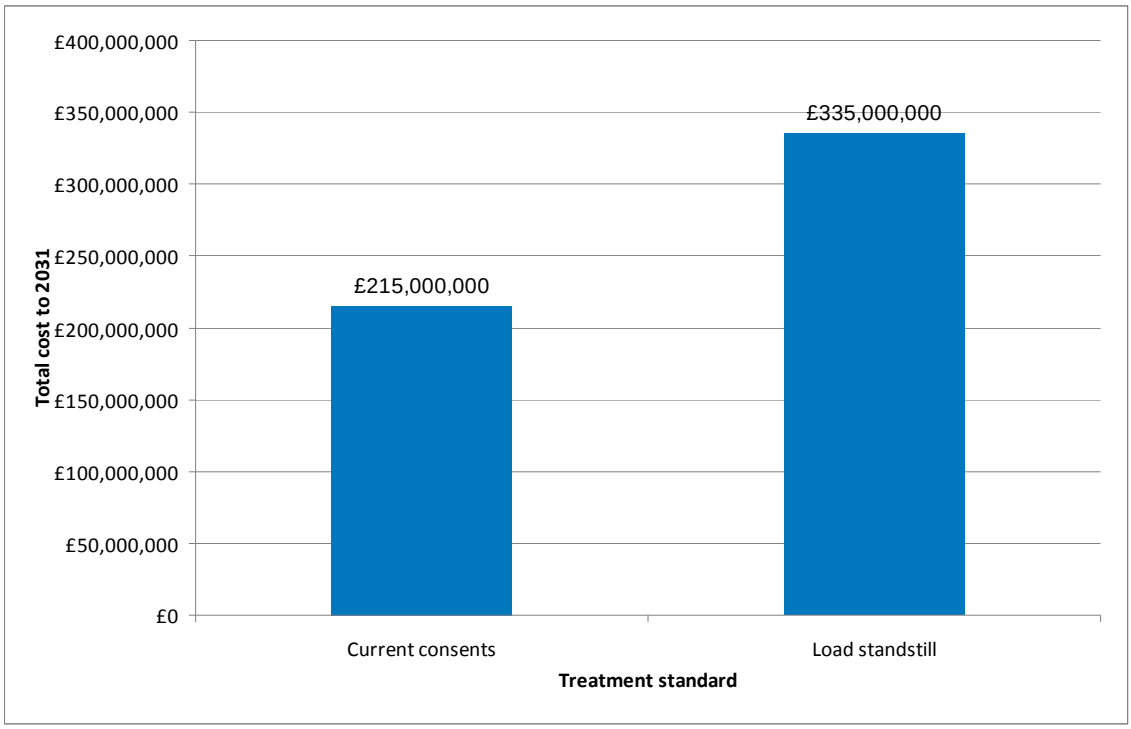
## 7.5 Managing London's wastewater infrastructure needs

Table 7.2 looked at how much extra investment in treatment capacity is needed to accommodate population growth at current standards of treatment. However, if the amount of load flowing through a sewage treatment works increases and there is not an improvement in the standard to which effluent is treated, there will be an increase in the amount of load discharged into watercourses. This could reduce water quality.

Figure 7.1 compares the costs of making these improvements with the costs of accommodating growth without raising standards of treatment. The improvements would maintain discharge loads at current consent levels by raising treatment standards as flow increases.

[44] The spending on these sewage treatment works has been driven by environmental improvements as well as by the need to create capacity to accommodate population growth. Thames Water splits this investment between environmental improvements and population growth. We have only taken account of the investment allocated to population growth.

## Figure 7.1 Impact of different treatment standards




Notes:

- These figures reflect a scenario of 33,400 new homes a year.
- These costs include the capital and operational costs for increasing treatment capacity. However they do not include costs for increasing hydraulic capacity, or any costs associated with the sewer network.
- These figures are additional to the cost of Thames Water's proposed works at the Thames Tideway and Deephams sewage treatment works during AMP5.
- Holding the amount of discharged load constant does not necessarily prevent deterioration in water quality. There are other factors which may cause a deterioration in water quality, such as diffuse pollution, pollution from other point sources and reduced river flows.

### What do these results show?

- To accommodate 33,400 new homes a year but discharge the same amount of load, Thames Water is likely to have to invest around £335 million in its sewage treatment works between now and 2031.
- This is £120 million more than would be needed to accommodate population growth without tightening treatment standards. If standards are not tightened there would be an increased discharge.
- These costs are additional to Thames Water's planned spend of around £270 million on accommodating growth. Add this investment to the figures in Table 6.3 when considering the full costs up to 2031.

**What other wastewater infrastructure costs may arise?**

The capacity constraints and costs identified in this section only relate to one aspect of maintaining water quality: ensuring that sewage treatment works have sufficient capacity to treat extra load from new households.

There are a number of other costs which will also be incurred. Because of data limitations, these costs could not be captured in this study. They include:

- **Investment driven by the Water Framework Directive** – where it is demonstrated to be cost-effective and not disproportionately expensive, additional investment in wastewater infrastructure will be required to meet the water quality objectives of the Water Framework Directive.
- **Hydraulic capacity of the sewer network and the London Tideway Tunnels** – Thames Water is currently investing heavily in improving the sewer network in London. This will increase hydraulic capacity, to prevent flooding and limit pollution from storm overflows. The £2.2 billion London Tideway Tunnels project will also increase capacity within the sewerage system.
- **Hydraulic capacity at sewage treatment works** – increased volumes of sewage from households may put pressure on the hydraulic capacity of sewage treatment works. Some works will need to be expanded to deal with a greater volume of effluent. Our study has not included the costs of this expansion.
- **Sludge disposal** – the sewage treatment process produces solid residual waste. This needs to be disposed of. Thames Water proposes to invest £195 million in improving sludge disposal at its sewage treatment works between 2010 and 2015. These costs are not included in this study.

## 7.6 Key findings and implications

### 7.6.1 Our key findings

London's sewage treatment works will need around 775,000 population equivalents of extra treatment capacity to accommodate 33,400 new homes a year up to 2031. This will require an extra investment of £215 million up to 2031. This is over and above the major capacity increases already planned for Thames Tideway.

If treatment standards are improved, so that there is no increase in the load discharged by sewage treatment works, the required investment will rise to £335 million by 2031. Costs for the growth scenarios planned by water companies will be incorporated in investment plans.

The key results for water quality and wastewater infrastructure, as shown in Tables 2.1 and 2.2, give a total cost of £605 million up to 2031. This reflects the costs of maintaining current levels of load discharged by sewage treatment works, and also includes planned spending on sewage treatment works under Thames Water's current investment plan.

In reality, the costs of managing water quality are expected to be even higher. There are a number of other costs associated with the sewer network and future treatment standards which we were not able to capture owing to data constraints.

### 7.6.2 Implications

#### Continue to invest in wastewater infrastructure

To accommodate population growth, and maintain or improve London's water quality, significant and sustained investment in waste water infrastructure will be required. The Environment Agency will need to work with Thames Water, Ofwat and others to ensure sufficient investment is made in London's wastewater infrastructure.

#### Consider the location and phasing of new homes

The location of new housing development can affect water quality. This impact should be considered in a similar way as for flood risk. Some catchments face more pressures than others. Equally, wastewater infrastructure can be subject to localised problems – such as bottlenecks in sewer capacity, or constraints on the environmental capacity of a sewage treatment works.

Water Cycle Studies (WCS) provide a framework for building a more detailed evidence base that takes account of growth and environmental needs. This evidence can be used when deciding on the location and phasing of developments and plans for new infrastructure[45].

#### Take account of the full costs of water quality

The full costs of managing water quality are likely to be much higher than the costs identified in this study. There are a number of other costs associated with the sewer network and future treatment standards which we were not able to capture owing to data constraints.

#### Make more information on wastewater infrastructure available

The amount of publicly available information on wastewater infrastructure is limited. As a result, it can be difficult to consider the additional capacity and investment needs for new housing. We would like to see a long-term planning mechanism and publicly available information comparable to that available in the Water Resource Management Plans. This would enable all the key organisations and partners to understand the scale of investment required and the implications for the way that new housing is planned and delivered.

[45] For Water Cycle Studies Guidance, see:
http://publications.environment-agency.gov.uk/pdf/GEHO0109BPFF-e-e.pdf

# 8 Water resources

## 8.1 Overview

London's households use more than 1.2 billion litres of water every day – an average of 160 litres per person. Underlying this is a vast network of infrastructure, including numerous raw water sources, treatment plants and a network of pipes to deliver water to homes and businesses. Supplying such a large amount of clean water to people's homes is a significant challenge, and one which will become more difficult in the future.

Water is an issue in London. At the Environment Agency, we have identified the city as being in an area of 'serious water stress'[46].

Some areas have reached or exceeded environmental limits on abstracting water. There are also growing pressures on London's water network. These include the additional demand from population growth and new housing, and the ability of aging infrastructure to meet modern day demand. Climate change will also affect future water supply. Our research suggests that, by the 2050s, summer river flows in the south east could fall by 50 to 80 per cent[47].

At the Environment Agency, we are responsible for managing water quality and quantity, and for safeguarding the water environment. We help central government and the Welsh Assembly Government create strategies for water and the environment. We also oversee water companies' planning, so that supplies are secure, even during droughts, and the companies' environmental impacts are kept to a minimum.

This section provides a strategic view of the challenges involved in supplying water to London's households up to 2031.

## 8.2 Our approach

Our methodology focuses on the balance between supply and demand. Where potential deficits have been identified, we have used unit cost curves to estimate the investment required to meet the shortfall. Much of the information comes from Water Resource Management Plans, which the water companies publish every five years[48].

The demand for water is calculated from figures for household population and the average amount of water consumed by each person. The supply of water has been derived from the baseline tables in the water companies' Water Resource Management Plans. We compare this supply with the demand for water in each year. We have also taken account of leakage levels and the need for a contingency – referred to as 'target headroom'[49]. We have evaluated the balance between supply and demand at the

46 As classified by the Environment Agency. See http://publications.environment-agency.gov.uk/pdf/GEHO0107BLUT-e-e.pdf

47 *Climate change and river flows in the 2050s*. See http://publications.environment-agency.gov.uk/pdf/SCHO1008BOSS-e-e.pdf

48 Data from Draft or Revised Draft WRMPs has been used. This may change in final plans. Thames Water's plan is subject to a public inquiry and may change as a result.

49 Target headroom is a buffer between the supply of and demand for water. It is designed to cater for specified uncertainties. See the Environment Agency's Water Resources Planning Guidelines at http://publications.environment-agency.gov.uk/pdf/GEHO1208BPDC-E-E.pdf

Water Resource Zone level[50] used by the water companies and have assumed that water cannot be transferred between these zones.

The baseline tables used do not include any of the AMP5 schemes apart from the demand-management measures needed to meet Ofwat's required water efficiency targets. We have not included the costs associated with meeting these targets.

We have derived the unit costs of meeting deficits from the list of feasible interventions set out by water companies in their Water Resource Management Plans. It is important to note that these interventions only increase the amount of water in supply – they do not manage demand.

Our study focuses on household water supply. However, this represents only a part of the challenge. Water companies also supply clean water to non-household users for commercial and industrial purposes.

For more information on our approach, please refer to the water resources section of the accompanying report, *A Methodology for Evaluating Environmental Infrastructure Needs.*

**Restoring sustainable abstraction**

We have estimated the scale of the required future investment in water resources infrastructure using the planned interventions by water companies for increasing water supply on the basis of current abstraction licences. In reality these licences may change over time. One of the principles of the Water Framework Directive is the promotion of sustainable water use. This may lead to changes in licences if abstraction is having an adverse effect on the environment.

Where changes to abstraction levels are required, demand-management measures are likely to play a central role in controlling the supply-demand balance. We will consider these measures before looking at solutions based on replacement water resources.

For further information see Environment Agency (2009) *Water for people and the environment: Water Resources Strategy*. Environment Agency. Bristol.

## 8.3 How does London manage water resources?

London's water resources are managed by four companies:

- Thames Water;
- Veolia Water Central;
- Sutton and East Surrey Water;
- Essex and Suffolk Water.

These companies supply about 2,400 megalitres of water each day for a wide range of uses. Figure 8.1 shows the water companies and Water Resources Zones in London.

50 London is supplied by six Water Resource Zones. None of these Water Resource Zones are completely contained within the boundaries of London. For the purpose of this study each Water Resource Zone has been split based on the proportion of the population in London within the zone.

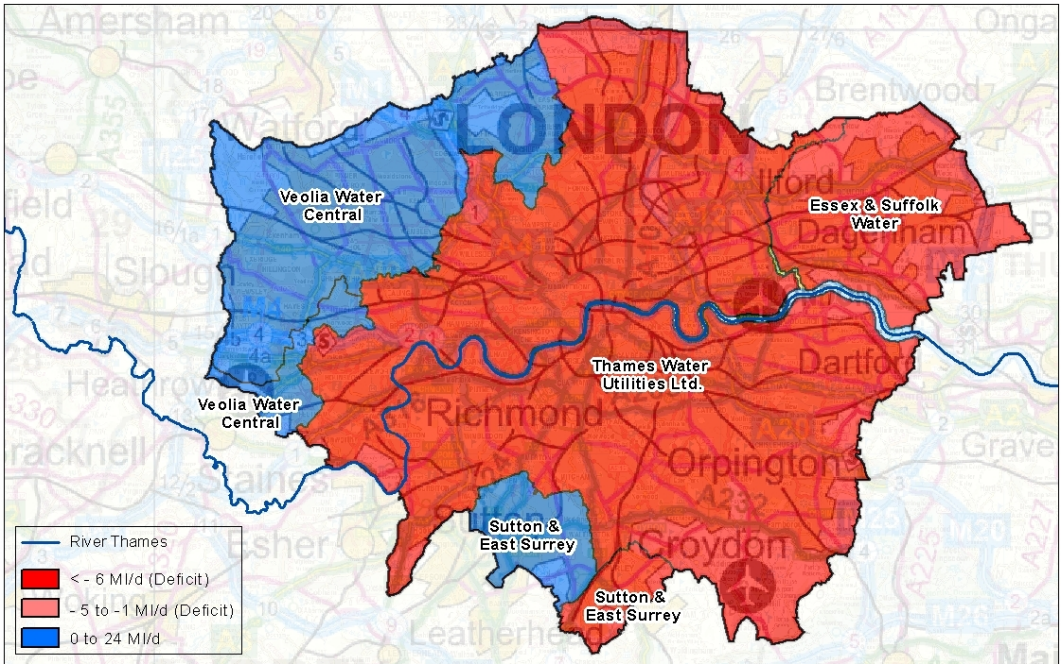
Water companies set out their long-term plans for managing future water needs in their Water Resource Management Plans. This long-term planning framework allows future problems and constraints to be identified at an early stage, and this ensures that sufficient investment can be put in place. Each water company is regulated by Ofwat. All licensable abstractions from rivers and groundwater are controlled and enforced by the Environment Agency.

Households use the most water within London (approximately 60 per cent of total water use). Average consumption is around 160 litres per person per day.

London faces severe constraints on its supply of water. It receives an average of 650 mm of rainfall a year, well below the 897 mm average for England and Wales. The River Thames and River Lea are classified as over-abstracted, and the overall amount of water abstracted from London's watercourses may have to be reduced to comply with the Water Framework Directive.

Most water comes from the abstractions and reservoir systems along the River Thames and River Lea. These are operated by Thames Water in addition to groundwater abstraction. Water is stored in reservoirs that can hold up to 203,000 megalitres at any one time.

**Figure 8.1 Supply-demand balance within London by Water Resource Zones**




The map above shows a supply-demand deficit in a dry year for a large proportion of London. The data we have used comes from the water company returns to Ofwat for the period 2008/9.

**What options are available for managing water resources?**

Water companies generally use a combination of demand and supply measures to meet water needs. This is known as a 'twin-track' approach.

**Increasing supply**

Water companies can develop new sources of water to increase the overall volume available for supply. This could include the development of new groundwater abstractions, desalination plants, effluent reuse schemes or reservoirs. Or they can pipe water into London from other areas. In general, there is limited scope for increasing supply at low cost. And in London such options tend to be relatively expensive.

**Managing demand**

If individuals use less water, less water needs to be supplied overall. Measures can be geared towards increasing water efficiency and changing individual behaviour.

Homes can be made more water efficient, by installing the right fittings inside the home and making the best use of water outside homes.

For new homes, the Code for Sustainable Homes sets out different standards for water efficiency. It covers:

- efficient fittings – in toilets and showers for example;
- efficient appliances – such as washing machines and dishwashers.

Water-efficient fittings and appliances can also be retrofitted to existing homes. Outside the home, measures such as water butts reduce the use of mains water.

We can also encourage people to change their behaviour and use less water. Education programmes – by water companies or the government – can help to achieve this. Another approach is to use price incentives, such as water meters. These link people's water bills to the amount of water they actually use.

**Reducing leakage**

Water companies lose a significant proportion of their water from leaking pipes. Leakage can be reduced by replacing vulnerable water mains, monitoring parts of the distribution network, or introducing new technologies. However it is often expensive to tackle these problems in London, where the majority of water mains are very old and replacement can cause significant disruption.

## 8.4 What water resources will London need in the future?

### 8.4.1 The additional capacity needed to support housing growth

Table 8.1 summarises the extra water that would be required to meet the demands for water from additional housing. The figures are based on three scenarios for housing growth.

**Table 8.1 Extra water required to support housing growth**

| | (Extra water required in megalitres per day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Housing growth per year** | **2010** | **2013** | **2016** | **2019** | **2022** | **2025** | **2028** | **2031** |
| **0** | 6 | 7 | 8 | 5 | 0 | 0 | 0 | 0 |
| **33,400** | 9 | 60 | 140 | 225 | 265 | 325 | 345 | 360 |
| **44,700** | 10 | 90 | 190 | 295 | 360 | 440 | 480 | 520 |

Notes:

- These figures reflect the total extra water required for London's six separate Water Resource Zones, within the London area only.
- These figures show the shortfall in the water supply if water companies take no action either to increase the supply of water, or to manage demand. We have not included any future interventions planned by water companies. However, the baseline tables do take account of interventions planned before 2010, including the Beckton Desalination Plant, which became operational in March 2010.
- The demand for water is based on average per capita consumption forecasts from the water companies' baseline tables. These meet Ofwat's water-efficiency targets, but do not include further interventions to reduce demand, such as metering.
- Even if there were no growth in housing we would see a shortfall in the water available within some of the six London Water Resource Zones. The pattern of extra water required reflects increases in target headroom across the modelled period and changes in leakage.

### What do these results show?

Action will be needed to balance the supply and demand of water in London. If housing growth reaches the target of 33,400 new homes a year, the water companies will need to manage a potential cumulative deficit of 360 megalitres a day by 2031. They will have to do this by:

- reducing demand; or
- increasing supply; or
- a combination of the two.

### What do these results mean?

Table 8.1 identifies further demands on London's water resources in the future. However, the water companies already estimate these deficits and plan how to deal with them. They do this through the Water Resources Management Planning process. This requires the water companies to plan for water resources 25 years in advance, and extend their plans every five years. So water companies should be tackling future deficits in time to prevent water shortages.

What the results do show is the scale of the challenge involved. London will need a sustained programme of measures and initiatives to manage its future water needs, especially if it is to deal with high levels of housing growth. Water companies are most likely to adopt a twin-track approach to managing these deficits – combining measures to manage demand and reduce leakage with increases in supply.

### 8.4.2 The additional investment needed to support housing growth

Table 8.2 outlines the total additional cost of providing enough water to support different levels of housing growth in London.

**Table 8.2 Additional costs for providing extra water under different housing growth scenarios**

| New homes per year | Total additional cost to 2031 *(£ millions)* | Average annual cost *(£ millions)* |
|---|---|---|
| 0 | 70 | 3 |
| 33,400 | 1,360 | 62 |
| 44,700 | 1,875 | 85 |

Notes:

- The additional cost is the extra cost above what was spent in 2008/09.
- These figures show the cost of increasing the supply of water to meet a deficit in any given year. The costs reflect the cheapest possible lifetime costs for increasing supply (taking into account environmental as well as financial costs). They do not include spending on managing demand or reducing leakage.
- These costs include the capital, operational, and social and environmental costs for increasing the supply of water to meet the potential deficits outlined in Table 7.1. They also include the additional maintenance costs for maintaining the infrastructure for water resources. Costs are taken from the list of feasible interventions set out by water companies in their Water Resource Management Plan tables.
- The cost in a scenario with no housing growth reflects an existing shortfall in the water available within some of London's six Water Resource Zones.

#### What do these results show?

- Housing growth will place a major strain on London's water resources infrastructure. Water companies could need to invest around £1.3 billion up to 2031 in order to accommodate annual housing growth of 33,400 new homes. This is the cost of increasing supply.
- Excluding existing shortfalls, the additional cost of providing water resource infrastructure for new homes could be around £1,290 million. This is quoted as a headline result for water resources in Table 3.1.

#### What do these results mean?

There would have to be major investment in London's water resources infrastructure if the effects of population growth were managed just by increasing the supply of water.

In reality, the water companies are most likely to take a twin-track approach, in which measures to increase the supply of water will be combined with managing demand and reducing leakage. Water companies will identify and manage required levels of investment through the Water Resource Management Plan process.

## 8.5 Managing London's water resources infrastructure needs

Table 8.2 shows the costs of supply-side interventions – dealing with population growth just by creating infrastructure to increase the supply of water. However, we are already taking too much water from both the River Thames and the Lower Lea. There may be limited scope for additional resources.

Managing the demand for water will be key to meeting the need for water. Demand-side interventions may include water metering, increased water efficiency and tighter building standards.

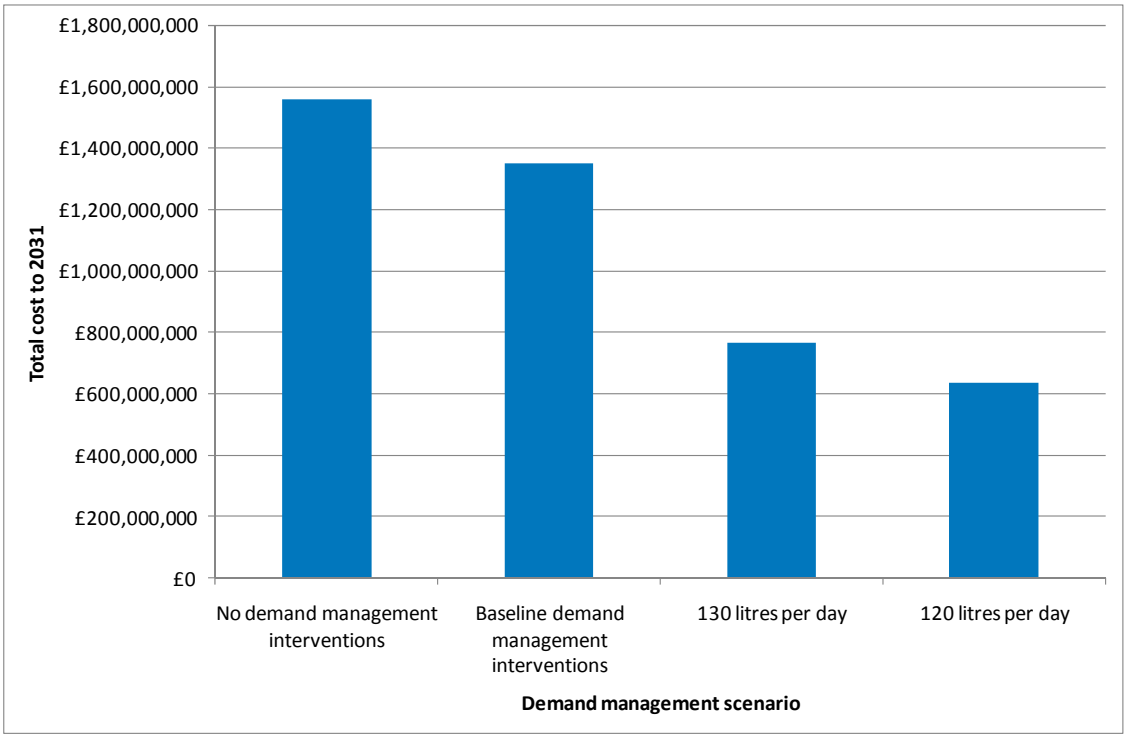
Figure 8.2 shows how different levels of demand affect the costs of supply-side interventions. The different scenarios reflect changes in the average amount of water consumed per person. Two scenarios are based on the reductions that Defra would like to see in England[51]: a reduction in consumption to 130 litres per person per day; and a reduction to 120 litres per person per day.

The four scenarios are:

- **No demand-management interventions** – average per capita consumption remains constant at 2008/09 levels for all years to 2031. This scenario ignores the baseline activities for water efficiency that are already planned. These activities will enable the water companies to meet Ofwat's targets for reductions in demand. This scenario is provided for comparison only.
- **Baseline demand-management interventions** – average per capita consumption will change in accordance with the water companies' forecasts in their baseline tables. This scenario does include their planned baseline activities for water efficiency. These activities will enable the water companies to meet Ofwat's targets for reductions in demand. However, it does not include any additional measures for managing demand.
- **Demand reduction to 130 litres per person per day** – average per capita consumption across new and existing homes falls gradually from 2008/09 levels, reaching 130 litres a day by 2031. This reflects an aspiration set out by Defra.
- **Demand reduction to 120 litres per person per day** – average per capita consumption across new and existing homes falls gradually from 2008/09 levels, reaching 120 litres a day by 2031. The achievement of this aspiration by Defra will depend on new technological developments and innovation.

[51] This is from Defra's *Future Water* report. See http://www.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf for more details.

## Figure 8.2 Impact of reducing household water consumption




Notes:

- These figures reflect a scenario where the Draft Replacement London Plan target of 33,400 new homes per year is met.
- The additional cost is the extra cost above what was spent in 2008-09.
- These figures show the cost of increasing the supply of water to meet a deficit in any given year. The costs include no spending on managing demand or reducing leakage. The costs reflect the cheapest possible lifetime costs for increasing supply (taking into account environmental as well as financial costs).
- These costs include the capital, operational and social and environmental costs for increasing the supply of water to meet the deficits outlined in Table 8.1, as well as the additional maintenance costs for maintaining water resources infrastructure.
- The figures do not include any costs for reducing the demand for water.

### What do these results show?

- Reducing the average amount of water consumed per person to 130 litres per person per day by 2031 could reduce the required investment in new supplies of water by more than £550 million. However, this figure does not reflect the costs of measures to reduce demand to this level.
- Further reductions, to 120 litres per person per day by 2031, could reduce the investment needed by a further £130 million.
- If London can achieve an average per capita consumption of 130 litres per person a day, the cost of new water resources infrastructure for new housing could be £740 million. This is a headline figure for water resources quoted in Table 3.2.

### What do these results mean?

Meeting Defra's water consumption target of 130 litres per person per day could almost halve the cost of the infrastructure needed to meet the demand from target housing

growth. This is compared to what would be needed at current levels of consumption. However, this cost saving needs to be considered in the context of the likely costs of reducing demand.

The Environment Agency's *Water Resources Strategy for England and Wales*[52] suggests that this target consumption could be achieved across England – through metering and comprehensive water efficiency measures in both new and existing homes. Our report also suggests that a further reduction (to 120 litres per person per day) could be achieved by also:

- improving water efficiency in outdoor areas;
- aiming for the highest water efficiency standard in new homes (see the Code for Sustainable Homes).

**What is involved in managing demand?**

There are a number of ways to reduce demand and achieve the cost savings outlined in Table 8.3. These include:

- increasing the number of homes with water meters;
- enforcing the Code for Sustainable Homes Level 3/4 standards for all new homes – so that per capita consumption for all new homes is 105 litres per person per day;
- using exemplar developments to pioneer higher standards for new homes;
- retrofitting existing homes with water-efficient appliances;
- encouraging people to change their behaviour and consume less water.

It is important to target demand-management measures at existing homes as well as new ones. Demand-management in new homes has a major role to play. But action to reduce demand from existing homes, even by small amounts, is crucial. Without this we may not meet aspirations for reducing consumption overall.

These measures will cost money. We need to compare the costs of achieving reductions with the costs savings demonstrated. For example, applying the Code for Sustainable Homes Level 3/4 standards (105 litres per person per day) would cost approximately £125 per new home. This increases to approximately £2,000 per home for Code Level 5/6 (80 litres per person per day). (Environment Agency (2007) *Assessing the cost of compliance for the Code for Sustainable Homes*,. Environment Agency. Bristol).

In their Water Resource Management Plans, the London water companies have outlined plans to reduce average household per capita consumption to around 145 litres per person per day by 2031. Compared with current levels, this would be a reduction in consumption of about 15 litres per person per day. The reduction would be achieved through a combination of measures, including increased metering and the water-efficiency measures required by Ofwat. The plans set the costs of reducing demand against the costs of developing new infrastructure.

[52] See page 51 at http://publications.environment-agency.gov.uk/pdf/GEHO0309BPKX-E-E.pdf for more information.

## 8.6 Key findings and implications

### 8.6.1 Our key findings

London is already in an area of 'serious water stress' and the highest investment need will be for water supply. Reducing per capita water consumption to an average of 130 litres per day across London could reduce future capital investment by around £550 million over the lifetime of the Draft Replacement London Plan. These findings should be considered alongside the cost of the range of demand management interventions necessary to reduce consumption.

To accommodate housing growth of 33,400 new homes a year, London will need to manage a potential shortfall of 360 megalitres per day of water by 2031. The cost of managing this through increased supply could be around £1.3 billion. In practice, a 'twin-track' approach that combines demand-management and increasing supply is most likely. This will be planned for by water companies through the Water Resource Management Plan process

London could reduce future supply costs by around £550 million up to 2031 by reducing average per capita consumption to 130 litres per day across new and existing homes. This would require investment in demand-side interventions such as metering, retrofitting and building to high water-efficiency standards. These interventions would be carried out by a range of organisations and businesses.

### 8.6.2 Implications

#### Ensure contingency planning

The Water Resources Management Plan and Price Review provide long-term planning processes for managing water resources needs. Water companies have made housing growth and population projections for the period to 2035. They have identified future capacity constraints and made plans to manage them.

However, different levels of housing and population growth, coupled with environmental constraints such as climate change, could exacerbate the pressures on London's water resources. This will need to be taken into account in future plans. It should also inform the way that new homes are planned, designed and delivered.

#### Recognise the benefits of demand management

There is limited scope for expanding London's water resources at a low cost. Demand-side interventions will be an essential part of managing needs for water. In this report, we show that reducing consumption could reduce the costs of increasing supply by £550 million. Depending on the costs of reducing demand, this may significantly reduce the overall net costs in the longer term.

It would be valuable to evaluate the costs of achieving different levels of reduction in demand, and to compare these costs with the potential savings identified in this report.

#### Advocate a partnership approach

The Environment Agency endorses the Draft Replacement London Plan's policies and initiatives on water efficiency and retrofitting. The water companies that serve the London area are also working closely to support and encourage demand management. However, more work is needed by partners to bring about a meaningful reduction in the per capita consumption of clean water.

This work should include:

- encouraging retrofitting in existing homes;
- ensuring that all new homes and buildings are built to Code level 3/4 of the Code for Sustainable Homes;
- encouraging exemplar projects to build to even higher water efficiency standards, such as Code for Sustainable Homes level 5/6;
- targeting research and education initiatives to changing public attitudes towards water usage – including the use of grey water[53] in gardens and toilets.

[53] Grey water is wastewater from baths, showers and washbasins. This water can be collected in a household re-use system and treated to a standard suitable for WC flushing.

# 9 Conclusions

## 9.1 Overview

This report shows how housing growth will affect London's environmental infrastructure up to 2031, over the period covered by the Draft Replacement London Plan.

If there is no change in the way services are used, London could need to spend an additional £140 million a year on environmental infrastructure. This would be a ten per cent increase on the estimated £1.4 billion already spent every year to support existing communities. The total additional spend by 2031 could be around £3 billion – less than 0.1 per cent of London's economic output over the same time period.

With interventions to manage demand London could reduce the total extra cost up to 2031 by almost £1 billion. The additional annual spending on environmental infrastructure would fall to £96 million: a six per cent increase on the amount already spent to support existing communities.

## 9.2 What we have found

Our findings allow us to compare the effects of housing growth on five areas of infrastructure: flood risk management; green infrastructure; waste; water quality and sewage treatment infrastructure; and water resources. By showing how the long-term costs change in different scenarios, we hope to contribute to discussions about the way that new housing and infrastructure is planned and delivered.

We have already identified London as being in an area of 'serious water stress'. It is therefore unsurprising that the highest investment need will be for clean water supply. London's infrastructure for wastewater treatment will also require substantial investment. This study has identified some of the costs, but the true figure is likely to be much higher owing to costs associated with the sewer network and future treatment standards.

Our findings show how we can help to protect London's environment over the longer term and reduce the scale of the additional investment needed – by changing the way resources are used and by building new developments in more appropriate places.

Looking only at resource use related to new homes, the cost savings from managing household waste more sustainably could be about £415 million to 2031. Reducing per capita water consumption to an average of 130 litres per day across London could reduce future capital spending costs by around £550 million[54].

Our findings in relation to flood risk management make very clear how the design and location of new homes is crucial in reducing risk. The most sustainable way of accommodating new housing growth in relation to flood risk is to locate new development in the areas of lowest risk. However, in London, many sites currently at risk of flooding will be redeveloped.

Improving the layout and design of these sites will reduce risks and avoid the need to construct new defences that will require future maintenance. If capital defence schemes were technically feasible and cost beneficial and were used to protect new homes from flooding, it could cost more than £7,500 on average for each new home

[54] The cost of demand-management is not included within this figure, and needs to be considered against this.

built in an area of existing fluvial flood risk. This would be around two thirds of the total environmental infrastructure investment required per new house. This cost is an estimated average: the actual cost for a particular home will be larger or smaller depending upon the local circumstance.

In flood risk management, the planners already have the framework in place to make the right decisions. The planning policy set out in PPS25 provides a clear route for managing the investment needs associated with building in the floodplain.

Our findings also reveal areas where fiscal incentives are helping to shape the delivery of environmental services. In waste, our figures show that London's waste authorities have a clear incentive to reduce the levels of waste produced and to divert waste away from landfill.

Green infrastructure offers many benefits to those who live and work in London, and to the many people who visit the capital every day. These benefits are social, economic and environmental. In this report, we have tried to establish what would be an appropriate level of green infrastructure and what improvements are needed. We argue that partners involved in growth must do more to prioritise, plan, and deliver green infrastructure. This approach would maximise the benefits from green infrastructure, and build cost-saving links with services for flood alleviation or water.

## 9.3 Our conclusions

In each chapter, we have explained what our findings mean for the way new housing should be planned and delivered. In this final section we set out our overall conclusions. We hope these will inform and shape the planning and delivery of new housing in London.

### Environmental infrastructure needs strategic, long-term planning

Our findings show that it is possible to reduce the future investment needed in environmental infrastructure to support housing growth. This reduction can be achieved by ensuring that houses are built in the right location and supported by measures to manage new and existing demand on services.

Strategic plans, such as the London Plan, should continue to endorse the principles of PPS25 on development and flood risk. They must also back demand-management interventions, including retrofitting and the design of new build to reach high sustainability standards. London boroughs must ensure that environmental infrastructure needs are included in local infrastructure plans[55]. Developers should also check with London boroughs and infrastructure providers about capacity constraints and opportunities before planning new build.

### Environmental infrastructure requires sustained investment

To continue to support, protect and enhance a growing city, there will need to be sustained investment in environmental infrastructure as well as support from strategic planning processes. Some investment will be made directly by infrastructure providers, but funds will also need to be collected from developers through levies and Section 106 agreements, especially for flood risk management and green infrastructure. The report has focused on investment needs associated with new housing only. Alongside this, around £33 billion will be spent to support existing communities. This includes the substantial investment associated with the River Thames tidal defences and also the Tideway Tunnel.

[55] For further information see Morphet, J. For the Planning Advisory Service (2009) A steps approach to infrastructure planning and delivery, Improvement and Development Agency: London.

### Planning mechanisms should better take account of linkages

A variety of planning mechanisms are in place across the five infrastructure areas that we have looked at in this report. However there are a number of key relationships and connections between the infrastructure areas that should be acknowledged and exploited. In particular, green infrastructure can contribute to water management and flood alleviation. There are also important links between the hydraulic capacity of the sewer network and the management of surface-water flooding that we have not been able to look at in detail in this report, owing to the lack of data.

### Location and phasing of development is key

We have assessed the scale of potential investment in environmental infrastructure for a range of demand scenarios. The location and phasing of development will have an important bearing on future costs. For flood risk management and water quality, location will be key to determining the final costs. Location choice will also have a bearing on the net loss of land performing green infrastructure functions. The phasing of development will be an important consideration for more location-specific infrastructure assessments that seek to determine what is required and when.

### Opportunities that new development offers to environmental infrastructure provision

Although new development increases the pressures on existing environmental infrastructure it also provides an opportunity to improve services - potentially benefiting both existing and new communities. Developer contributions or levy schemes drawing funding from new development provide a way of providing or improving infrastructure. Major development can also be a catalyst for demand-management measures in new and existing homes, for example through retrofitting programmes or the provision of new waste-management facilities.

### Demand-management measures will reduce capital costs

Our findings have shown that interventions to reduce the demand for water and reduce the generation of household waste could play an important role in reducing the investment required in capital infrastructure. When planning services, infrastructure providers and the wider partners involved in delivering new housing should ensure that they invest in using resources sustainably. This should include the delivery of new homes and other buildings to ambitious standards and the retrofitting of existing homes and buildings. It should also include the development of exemplar schemes to show how further progress can be made. For water use this should include development to Code for Sustainable Homes Level 5/6.

### A wide range of partners needs to be involved

Many bodies influence the planning and delivery of new housing and will therefore have a bearing on its associated demand on environmental infrastructure. In order to ensure that future environmental infrastructure is well managed, partnership working will be essential between the Greater London Authority, the London boroughs, water companies and agencies such as the Environment Agency, Natural England and housing delivery bodies. Bodies such as the London Waste and Recycling Board may also have a role in the delivery of infrastructure or helping to influence behaviour. It will also be essential for infrastructure providers to work with the London boroughs in order to draw out and maximise the benefits from linkages between the five areas.

## 9.4 Areas for further work

This report provides strategic evidence on the scale of investment needed in environmental infrastructure to support housing growth in London. Our results suggest that costs could be significantly reduced by managing demand and building new homes in the right places.

Our findings could be taken further by infrastructure studies at local authority level and by assessments for specific locations. These may include Water Cycle Studies[56].

When we drew up the methodology for this study, we found great variation in the quality and availability of data. The data on green infrastructure and water quality is much less detailed than the information available on water resources, flood risk management and household waste. There is considerable scope for improving the quality and quantity of publicly available information.

Data constraints also put some issues outside the scope of this report. One key issue that we were unable to cover was the management of surface water flooding. This will be an important consideration for new and existing housing. However, there is ongoing research to improve our understanding of surface-water flood risks and to show how those risks can be managed.

This study considers the effects of reducing demand for water resources and waste infrastructure. However, we have not attempted to evaluate the costs of the measures needed to achieve that reduction in demand. More work in this area would improve the results of this report. Any further study would need to assess how reductions could be achieved, and what they would cost. This would provide a clearer picture of the benefits of demand reduction.

Equally there is scope for exploiting the links between different areas of environmental infrastructure. Green infrastructure is the most obvious area for this, as the benefits to flood alleviation and water services are known. Future work should assess the possible options for reducing costs by making more of these links.

[56] For more information on Water Cycle Studies see: http://publications.environment-agency.gov.uk/pdf/GEHO0109BPFF-e-e.pdf

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