London’s Environmental Infrastructure Needs: A Strategic Study

Technical Annex

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1 Introduction

1.1 Overview

This Technical Annex provides details of the model that has been used to inform the London Environmental Infrastructure Needs Study. The Technical Annex explains the steps followed in the model, and lists the calculations that underpin the results presented in the main report.

For more information on the general methodology used in the London Environmental Infrastructure Needs Study, refer to the accompanying document, *A Methodology for Evaluating Environmental Infrastructure Needs.*

1.2 Disclaimer

This Technical Annex outlines the data and assumptions we have used in this study, many of which are specific to London. It does not, however, give a full explanation of the reasons behind the methodology used, or the assumptions made. This level of detail is included in *A Methodology for Evaluating Environmental Infrastructure Needs*.

While the data used in the London Environmental Infrastructure Needs Study is the best available in the public domain, there are limitations on how well it can be extrapolated to forecast future events. This study has aimed to avoid predicting exactly what will happen in the future, and instead presents outcomes for carefully defined hypothetical scenarios.

The forecasts we present here are, in our view, the most likely outcomes for the future. However, costs over time vary from year to year, particularly as technologies change and the price of raw materials and labour go up or down. So while we present our best estimates of costs in this report, they must be used with this stipulation in mind.

Many of the detailed results presented in this Technical Annex, including cost per home figures, and costs for individual London Boroughs, must be treated with caution. These results have been presented to aid improved understanding of how the findings presented in the main report have been arrived at. These figures are not suitable for informing further detailed modelling work, nor as the basis for detailed plans.

The majority of information derived for this project was sought from public records. If you would like to use any information presented here, please refer to the primary source itself. The data collected was manipulated for the purpose of this project and the specific objectives the project identified.

1.3 Discounting of costs

The costs in this study have not been discounted in any way. They are expressed as 2009 prices, with no inflation, real interest rates or time preferences taken into account. The costs in this study are intended to be indicative, and are left undiscounted to allow clearer comparisons to be drawn.

2 General demand

2.1 Key data sources

The general demand data used in the model have been derived from:

- Department for Communities and Local Government statistics on Housing and Neighbourhoods;
- The Draft Replacement London Plan; and
- The Generalised Land Use Database.

2.2 Number of new and existing homes

The number of existing homes in each London Borough is derived from Department for Communities and Local Government statistics on Housing and Neighbourhoods.

The number of new homes across London is an input variable in the model. The proportion of new homes allocated to each London Borough is derived from the Draft Replacement London Plan.

Table 2.1 shows the number of existing and new homes in each London Borough, under the Draft Replacement London Plan scenario of 33,400 new homes per year.

Table 2.1 Number of new and existing homes in each London Borough under the Draft Replacement London Plan scenario

London Borough	Existing homes	New homes per year	Total new homes by 2031
Barking and Dagenham LB	70,028	1,511	33,245
Barnet LB	135,618	2,257	49,647
Bexley LB	94,278	335	7,376
Brent LB	107,502	1,066	23,448
Bromley LB	133,448	565	12,439
Camden LB	99,007	665	14,641
City and County of the City of London	5,839	110	2,422
City of Westminster LB	118,716	771	16,953
Croydon LB	141,868	1,331	29,282
Ealing LB	125,445	891	19,595
Enfield LB	119,379	560	12,329
Greenwich LB	101,036	2,597	57,133

London Borough	Existing homes	New homes per year	Total new homes by 2031
Hackney LB	96,596	1,161	25,539
Hammersmith and Fulham LB	80,326	615	13,540
Haringey LB	100,444	821	18,054
Harrow LB	84,614	350	7,706
Havering LB	98,732	1,236	27,190
Hillingdon LB	102,500	620	13,650
Hounslow LB	92,988	470	10,348
Islington LB	93,437	1,171	25,759
Kensington and Chelsea LB	86,116	585	12,880
Kingston upon Thames LB	63,681	375	8,256
Lambeth LB	128,669	1,256	27,631
Lewisham LB	114,939	1,106	24,328
Merton LB	79,295	320	7,045
Newham LB	100,346	2,502	55,041
Redbridge LB	98,432	761	16,733
Richmond upon Thames LB	80,594	245	5,394
Southwark LB	122,467	2,007	44,143
Sutton LB	78,780	210	4,623
Tower Hamlets LB	98,799	2,887	63,518
Waltham Forest LB	96,582	761	16,733
Wandsworth LB	130,533	1,281	28,181

2.3 Population

The population of each London Borough is calculated by multiplying the number of homes by the occupancy of each home.

2.3.1 Occupancy rate

The occupancy rate for London is based on the Draft Replacement London Plan forecast, constant across London Boroughs (see Table 2.2). However, it is important to note the following:

- The Water Resources and Water Quality modules use occupancy rates forecast by water companies. These occupancy rates are given at the Water Resource Zone level which is used by water companies for water resources planning; and
- The zero housing growth scenario uses a constant occupancy rate (so that there is no change in population).

Table 2.2 London-wide occupancy rate

	2010	2013	2016	2019	2022	2025	2028	2031
Average household size	2.32	2.30	2.28	2.26	2.25	2.23	2.23	2.23

2.3.2 Household population

Forecast household population for each London Borough is shown in Table 2.3.

Table 2.3 Number of new and existing homes in each London Borough under the Draft Replacement London Plan scenario

London Borough	Household population *2009*	Household population *2031*	Net growth in household population *2009 - 2031*
Barking and Dagenham LB	163,165	230,299	67,133
Barnet LB	315,990	413,141	97,151
Bexley LB	219,668	226,687	7,020
Brent LB	250,480	292,017	41,538
Bromley LB	310,934	325,329	14,395
Camden LB	230,686	253,435	22,749
City and County of the City of London	13,605	18,422	4,817
City of Westminster LB	276,608	302,541	25,933
Croydon LB	330,552	381,664	51,112
Ealing LB	292,287	323,438	31,152
Enfield LB	278,153	293,709	15,556
Greenwich LB	235,414	352,716	117,302
Hackney LB	225,069	272,361	47,293
Hammersmith	187,160	209,321	22,162

London Borough	Household population *2009*	Household population *2031*	Net growth in household population *2009 - 2031*
and Fulham LB			
Haringey LB	234,035	264,249	30,215
Harrow LB	197,151	205,873	8,722
Havering LB	230,046	280,807	50,761
Hillingdon LB	238,825	259,015	20,190
Hounslow LB	216,662	230,439	13,777
Islington LB	217,708	265,808	48,099
Kensington and Chelsea LB	200,650	220,760	20,110
Kingston upon Thames LB	148,377	160,420	12,043
Lambeth LB	299,799	348,548	48,750
Lewisham LB	267,808	310,566	42,758
Merton LB	184,757	192,539	7,781
Newham LB	233,806	346,513	112,707
Redbridge LB	229,347	256,817	27,470
Richmond upon Thames LB	187,784	191,753	3,969
Southwark LB	285,348	371,540	86,192
Sutton LB	183,557	185,990	2,432
Tower Hamlets LB	230,202	361,966	131,764
Waltham Forest LB	225,036	252,691	27,655
Wandsworth LB	304,142	353,932	49,791

2.4 Land developed

The total amount of land developed is calculated by multiplying the density of new homes by the number of new homes in each London Borough.

2.4.1 Housing density

The current housing density is calculated for each London Borough by dividing the number of existing homes by the area of domestic buildings (derived from the Generalised Land Use Database). Table 2.4 shows housing density figures for each London Borough. It is assumed that housing density does not change from current levels over the modelled period.

2.4.2 Land developed

Table 2.4 shows the amount of land developed in each London Borough under the 33,400 new homes per year scenario.

Table 2.4 Housing density and area of land developed in each London Borough under the Draft Replacement London Plan scenario

London Borough	Housing density *(homes / hectare)*	Land developed each year *(hectares)*	Total land developed by 2031 *(hectares)*
Barking and Dagenham LB	226.33	6.68	146.89
Barnet LB	188.07	12.00	263.98
Bexley LB	211.07	1.59	34.94
Brent LB	214.61	4.97	109.26
Bromley LB	166.01	3.41	74.93
Camden LB	371.77	1.79	39.38
City and County of the City of London	245.46	0.45	9.87
City of Westminster LB	432.83	1.78	39.17
Croydon LB	186.54	7.14	156.97
Ealing LB	225.19	3.96	87.01
Enfield LB	199.27	2.81	61.87
Greenwich LB	235.46	11.03	242.64
Hackney LB	383.91	3.02	66.52
Hammersmith and Fulham LB	327.47	1.88	41.35
Haringey LB	237.96	3.45	75.87
Harrow LB	181.01	1.94	42.57
Havering LB	166.73	7.41	163.08
Hillingdon LB	178.39	3.48	76.52
Hounslow LB	221.89	2.12	46.63
Islington LB	412.93	2.84	62.38
Kensington and Chelsea LB	362.13	1.62	35.57
Kingston upon Thames LB	189.67	1.98	43.53
Lambeth LB	306.04	4.10	90.28

London Borough	Housing density *(homes / hectare)*	Land developed each year *(hectares)*	Total land developed by 2031 *(hectares)*
Lewisham LB	253.47	4.36	95.98
Merton LB	210.00	1.52	33.55
Newham LB	232.39	10.77	236.85
Redbridge LB	189.33	4.02	88.38
Richmond upon Thames LB	195.56	1.25	27.58
Southwark LB	368.03	5.45	119.94
Sutton LB	193.66	1.09	23.87
Tower Hamlets LB	626.35	4.61	101.41
Waltham Forest LB	226.33	3.45	75.94
Wandsworth LB	188.07	4.61	101.49

3 Flood and Coastal Risk Management (FCRM)

3.1 Key data sources

The data used in this module of the model are derived from:

- National Flood Risk Assessment (NaFRA) 2008-09; and
- The Long Term Investment Strategy (LTIS) produced for the Environment Agency.

3.2 Number of new homes at flood risk

We assume that the proportion of new homes at risk of flooding is equal to the proportion of land at risk of flooding in each London Borough. This information, derived from NaFRA, is shown in Table 3.1.

To derive the number of homes at greater than 1% annual probability of flooding from the NaFRA information, we have assumed an even distribution of risk within the moderate risk category. This means that 20% of homes in the moderate risk band have a greater than 1% annual probability of flooding.

Table 3.1 Proportion of each London Borough with greater than 1% annual probability of flooding

London Borough	Proportion of land at significant risk	Proportion of land at moderate risk	Calculated proportion of land at greater than 1% risk of flooding
Barking and Dagenham LB	14.28%	1.85%	14.65%
Barnet LB	1.72%	0.68%	1.85%
Bexley LB	8.50%	0.37%	8.57%
Brent LB	1.60%	1.30%	1.85%
Bromley LB	1.01%	0.54%	1.11%
Camden LB	0.00%	0.00%	0.00%
City and County of the City of London	8.54%	0.00%	8.54%
City of Westminster LB	2.59%	0.00%	2.59%
Croydon LB	0.60%	0.30%	0.66%
Ealing LB	1.77%	0.70%	1.91%
Enfield LB	5.07%	5.13%	6.10%
Greenwich LB	6.83%	0.42%	6.91%

London Borough	Proportion of land at significant risk	Proportion of land at moderate risk	Calculated proportion of land at greater than 1% risk of flooding
Hackney LB	1.94%	4.25%	2.79%
Hammersmith and Fulham LB	4.43%	0.00%	4.43%
Haringey LB	0.74%	2.16%	1.18%
Harrow LB	0.97%	1.39%	1.25%
Havering LB	9.01%	1.83%	9.37%
Hillingdon LB	4.60%	4.05%	5.41%
Hounslow LB	3.02%	0.60%	3.14%
Islington LB	0.00%	0.00%	0.00%
Kensington and Chelsea LB	2.10%	0.00%	2.10%
Kingston upon Thames LB	4.19%	3.95%	4.98%
Lambeth LB	1.80%	0.18%	1.83%
Lewisham LB	2.92%	1.47%	3.21%
Merton LB	6.78%	3.03%	7.38%
Newham LB	6.66%	1.26%	6.91%
Redbridge LB	5.01%	1.97%	5.41%
Richmond upon Thames LB	13.42%	3.35%	14.09%
Southwark LB	3.48%	0.00%	3.48%
Sutton LB	1.92%	0.64%	2.04%
Tower Hamlets LB	9.23%	0.00%	9.23%
Waltham Forest LB	6.70%	5.57%	7.81%
Wandsworth LB	4.63%	1.19%	4.87%

It is assumed that the number of new homes in each London Borough is evenly distributed across the area. Table 3.2 shows the number of new homes in each London Borough with a greater than 1% annual probability of flooding.

Table 3.2 Number of new homes built in an area of flood risk in each London Borough under the Draft Replacement London Plan scenario

London Borough	New homes per year	New homes per year at greater than 1% risk of flooding	Total new homes at greater than 1% risk of flooding up to 2031
Barking and Dagenham LB	1,511	221	4,870
Barnet LB	2,257	42	920
Bexley LB	335	29	632
Brent LB	1,066	20	435
Bromley LB	565	6	139
Camden LB	665	0	0
City and County of the City of London	110	9	207
City of Westminster LB	771	20	439
Croydon LB	1,331	9	194
Ealing LB	891	17	373
Enfield LB	560	34	752
Greenwich LB	2,597	180	3,949
Hackney LB	1,161	32	713
Hammersmith and Fulham LB	615	27	600
Haringey LB	821	10	212
Harrow LB	350	4	96
Havering LB	1,236	116	2,549
Hillingdon LB	620	34	738
Hounslow LB	470	15	325
Islington LB	1,171	0	0
Kensington and Chelsea LB	585	12	270
Kingston upon Thames LB	375	19	411
Lambeth LB	1,256	23	507
Lewisham LB	1,106	36	781
Merton LB	320	24	520
Newham LB	2,502	173	3,804
Redbridge LB	761	41	904
Richmond upon Thames LB	245	35	760

London Borough	New homes per year	New homes per year at greater than 1% risk of flooding	Total new homes at greater than 1% risk of flooding up to 2031
Southwark LB	2,007	70	1,536
Sutton LB	210	4	94
Tower Hamlets LB	2,887	266	5,860
Waltham Forest LB	761	59	1,307
Wandsworth LB	1,281	62	1,371

3.3 Flood defences required

The length of flood defence required is derived from:

1. the number of new homes (determined in Section 3.2);
2. the density of housing development; and
3. the number of kilometres of defences required per hectare of land developed.

3.3.1 Density of housing development

The density of housing within a London Borough was determined from the number of properties and the area of housing development. This is calculated by dividing the number of existing homes in each London Borough by the area of domestic buildings (derived from the Generalised Land Use Database). It was assumed that new housing will follow the same density as existing housing. The number of new homes can be used to generate the area of land developed for new housing. The results of these calculations are shown in Table 3.3.

3.3.2 Number of kilometres of defences required

It is assumed that 0.5 km of flood defence is required for every 1 hectare of new development built in an area with greater than 1% annual probability flood risk. Figure 3.1 shows the assumed shape of an average hectare. This assumption was used to determine the total length of new flood defences required, shown in Table 3.3.

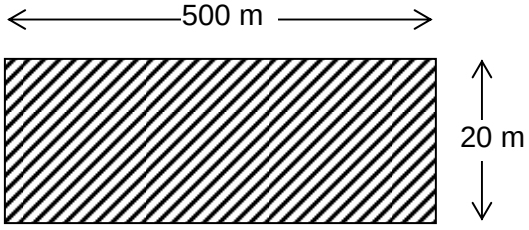

Figure 3.1 Generic shape of hectare within flood risk area

Table 3.3 Length of flood defence required per London Borough

London Borough	Housing density *(Properties per hectare of developed land)*	Total land developed for new housing up to 2031 *(Hectares)*	Total length of new flood defences required *(km)*
Barking and Dagenham LB	226	21.52	10.758
Barnet LB	188	4.89	2.447
Bexley LB	211	2.99	1.497
Brent LB	215	2.03	1.013
Bromley LB	166	0.83	0.417
Camden LB	372	0.00	0.000
City and County of the City of London	245	0.84	0.422
City of Westminster LB	433	1.01	0.507
Croydon LB	187	1.04	0.519
Ealing LB	225	1.66	0.829
Enfield LB	199	3.77	1.887
Greenwich LB	235	16.77	8.387
Hackney LB	384	1.86	0.928
Hammersmith and Fulham LB	327	1.83	0.916
Haringey LB	238	0.89	0.446
Harrow LB	181	0.53	0.266
Havering LB	167	15.29	7.644
Hillingdon LB	178	4.14	2.069
Hounslow LB	222	1.46	0.732
Islington LB	413	0.00	0.000
Kensington and Chelsea LB	362	0.75	0.373
Kingston upon Thames LB	190	2.17	1.084
Lambeth LB	306	1.66	0.828
Lewisham LB	253	3.08	1.541
Merton LB	210	2.48	1.239
Newham LB	232	16.37	8.184

London Borough	Housing density *(Properties per hectare of developed land)*	Total land developed for new housing up to 2031 *(Hectares)*	Total length of new flood defences required *(km)*
Redbridge LB	189	4.78	2.389
Richmond upon Thames LB	196	3.89	1.944
Southwark LB	368	4.17	2.087
Sutton LB	194	0.49	0.244
Tower Hamlets LB	626	9.36	4.678
Waltham Forest LB	220	5.93	2.966
Wandsworth LB	278	4.94	2.469

3.4 Evaluating the cost

The flood protection cost consists of:

1. Capital and maintenance cost for construction of the flood defence;
2. Labour costs for construction and maintenance; and
3. Construction and maintenance costs of compensatory storage.

The cost for constructing the capital flood defence is based on costs per kilometre given in the Long Term Investment Strategy cost model. This study uses a range of different costs for different types of defences. We have used a weighted average, based on the frequency of use of different defences in London. The average cost used is £1,087,878 per kilometre for construction and £4,355 per kilometre per year for maintenance.

The costs for labour and compensatory storage are determined using the uplifts shown in Table 3.4. The Long Term Investment Strategy assumes that labour represents 33% of the capital and maintenance costs of constructing the flood defence. The compensatory storage cost uplift is based on advice and case studies provided by the Environment Agency.

Table 3.4 FCRM cost uplifts

Cost type	Construction of the flood defence	Labour cost uplift	Compensatory storage cost uplift
Capital cost	100%	33%	200%
Maintenance cost	100%	33%	100%

4 Green Infrastructure

4.1 Key data sources

The data used in this module are derived from:

- The Generalised Land Use Database (GLUD); and
- Various cost case studies, conducted by Halcrow and CABE Space.

4.2 Green Infrastructure supply

The amount of Green Infrastructure currently available within each London Borough is assumed to be equivalent to the amount of existing greenspace. This is derived from the Generalised Land Use Database and is shown in Table 4.1.

Table 4.1 Current greenspace / Green Infrastructure levels in each London Borough

London Borough	Greenspace / Green Infrastructure *(Hectares)*	Total area of borough *(Hectares)*	Percentage greenspace *(%)*
Barking and Dagenham LB	1,268	3,778	33.6%
Barnet LB	3,584	8,674	41.3%
Bexley LB	2,013	6,426	31.3%
Brent LB	949	4,324	21.9%
Bromley LB	8,675	15,015	57.8%
Camden LB	540	2,180	24.8%
City and County of the City of London	15	315	4.8%
City of Westminster LB	3,210	2,203	21.5%
Croydon LB	1,715	8,652	37.1%
Ealing LB	3,750	5,553	30.9%
Enfield LB	1,728	8,220	45.6%
Greenwich LB	443	5,038	34.3%
Hackney LB	327	1,906	23.2%
Hammersmith and Fulham LB	755	1,716	19.1%
Haringey LB	1,744	2,959	25.5%

Harrow LB	6,788	5,047	34.6%
Havering LB	5,696	11,447	59.3%
Hillingdon LB	2,242	11,570	49.2%
Hounslow LB	184	5,659	39.6%
Islington LB	187	1,486	12.4%
Kensington and Chelsea LB	1,357	1,239	15.1%
Kingston upon Thames LB	470	3,725	36.4%
Lambeth LB	795	2,725	17.3%
Lewisham LB	1,300	3,532	22.5%
Merton LB	921	3,761	34.6%
Newham LB	2,292	3,868	23.8%
Redbridge LB	2,983	5,644	40.6%
Richmond upon Thames LB	744	5,877	50.8%
Southwark LB	1,405	2,990	24.9%
Sutton LB	321	4,385	32.0%
Tower Hamlets LB	1,218	2,157	14.9%
Waltham Forest LB	948	3,882	31.4%
Wandsworth LB	474	3,522	26.9%

4.3 Green Infrastructure demand

The amount of Green Infrastructure required is the sum of:

1. the potential total area lost from housing development (the impact of new homes); and
2. the total area required to increase Green Infrastructure within the Inner London Boroughs

4.3.1 Impact of new homes on Green Infrastructure

The amount of land used for housing development in each London Borough is derived from Table 2.4. 96% of London's new homes are scheduled to be built on brownfield land. We have assumed that brownfield land is Green Infrastructure, unless it is currently in use. Because 90% of brownfield land is currently in use, the proportion of new homes built on Green Infrastructure is assumed to be 13.6%[1]. Therefore, the total area required to offset housing development is calculated from the total land

[1] These figures are taken from the London Development Agency's Brownfield Land Database. See www.londonbrownfieldsites.org/ for more details.

developed, multiplied by this assumed percentage of Green Infrastructure. The result of this calculation is shown in Table 4.2.

4.3.2 Targets for increases in Green Infrastructure

Targets for increasing Green Infrastructure have been applied to Inner London Boroughs. The percentage targets (5% and 10% have been used as scenarios in the main report) are multiplied by the existing greenspace in relevant London Boroughs. The amount of greenspace is derived from the Generalised Land Use Database and is shown in Table 4.1.

4.3.3 Demand for new Green Infrastructure

The different sources of demand for new Green Infrastructure are shown in Table 4.2.

Table 4.2 Extra Green Infrastructure required in each London Borough

London Borough	Green Infrastructure required by 2031 to offset development losses from development *(Hectares)*	Extra Green Infrastructure required by 2031 to meet 5% greening in Inner London *(Hectares)*	Extra Green Infrastructure required by 2031 to meet 10% greening in Inner London *(Hectares)*
Barking and Dagenham LB	19.977	0.000	0.000
Barnet LB	35.901	0.000	0.000
Bexley LB	4.752	0.000	0.000
Brent LB	14.859	0.000	0.000
Bromley LB	10.191	0.000	0.000
Camden LB	5.356	25.809	51.565
City and County of the City of London	1.342	0.725	1.449
City of Westminster LB	5.327	153.355	306.393
Croydon LB	21.348	0.000	0.000
Ealing LB	11.834	0.000	0.000
Enfield LB	8.415	0.000	0.000
Greenwich LB	32.999	21.157	42.270
Hackney LB	9.047	15.632	31.231
Hammersmith and Fulham LB	5.623	36.050	72.025
Haringey LB	10.318	0.000	0.000

London Borough	Green Infrastructure required by 2031 to offset development losses from development *(Hectares)*	Extra Green Infrastructure required by 2031 to meet 5% greening in Inner London *(Hectares)*	Extra Green Infrastructure required by 2031 to meet 10% greening in Inner London *(Hectares)*
Harrow LB	5.790	0.000	0.000
Havering LB	22.179	0.000	0.000
Hillingdon LB	10.406	0.000	0.000
Hounslow LB	6.342	0.000	0.000
Islington LB	8.484	8.944	17.870
Kensington and Chelsea LB	4.837	64.836	129.538
Kingston upon Thames LB	5.920	0.000	0.000
Lambeth LB	12.279	37.988	75.896
Lewisham LB	13.053	62.129	124.130
Merton LB	4.563	0.000	0.000
Newham LB	32.211	0.000	0.000
Redbridge LB	12.019	0.000	0.000
Richmond upon Thames LB	3.751	0.000	0.000
Southwark LB	16.312	67.133	134.128
Sutton LB	3.247	0.000	0.000
Tower Hamlets LB	13.792	58.203	116.286
Waltham Forest LB	10.327	0.000	0.000
Wandsworth LB	13.802	22.623	45.198

4.4 Green Infrastructure cost

The average cost per hectare used in this study is based on case studies for the costs to construct and maintain high quality parks. CABE Space have produced a framework for valuing the infrastructure costs associated with parks[2], which has been used to derive estimated average costs. The average cost per hectare for this type of Green Infrastructure is estimated at £178,328 per hectare.

The costs identified for Green Infrastructure do not take land costs into account.

[2] See http://www.cabe.org.uk/public-space/parks/assets-examples for more information on this.

Table 4.3 shows the estimated costs of achieving the required levels of Green Infrastructure for each London Borough.

Table 4.3 Costs of providing extra Green Infrastructure

London Borough	Total cost of Green Infrastructure required by 2031 to offset development losses from development *(£)*	Total cost of Green Infrastructure required by 2031 to meet 5% greening in Inner London *(£)*	Total cost of Green Infrastructure required by 2031 to meet 10% greening *(£)*
Barking and Dagenham LB	£3,562,462	£0	£0
Barnet LB	£6,402,155	£0	£0
Bexley LB	£847,456	£0	£0
Brent LB	£2,649,758	£0	£0
Bromley LB	£1,817,309	£0	£0
Camden LB	£955,120	£4,602,539	£9,195,555
City and County of the City of London	£239,290	£129,320	£258,373
City of Westminster LB	£949,900	£27,347,529	£54,638,475
Croydon LB	£3,806,971	£0	£0
Ealing LB	£2,110,289	£0	£0
Enfield LB	£1,500,555	£0	£0
Greenwich LB	£5,884,611	£3,772,891	£7,537,975
Hackney LB	£1,613,361	£2,787,552	£5,569,337
Hammersmith and Fulham LB	£1,002,776	£6,428,715	£12,844,130
Haringey LB	£1,839,996	£0	£0
Harrow LB	£1,032,434	£0	£0
Havering LB	£3,955,184	£0	£0
Hillingdon LB	£1,855,740	£0	£0
Hounslow LB	£1,130,992	£0	£0
Islington LB	£1,512,917	£1,594,975	£3,186,651
Kensington and Chelsea LB	£862,565	£11,562,050	£23,100,178
Kingston upon Thames LB	£1,055,698	£0	£0

London Borough	Total cost of Green Infrastructure required by 2031 to offset development losses from development *(£)*	Total cost of Green Infrastructure required by 2031 to meet 5% greening in Inner London *(£)*	Total cost of Green Infrastructure required by 2031 to meet 10% greening *(£)*
Lambeth LB	£2,189,644	£6,774,228	£13,534,439
Lewisham LB	£2,327,786	£11,079,373	£22,135,821
Merton LB	£813,662	£0	£0
Newham LB	£5,744,176	£0	£0
Redbridge LB	£2,143,367	£0	£0
Richmond upon Thames LB	£668,948	£0	£0
Southwark LB	£2,908,972	£11,971,765	£23,918,761
Sutton LB	£579,004	£0	£0
Tower Hamlets LB	£2,459,413	£10,379,281	£20,737,086
Waltham Forest LB	£1,841,667	£0	£0
Wandsworth LB	£2,461,368	£4,034,240	£8,060,134

5 Waste management

5.1 Key data sources

The data used in this module of the model are derived from:

- WasteDataFlow statistics (collated by Defra) for household and municipal waste for each London Borough[3];
- WRAP Gate Fee Surveys[4], which give market rates for different types of facilities;
- Environment Agency permit data on waste facilities[5].

5.2 Waste Authorities in London

Modelling of the Waste requirements for London was carried out at the Waste Authority level on a year-by-year basis. Table 5.1 provides details of which London Boroughs operate as Unitary Waste Authorities, and which dispose of waste through Waste Collection Authorities.

Table 5.1 Waste Authority arrangements for London Boroughs

Waste Disposal Authority	Waste Collection Authority
North London WDA	Barnet, Camden, Enfield, Islington, Hackney, Haringey, Waltham Forest
West London WDA	Brent, Ealing, Harrow, Hillingdon, Hounslow, Richmond
East London WDA	Newham, Barking and Dagenham, Redbridge, Havering
Western Riverside WDA	Hammersmith and Fulham, Kensington and Chelsea, Lambeth, Wandsworth
Unitary Waste Authorities	
City of Westminster, City of London, Bexley, Bromley, Croydon, Greenwich, Kingston, Lewisham, Merton, Southwark, Sutton, Tower Hamlets	

5.3 Household waste generation

The amount of household waste produced in 2008-09 is obtained from WasteDataFlow and used to generate a baseline of waste generation for each London Borough (see Table 5.2 for details).

[3] www.**wastedataflow**.org/

[4] See http://www.wrap.org.uk/downloads/W504GateFeesWEB.38609f80.7613.pdf for the 2009 report.

[5] This information is available on request from the Environment Agency.

Table 5.2 Aggregate baseline for household waste generation and streams, 2008/09

Household waste generation determinants		
Household waste generated per person per year *(kg per person)*		365.8
Population		7,644,809
Variable	**Proportion** *(%)*	**Total waste** *(tonnes)*
Recycling	23.07	645,166
Composting	6.14	171,822
Energy from Waste	20.21	564,989
Landfill	50.58	1,414,258

From this baseline, the model generates a forecast of the amount of household waste generated in each stream to 2031. These changes are assumed to occur linearly. The key variables influencing future waste streams are:

1. Population (determined in the general demand module of the methodology);
2. Waste generated per person (varies over time between different scenarios); and
3. % of household waste allocated between recycling, composting, Energy from Waste and landfill (varies over time between different scenarios).

5.4 Household waste disposal

The method used to determine the capacity of infrastructure varies between the two approaches.

5.4.1 Market Approach

Waste Authorities pay by the tonne for the waste they produce, and there are no explicit capacity limits in the model.

5.4.2 Internal Capacity Approach

This approach predicts the extra capacity of waste facilities required within London to manage all household waste. The extra capacity required depends on three main factors:

1. The total amount of waste generated and how this is split within each stream (recycling, composting, Energy from Waste and landfill). This is derived from the process described in section 5.3;
2. The proportion of household waste managed within London; and

3. The current capacity of London's waste management facilities.

The proportion of household waste generated and managed within London changes over the modelled period, from the baseline in 2009 to the 2031 aspiration, as shown in Table 5.3.

Table 5.3 Proportion of household waste managed within London

	2010	2013	2016	2019	2022	2025	2028	2031
% municipal waste managed internally	56 %	64%	69%	75%	81%	87%	92%	100 %

The current capacity of waste management facilities in London is calculated from Environment Agency permit data. These facilities also handle Commercial and Industrial waste and the non-household element of municipal waste, however the capacity dedicated to these waste streams is assumed to remain static.

For 2008-09, the facilities are divided according to the amount of waste in each of these streams, and the capacity that is available for household waste is identified. From this baseline position, all future capacity requirements refer to household waste only.

Figure 5.2 shows how much extra capacity is required at different types of waste management facility within London.

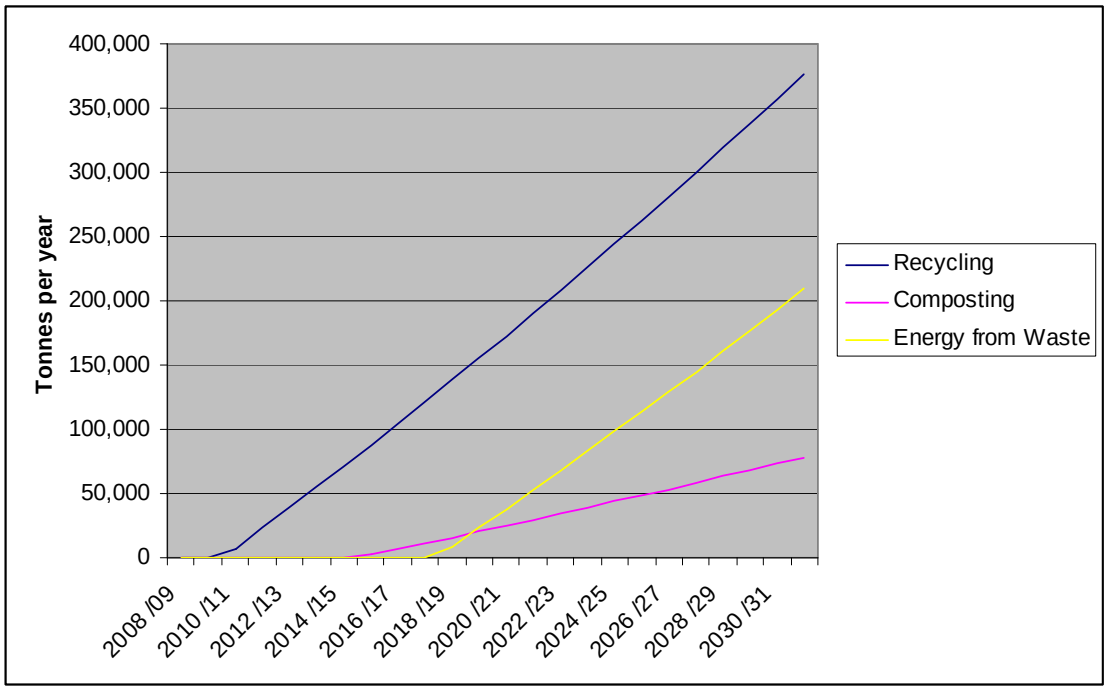

Figure 5.2 Extra capacity required at waste management facilities for London to achieve waste self-sufficiency by 2031

5.5 Cost for waste management

5.5.1 Market Approach

The cost for managing household waste consists of:

1. collection cost[6];
2. disposal cost[7]; and
3. for landfill waste, landfill tax is also applied.

Collection costs are derived from WasteDataFlow data, and modelled for each Waste Authority.

Waste disposal costs are derived from WRAP Gate Fee Surveys, and are shown in Table 5.4. The total cost of disposal is calculated by multiplying the total tonnage of household waste generated in each stream, by the gate fee per tonne.

For landfill, the costs per tonne of landfill tax also need to be added. The schedule of landfill tax used in the model is shown in Table 5.5.

Table 5.4 Costs per tonne for collecting and disposing of household waste

Waste process	Cost *(£ per tonne)*
Collection cost (average across London)	£56.32
Recycling	£22.50
Composting	£39.00
Energy from Waste	£81.50
Landfill	£21.50 + landfill tax (see Table 4.4)

Table 5.5 Landfill tax per tonne

£ per tonne						
Type of cost	**2009**	**2010**	**2011**	**2012**	**2013**	**2015 - 2031**
Landfill tax per tonne	40	48	56	64	72	80

5.5.2 Internal Capacity Approach

The costs in the Internal Capacity Approach are based on the extra capacity required for each waste process. Table 5.6 sets out the capital and operational costs per tonne for each process. The costs per tonne depend on the size of some of the facilities; we have modelled different sized facilities where appropriate. We have assumed that the

[6] Collection costs include the cost of collecting and transporting household waste.
[7] Disposal cost is the cost to treat, process or landfill waste.

average recycling facility has an annual capacity of 85,000 tonnes, and the average Energy from Waste facility has a capacity of 240,000 tonnes per year.

Table 5.6 Costs per tonne for extra capacity of waste facilities in London

Waste process	Average tonnage of capacity per year	Capital cost *(£ per extra tonne of capacity)*	Operational cost per year *(£ per extra tonne of capacity)*
Recycling facility	10,000	£70.30	£38.31
	25,000	£92.46	£48.24
	50,000	£135.30	£66.58
	85,000	£216.34	£109.17
Energy from Waste facility	60,000	£717.08	£0
	120,000	£638.61	£0
	240,000	£568.73	£0
	480,000	£506.49	£0
Composting facility		£100	£20

6 Water Quality

6.1 Key data sources

The data used in this module of the model are derived from:

- Cost curve information provided to Halcrow by Ofwat;
- Annual Return (June Return) tables submitted to Ofwat in 2009; and
- London Borough/Sewage Treatment Works distribution matrix from Thames Water (provided under a Confidentiality Agreement between Thames Water and Halcrow Group Ltd).

6.2 Demand for sewage treatment

Modelling of the STW load treatment requirements for London was carried out at the Sewage Treatment Works catchment level on a year-by-year basis. There are eight STWs, split between Thames Tideway and non-Tideway sites, as follows:

- Tideway sites: Beckton, Riverside, Mogden, Long Reach and Crossness;
- Non-tideway sites: Beddington, Deephams and Hogsmill.

Population estimates for the whole of London have been estimated using occupancy rate figures from Water Resource Management Plan tables (WRP1-BL), assuming that water supply customers are equal in number to wastewater producing customers.

Each of the 33 London Boroughs was assigned to one or more of the eight sewage treatment works catchments based on data provided by Thames Water.

The household population in each sewage treatment works catchment is shown in Table 6.1.

Table 6.1 Population for each sewage treatment works catchment

Water Resource Zone	Household population *2009*	Household population *2031*	Net change in population *2009 – 2031*
Beckton	2,727,541	3,212,876	513,796
Beddington	322,584	379,984	60,766
Crossness	1,818,931	2,142,590	342,638
Deephams	720,579	848,798	135,738
Hogsmill	163,328	192,390	30,767
Long Reach	666,271	784,826	125,508
Mogden	1,528,019	1,799,913	287,838
Riverside	389,489	458,794	73,369

6.2.1 Adjusting population to population equivalent

Both capacity and demand for sewage treatment is expressed in population equivalent terms[8]. Population equivalent is not always equal to population, and adjustment factors have been worked out based on the ratio of population equivalent to population in the baseline year. It is assumed that these proportions remain constant across the modelled period.

The adjustment for each sewage treatment works are shown in Table 6.2.

Table 6.2 Population equivalent adjustment factors

Sewage treatment works	Ratio of population equivalent to connected population
Beckton	119.6%
Beddington	108.2%
Crossness	103.4%
Deephams	113.6%
Hogsmill	111.9%
Long Reach	118.7%
Mogden	120.4%
Riverside	99.4%

6.3 Sewage treatment capacity

Sewage treatment capacity is assessed in population equivalent terms. Thames Water has indicated that upgrades being carried out under AMP4 and AMP5 will provide sufficient headroom to accommodate their growth forecasts up to certain points. Table 6.3 shows the planning horizons for each sewage treatment works.

Table 6.3 Planning horizons for London sewage treatment works

Sewage treatment works	Year up to which STW has sufficient capacity and headroom
Beckton	2021
Beddington	2015
Crossness	2021
Deephams	2021
Hogsmill	2015
Long Reach	2021
Mogden	2021
Riverside	2021

[8] One population equivalent is roughly the amount of load produced by one person. One population equivalent is the biodegradable load (matter) in waste water having a 5-day biochemical oxygen demand (BOD) of 60g oxygen per day, as defined in the Urban Waste Water Treatment Directive (91/271/EEC).

The modelled treatment capacity of each sewage treatment works is equal to Thames Water's population forecast in the year shown in Table 6.3. Table 6.4 shows the treatment capacity for each sewage treatment works.

Table 6.4 Treatment capacity at each sewage treatment works

Sewage treatment works	Sewage treatment capacity (after AMP5 works) *(population equivalents)*
Beckton	3,601,396
Beddington	363,450
Crossness	2,075,497
Deephams	903,775
Hogsmill	190,280
Long Reach	873,167
Mogden	2,031,367
Riverside	427,179

6.4 Treatment cost

The total cost for meeting the potential deficit consists of:

1. Capital cost (CAPEX); and
2. Operational cost (OPEX);

For every Sewage Treatment Catchment, the total deficit for each year is set against the cost curves to establish the capital and operational costs to meet it.

6.4.1 Capital cost

To calculate the capital cost for providing the treatment capacity, the model adopts a cost curve obtained from Ofwat. This cost curve is expressed as:

$$y = 1.3988x^{-0.3938}$$

- where **y** is cost per increase in population equivalent treatment capacity in thousands of pounds (2007-08 prices); and
- **x** is the original size of treatment works in thousands PE.

However, we have made two amendments to the curve:

1. We have assumed that there is a minimum cost of £181.55 per population equivalent, which occurs with STW size of 500,000 p.e. This is based on advice from Thames Water; and

2. We have applied a 50% uplift factor for London (Ofwat were unable to provide us with a figure for this, but it represents the upper bound Ofwat would accept from water companies in their submissions).

The costs of the AMP5 growth schemes are not included in our cost estimates.

6.4.2 Operational cost

The operational cost per unit for providing treatment capacity is obtained from water companies' June Return, which is shown in Table 6.5. We have assumed that this remains constant across the modelled period.

Table 6.5 Operational cost per year per unit per treatment capacity

Sewage treatment works	Annual opex per population equivalent
Beckton	£2.33
Beddington	£4.35
Crossness	£4.37
Deephams	£4.82
Hogsmill	£7.72
Long Reach	£1.82
Mogden	£2.55
Riverside	£6.13

6.5 Modelling changes in consent levels to achieve load standstill

The load standstill scenario models a constant amount of load discharged by sewage treatment works. The total cost is the sum of the cost to increase treatment capacity plus the costs of removing additional load from the wastewater. The costs to remove additional load are based on cost curves per kilogram of load removed from wastewater.

We have combined cost figures provided by Ofwat[9] (which gives the cost per kilogram) with modelling work done by Halcrow[10] (which shows how the costs change as consents get tighter).

The Ofwat figures show how much it costs to remove each additional kilogram of load at a Sewage Treatment Works, which can be used to show the cost of holding output load from STWs constant.

The Halcrow model is used to derive the relative costs of increasing treatment standards for different consent levels, so that STWs with tighter consents have a higher cost per kg of load removed.

The steps for calculating equivalent annualised costs for achieving load standstill are:

[9] http://www.ofwat.gov.uk/regulating/rpt_com_oxera080107.pdf.
[10] *Sewage Infrastructure and Growth in the South East – Implications of the Water Framework Directive*. Report produced for XXXX. This work is yet to be published.

1. Multiply load produced per person per day (60g) by the population for each catchment. This gives the total amount of load entering each sewage treatment works each day. Multiply this figure by 365 to give the annual load;
2. Subtract the load generated (from step 1) from the 2008-09 level of load produced. This gives the additional load for each year which needs to be removed;
3. Establish the consent level required to meet load standstill at each sewage treatment works. This is done by dividing the amount of output load necessary (equal to load in 2008-09) by the total amount of wastewater entering the sewage treatment works (derived from Water Resources module);
4. Calculate cost of per extra kilogram of load removed for each sewage treatment works. The cost curve is expressed as:

$$y = 1.6 * 14.1059x^{-1.1494}$$

   - where y is the cost per kilogram of extra load removed in £; and
   - x is the consent level for BOD for the sewage treatment works, expressed in milligrams per litre.

5. Multiply the cost per kilogram by the kilograms of additional load to be removed, to give the total equivalent annualised cost for achieving load standstill.

7 Water Resources

7.1 Key data sources

The data used in this module of the model are derived from:

- Water companies' draft Water Resource Management Plans (dWRMP) from 2010-2035. We have used Dry Year Annual Average[11] tables from Revised Draft Water Resource Management Plans for all of the six Water Resource Zones in London;
- June Return tables submitted to Ofwat by water companies in 2009; and
- Local Authority/Water Resource Zone distribution matrix for the UK from the Environment Agency Water Resources team[12].

7.2 Water Demand

The total demand for water from households, by Water Resource Zone, is made up of the amount of water consumed, plus leakage and an allowance for target headroom.

7.2.1 Amount of water consumed

The total demand for water in London is calculated by multiplying the total household population by the average Per Capita Consumption of water.

Total household population is generated within the model, by multiplying the number of homes by the occupancy rates forecast by water companies (which are different to the occupancy rates forecast by government). See Table 7.3 for our household population forecasts.

Average Per Capita Consumption is a variable in the model. (See Table 7.3 in the *London Environmental Infrastructure Needs Study* report for details).

1. Each of London's 33 Boroughs were assigned to one or more Water Resource Zones, using allocation factors provided by the Environment Agency. These allocation factors indicate what proportion of each London Borough is in a given Water Resource Zone (see Table 3.3 for details).
2. The forecast housing and population growth for each London Borough (from Section 1: General Demand) is then assigned to Water Resource Zones using the factors in Table 7.1. Tables 7.2 and 7.3 set out the forecast housing and population growth for each Water Resource Zone between 2009 and 2031, under the 33,400 new homes per year scenario.
3. The amount of water consumed is determined by multiplying the population shown in Table 7.3 by the Average Per Capita Consumption. Table 7.4 sets out the forecast water consumed for each Water Resource Zone between 2009 and

[11] The Sutton and East Surrey Water Resource Zones both have plans for critical periods. This study has used Dry Year Annual Average for consistency. This means that some of the issues faced by these two Water Resource Zones at critical periods are not taken into account.
[12] The six Water Resource Zones serving London are: London (Thames Water); Central (Veolia Central); Southern (Veolia Central); Essex (Essex and Suffolk); Sutton (Sutton and East Surrey); and East Surrey (Sutton and East Surrey).

2031, under the 33,400 new homes per year scenario for an Average Per Capita Consumption following Water Resource Management Plan baseline tables.

Table 7.1 Proportion of London Boroughs in each Water Resource Zone

London Borough	London	Essex	Sutton	East Surrey	Central	South
Barking and Dagenham LB	0%	100%	0%	0%	0%	0%
Barnet LB	18%	0%	0%	0%	82%	0%
Bexley LB	100%	0%	0%	0%	0%	0%
Brent LB	41%	0%	0%	0%	59%	0%
Bromley LB	100%	0%	0%	0%	0%	0%
Camden LB	100%	0%	0%	0%	0%	0%
City and County of the City of London	100%	0%	0%	0%	0%	0%
City of Westminster LB	100%	0%	0%	0%	0%	0%
Croydon LB	59%	0%	6%	35%	0%	0%
Ealing LB	47%	0%	0%	0%	36%	17%
Enfield LB	95%	0%	0%	0%	5%	0%
Greenwich LB	100%	0%	0%	0%	0%	0%
Hackney LB	100%	0%	0%	0%	0%	0%
Hammersmith and Fulham LB	100%	0%	0%	0%	0%	0%
Haringey LB	100%	0%	0%	0%	0%	0%
Harrow LB	0%	0%	0%	0%	100%	0%
Havering LB	0%	100%	0%	0%	0%	0%
Hillingdon LB	0%	0%	0%	0%	93%	7%
Hounslow LB	74%	0%	0%	0%	0%	26%
Islington LB	100%	0%	0%	0%	0%	0%
Kensington and Chelsea LB	100%	0%	0%	0%	0%	0%
Kingston upon Thames LB	100%	0%	0%	0%	0%	0%
Lambeth LB	100%	0%	0%	0%	0%	0%

London Borough	London	Essex	Sutton	East Surrey	Central	South
Lewisham LB	100%	0%	0%	0%	0%	0%
Merton LB	84%	0%	16%	0%	0%	0%
Newham LB	100%	0%	0%	0%	0%	0%
Redbridge LB	55%	45%	0%	0%	0%	0%
Richmond upon Thames LB	100%	0%	0%	0%	0%	0%
Southwark LB	100%	0%	0%	0%	0%	0%
Sutton LB	2%	0%	98%	0%	0%	0%
Tower Hamlets LB	100%	0%	0%	0%	0%	0%
Waltham Forest LB	100%	0%	0%	0%	0%	0%
Wandsworth LB	100%	0%	0%	0%	0%	0%

Table 7.2 Housing numbers for each Water Resource Zone under the 33,400 new homes per year scenario

Water Resource Zone	Number of houses *2009*	Number of houses *2031*	Net housing growth *2009 - 2031*
London (Thames)	2,462,940	3,022,835	559,895
Essex (Essex and Suffolk)	212,879	280,863	67,983
Sutton (Sutton and East Surrey)	97,629	104,892	7,263
East Surrey (Sutton and East Surrey)	50,019	60,338	10,319
South (Veolia Water Central)	52,790	59,790	7,000
Central (Veolia Water Central)	404,720	487,053	82,332
Total in London	**3,280,978**	**4,015,771**	**734,793**

Table 7.3 Population figures for each Water Resource Zone under the 33,400 new homes per year scenario

Water Resource Zone	Population *2009*	Population	Population growth *2009 - 2031*
London (Thames)	6,226,626	7,494,997	1,268,371

Water Resource Zone	Population *2009*	Population	Population growth *2009 - 2031*
Essex (Essex and Suffolk)	539,906	689,642	149,736
Sutton (Sutton and East Surrey)	239,432	238,389	-1,043
East Surrey (Sutton and East Surrey)	127,561	147,072	19,511
South (Veolia Water Central)	136,116	142,253	6,137
Central (Veolia Water Central)	1,057,691	1,200,166	142,475
Total in London	**8,327,333**	**9,912,519**	**1,585,186**

Table 7.4 Amount of water consumed for each Water Resource Zone under the 33,400 new homes per year scenario with an Average Per Capita Consumption reaching 130 litres per person per day by 2031.

Water Resource Zone	Average Per Capita Consumption 2009 (L/person/day)	Average Per Capita Consumption 2031 (L/person/day)[13]	Water Consumed 2009 (Ml/day)	Water Consumed 2031 (Ml/day)
London (Thames)	162	130	1,009	956
Essex (Essex and Suffolk)	164	130	89	87
Sutton (Sutton and East Surrey)	190	130	24	19
East Surrey (Sutton and East Surrey)	172	130	41	31
South (Veolia Water Central)	186	130	25	19
Central (Veolia Water Central)	168	130	177	155
Total in London	**164**	**130**	**1366**	**1267**

[13] 130 litres per person per day is based on a Defra aspiration that applies to normal year annual average consumption. In this study, we have applied the aspiration to dry year annual average scenarios for indicative purposes.

7.2.2 Leakage

Leakage is calculated as a percentage of household consumption from the Water Resource Management Plan baseline tables:

$$\%\text{Leakage} = \frac{\text{Total Leakage}}{\text{Household consumption}}$$

This percentage is then multiplied by the amount consumed for a scenario to determine the amount of leakage added to the demand. The leakage percentages for the six Water Resource Zones are shown in Table 7.5.

The modelled leakage allowance for the 33,400 new homes per year scenario is shown in Table 7.6.

Table 7.5 Percentage leakage for all six Water Resource Zones

Water Resource Zone	Leakage *(%) 2009*	Leakage *(%) 2031*
London (Thames)	58.34%	49.13%
Essex (Essex and Suffolk)	25.22%	28.90%
Sutton (Sutton and East Surrey)	20.21%	18.81%
East Surrey (Sutton and East Surrey)	22.92%	20.91%
South (Veolia Water Central)	21.83%	21.61%
Central (Veolia Water Central)	43.74%	42.43%

Table 7.6 Amount of leakage for each Water Resource Zone under the 33,400 new homes per year scenario with an Average Per Capita Consumption following Water Resource Management Plan baseline tables.

Water Resource Zone	Leakage *(Megalitres per day) 2009*	Leakage *(Megalitres per day) 2031*
London (Thames)	589	470
Essex (Essex and Suffolk)	22	25
Sutton (Sutton and East Surrey)	5	4
East Surrey (Sutton and East Surrey)	8	6
South (Veolia Water Central)	6	4
Central (Veolia Water Central)	78	66
Total in London	**708**	**575**

7.2.3 Target Headroom

Target Headroom is calculated as a percentage of total water delivered from the Water Resource Management Plan baseline tables:

$$\%\,\text{Target Headroom} = \frac{\text{Target Headroom}}{\text{Household consumption}}$$

This percentage is then multiplied by the amount consumed for a scenario to determine the amount of Target Headroom added to the demand. The Target Headroom percentages for the six Water Resource Zones are shown in Table 7.7.

Table 7.7 Percentage target headroom for all six Water Resource Zones

Water Resource Zone	Target headroom *(%) 2009*	Target headroom *(%) 2031*
London (Thames)	8.04%	15.40%
Essex (Essex and Suffolk)	5.54%	8.46%
Sutton (Sutton and East Surrey)	9.15%	10.47%
East Surrey (Sutton and East Surrey)	29.60%	29.66%
South (Veolia Water Central)	5.05%	13.84%
Central (Veolia Water Central)	7.30%	14.51%

Table 7.8 Amount of target headroom for each Water Resource Zone under the 33,400 new homes per year scenario with an Average Per Capita Consumption following Water Resource Management Plan baseline tables.

Water Resource Zone	Target headroom *(Megalitres per day) 2009*	Target headroom *(Megalitres per day) 2031*
London (Thames)	82	175
Essex (Essex and Suffolk)	14	22
Sutton (Sutton and East Surrey)	19	21
East Surrey (Sutton and East Surrey)	5	6
South (Veolia Water Central)	5	12
Central (Veolia Water Central)	19	39
Total in London	**143**	**274**

7.2.4 Total demand

Table 7.9 shows the total demand for water (amount of water consumed plus leakage, plus target headroom) in 2009 and 2031 under a scenario with 33,400 new homes per

year, and average Per Capita Consumption following Water Resource Management Plan baseline tables.

Table 7.9 Total household demand for water

Water Resource Zone	Total demand *(megalitres per day)* *2009*	Total demand *(megalitres per day)* *2031*	Net change in demand *(megalitres per day)* *2009 – 2031*
London (Thames)	1679.18	1871.28	192.10
Essex (Essex and Suffolk)	124.75	146.39	21.65
Sutton (Sutton and East Surrey)	54.35	54.98	0.63
East Surrey (Sutton and East Surrey)	48.60	53.29	4.69
South (Veolia Water Central)	35.41	42.29	6.88
Central (Veolia Water Central)	274.62	303.90	29.28

7.3 Water supply

The total supply for London households, by Water Resource Zone, is determined from the Water Available For Use (WAFU) from the water companies' Water Resource Management Plan baseline tables for the study area. Two adjustments are made to the total WAFU figure:

1. The proportion of WAFU available for London is calculated, based on London factors;
2. Water consumed by non-household customers and water taken unbilled are subtracted from the total WAFU.

7.3.1 Calculating the proportion of each Water Resource Zone that is in London

To work out what proportion of each Water Resource Zone is in London, we have calculated a London factor, which gives the proportion of each Water Resource Zone that is within London.

Table 7.10 London factors for each Water Resource Zone (the proportion of the Water Resource Zone within London)

Water Resource Zone (and Company)	London factor *(%)*
London (Thames)	100%

Water Resource Zone (and Company)	London factor *(%)*
Essex (Essex and Suffolk)	36%
Sutton (Sutton and East Surrey)	83%
East Surrey (Sutton and East Surrey)	37%
South (Veolia Water Central)	28%
Central (Veolia Water Central)	65%

Table 7.12 shows the Water Available For Use for each of the six Water Resource Zones in 2009, and in 2031.

Table 7.12 Water Available For Use in each Water Resource Zone in London

Water Resource Zone	Water Available For Use for London households *(Megalitres per day)* *2009*	Water Available For Use for London households *(Megalitres per day)* *2031*	Net change in Water Available For Use *(Megalitres per day)* *2009 - 2031*
London (Thames)	1,532.28	1599.31	67.03
Essex (Essex and Suffolk)	109.26	106.41	-2.85
Sutton (Sutton and East Surrey)	55.17	57.40	2.23
East Surrey (Sutton and East Surrey)	41.99	41.52	-0.47
South (Veolia Water Central)	34.80	35.84	1.04
Central (Veolia Water Central)	271.96	297.20	25.24
Total in London	**2,045.47**	**2,137.68**	**92.21**

7.4 Costs

The total cost for meeting the potential deficit consists of:

1. Capital cost (CAPEX);
2. Operational cost (OPEX);
3. Social and Environmental (S&E) cost; and
4. Annual per home maintenance cost.

For every Water Resource Zone, the total deficit for each year is set against the cost curves to establish the capital, operational and social and environmental costs to meet it.

7.4.1 Capital, Operational and Social & Environmental Costs

The Capital, Operational and Social & Environmental Costs are calculated using a similar method and the same source. We have derived unit cost curves based on the lists of feasible interventions provided by water companies in their Water Resource Management Plan tables (Table WRP2).

The capital and social and environmental costs are treated as single costs, and are only counted once in the overall costs. Operational spending is counted every year over the life of the model.

In Water Resource Management Plan tables, these costs are presented in terms of their Net Present Value. These costs are converted into 2009 prices by removing the discount rate of 4.5%[14] that is applied by the water companies.

The steps followed to derive cost curves for each water company are:

1. The list of feasible options were sorted according to their Average Incremental Social Cost (AISC)[15], with the lowest cost first;
2. Any duplicate options were removed from the list of interventions, and any phased interventions listed in the right order (e.g., if a reservoir has two phases, the second phase should not appear before the first phase in the list);
3. Cumulative Water Available For Use provided by the options was calculated, as well as the cumulative capital, operational and social and environmental cost (i.e., for the third intervention on the list, the cumulative value would be the sum of the first three interventions);
4. The capital, operational and social and environmental cost per megalitre per day of Water Available For Use were calculated for each intervention.

The compound cost curves for the Thames Water London Water Resource Zone, Essex Water Resource Zone, Central Water Resource Zone and Southern Water Resource Zones are shown in Figures 7.1 – 7.4 respectively. For the East Surrey and Sutton Water Resource Zones, no supply-side interventions are provided in the draft Water Resource Management Plans and no deficit arises over the modelled period.

[14] 4.5% is the discount rate that Ofwat requires water companies to use in calculating Net Present Values.
[15] The average incremental social cost (AISC) of a scheme is calculated by the water companies for their Water Resources Management Plan. It equals the net present value of scheme costs divided by its discounted contribution to balancing supply and demand.

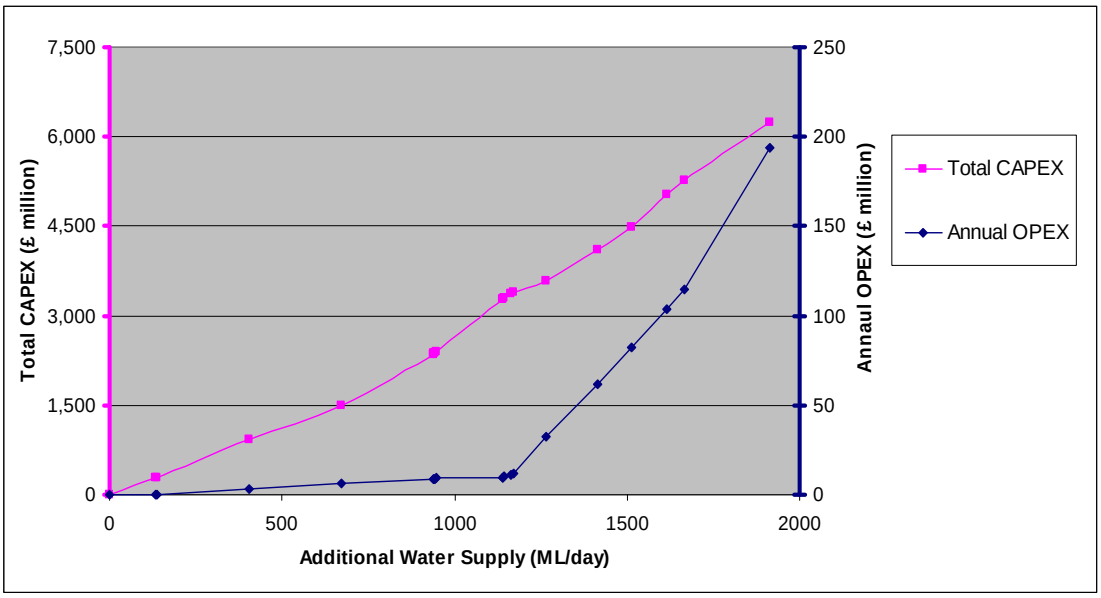

Figure 7.1 Compound cost curve for additional water supply for the Thames Water London Water Resource Zone. Some feasible options have been removed from this curve for clarity.

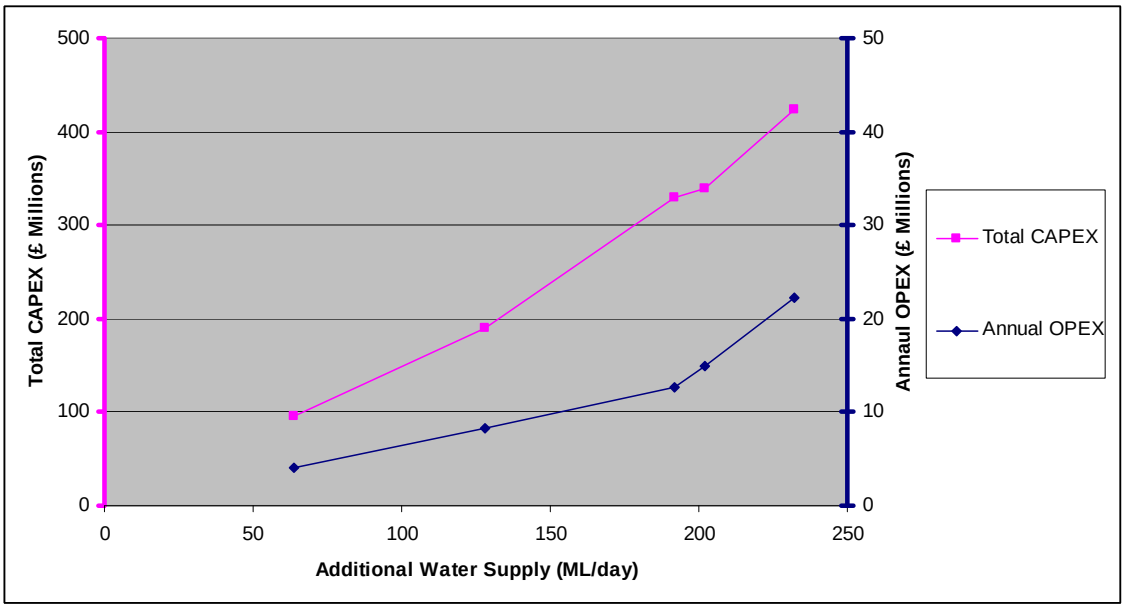

Figure 7.2 Compound cost curve for additional water supply for Essex Water Resource Zone

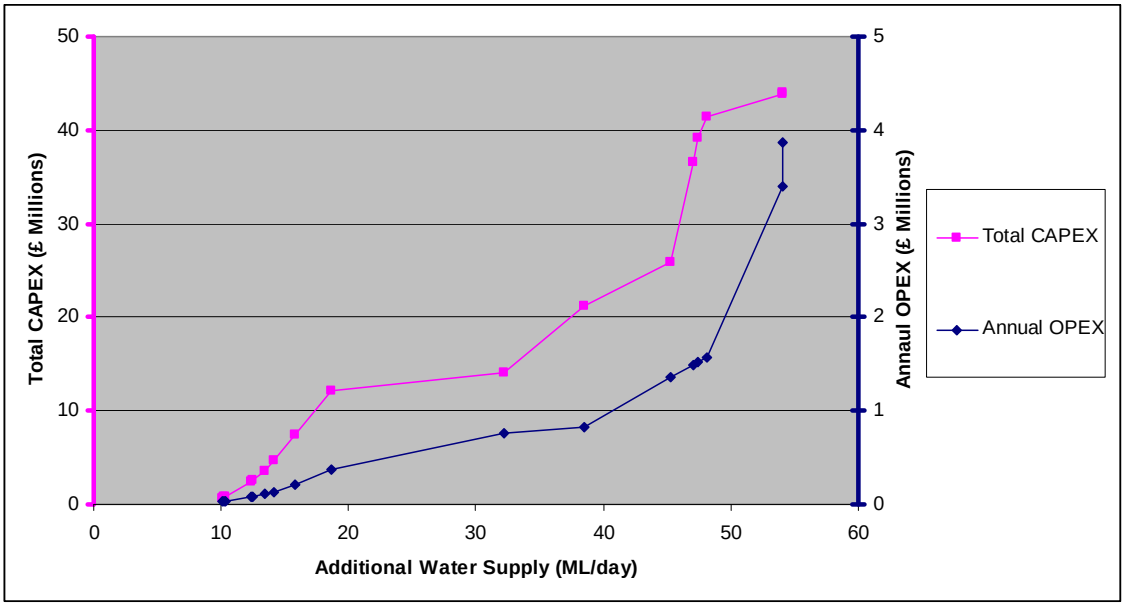

Figure 7.3 Compound cost curve for additional water supply for Central Water Resource Zone

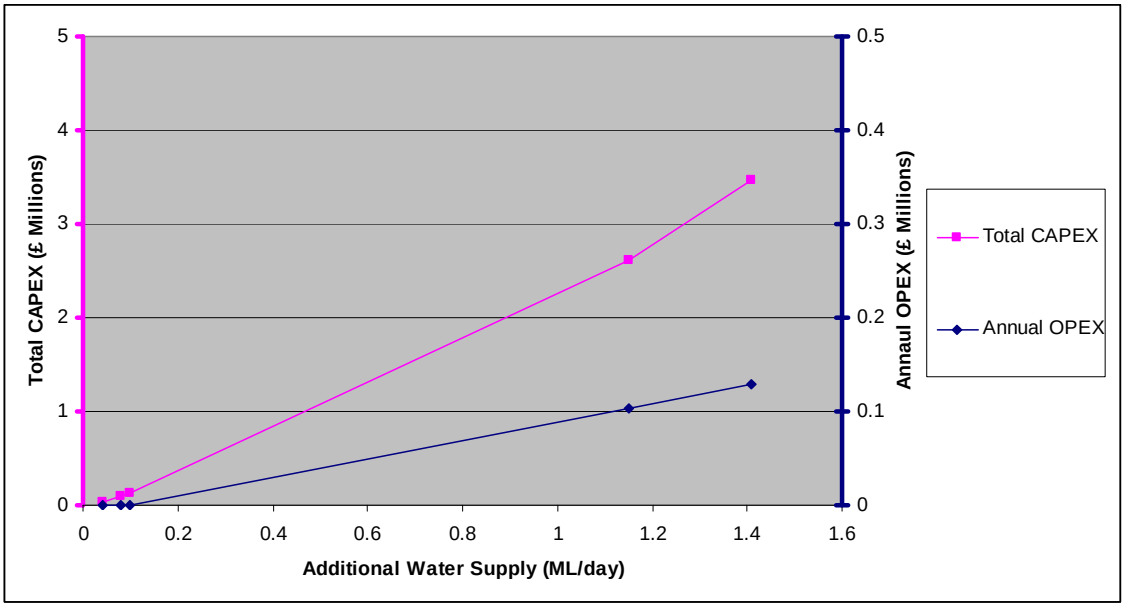

Figure 7.4 Compound cost curve for additional water supply for Southern Water Resource Zone

7.4.2 Annual per home maintenance cost

The annual maintenance cost for providing water supply to each new home is derived from June Return data. The costs for maintaining base service per home is provided in Table D of the June Return for each water company. The average value for all water companies was used to account for fluctuations in cost and activity within the available data. The average value is £53.51 per home.

The total capital maintenance cost is derived by multiplying the number of new homes by this annual cost per home.

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