OPDC
OLD OAK AND
PARK ROYAL
DEVELOPMENT
CORPORATION

OPDC Environmental Standards Study

Executive Summary

June 2017

MAYOR OF LONDON

ATKINS

Executive Summary

Background

It is the aspiration of the Old Oak and Park Royal Development Corporation (OPDC) to deliver a new part of London that is an exemplar in environmental sustainability, and realise the wider investment potential from the HS2 and Crossrail transport infrastructure projects.

The OPDC area has been identified to have the capacity to deliver a minimum additional 26,000 homes and indicative 59,000 jobs, representing London and the UK's largest regeneration project. At over 120ha of developable land, Old Oak provides particular opportunities for a range of supporting uses.

Purpose of Study

Atkins was tasked with the development of a set of aspirational and deliverable environmental sustainability targets that will enable all future development across the Old Oak Common and Park Royal sites to be exemplar in construction and operation.

The study outcomes are being used to evidence OPDC's emerging Local Plan. They will guide future development, and will set the environmental sustainability performance context for the subsequent preparation of an OPDC area-wide strategy for the integrated delivery and management of utilities and other infrastructure that will follow in 2017.

London Plan targets provide examples of good practice but some are a challenge to achieve and a number are not up to date. There have also been recent advances in thinking around social and natural capital. The project is expected to adopt and where possible exceed the London Plan policies and set a benchmark for best practice.

Approach

Our approach has been to provide strategic, smart and conceptual thinking that defines what OPDC is trying to achieve and provides the rationale and high level evidence to support the adoption of goals and objectives in the emerging Local Plan.

1. The output aims to be strategic and holistic, setting out a clear vision, goals and key objectives supported by clear guidance and targets that will be relevant over the life of the project and across the different components of the project.
2. Recommendations are supported by relevant, high level evidence informed by our analyses and best practice around the world with the key challenges identified.
3. The key recommended targets and guidance will inform the brief for other infrastructure and masterplanning studies. High level ambitions have been set but the actual targets will only be determined once feasibility has been undertaken.
4. Feasibility will be undertaken as part of future studies, the guidance we have provided will inform options for meeting the targets and a review of deliverability including cost.
5. The process of arriving at an agreed vision, goals, targets and vision will be ongoing and informed through a stakeholder engagement process.

Project Challenges

One of the key challenges throughout this project has been the need to take on board other related studies which are taking place in parallel. Where studies have been delayed or not yet started we have had to undertake some initial analyses to be able to progress and meet the timeframes for the Draft Local Plan. One example is the recommendation for the quantum of accessible open space, we have undertaken some robust but high level analysis which will need to be tested by a full open space strategy and the masterplanning exercise.

We have also undertaken extensive energy modelling. An energy model was generated for Old Oak and Park Royal developments based on a mixture of industry accepted energy benchmarks and measured data. This helped us to evaluate the overall energy demand and supply balance of the two developments under different energy performance scenarios, in addition to supporting the carbon analysis.

A separate water study to define the level of SuDS required onsite is on-going at the time of completing this report, this will update the Water section in Chapter 4 and the Flood Risk section in Chapter 5 of the main report.

Another challenge has been the breadth of topics which could be covered under an environmental target setting study. The study has grown from setting targets for environmental topics to developing targets and guidance on sustainability and design issues which are all interrelated and interdependent.

Future studies will take forward the high level, site-wide analyses to inform more detailed targets and guidance for the site and different areas within the site.

The Car Giant site at Old Oak with Park Royal in the distance. Today, Old Oak is 135 hectares of industrial and railway land in west London. The area has limited public transport access and is occupied primarily by railway depots, rail lines, waste sites, Car Giant (a second-hand car dealership), light industrial premises and a small number of residential units.

The Vision

We have proposed an environmental vision which looks beyond the environmental impacts of developments and considers the need to address wellbeing:

> “To be a flagship zero carbon, resource efficient development which is resilient to climate change and promotes smart and healthy behaviours, environmental health and mental and physical wellbeing.”

The Opportunity

The Challenge of Super Density

Providing high quality and sustainable housing at the very high densities proposed presents a number of interrelated challenges, in particular, how to provide sufficient, high quality, well lit, green infrastructure to promote the health and wellbeing of the residents and workers and to mitigate flood risk and overheating, key risks to London from the effects of predicted climate change.

Another key issue with this level of density is how to reconcile the competing demands for space, particularly at basement/podium and rooftop level.

Wormwood Scrubs

Insufficient onsite provision of public open space is also likely to put unacceptable pressure on Wormwood Scrubs. The capacity of Wormwood Scrubs to absorb the increase in population and the proposed level of public open space required onsite will need to be tested through a future open space strategy.

Zero Carbon

Old Oak presents an opportunity for creating a new model of low/zero carbon development, with the potential to be a ground-breaking exemplar for London and the UK. Substantial reductions in transport related emissions are achievable with a fully integrated approach to urban form, movement, open space, green infrastructure and microclimate across the site.

To achieve an ambition of operational zero carbon for Old Oak in the short-medium term, there is likely to be a need to offset significant net carbon emissions, either through onsite or offsite sequestration, other designated offsite carbon reduction initiatives or carbon pricing. In the longer term, as the carbon intensity of grid electricity is expected to fall and energy efficiencies increase it may be possible for the new development to be carbon positive.

Zero Waste

There is a huge opportunity to promote a local economy based on ‘Circular Economy’ principles, which is waste free through maximising recycling and composting with minimal associated carbon emissions.

Park Royal

It is important that Park Royal functions efficiently as a reservoir of strategic industrial land. There is an opportunity to intensify this land to make it operate more efficiently, exploit the proposed high level of accessibility, new cycle and pedestrian connections and new amenities, and undertake modernisation and improvements to existing stock and sites.

Headline Recommendations

- Adopt the C40 Cities Climate Positive Framework (C40 CCPF) for all or part of the site.
- Develop an onsite 'virtual power plant' using modern smart grid technology capable of integrating electrical supply from a range of local sources, including CHP plant, energy from waste plant, solar PV arrays and energy storage.
- Develop onsite multi-source, lower temperature heat and higher temperature cooling networks.
- Fully incorporate waste facilities within new buildings to ensure 100% of user recyclable waste can be collected and stored within plot.
- Develop onsite integrated construction, demolition and excavation waste consolidation, storage and processing facilities.
- Develop onsite and/or offsite energy from waste/anaerobic digestion facilities capable of handling existing and potential waste streams from both Park Royal and Old Oak
- Develop onsite and/or offsite waste management facilities to recycle operational waste (organic and dry recyclable) generated from development at Old Oak and industrial activities at Park Royal.
- Support zero emission 'last mile' deliveries and implementation of Freight Consolidation Centres.
- Designate the entire OPDC area as a Low Emission Neighbourhood.
- Strong focus on transport related measures to reduce overall air emissions.
- Public spaces should benefit from good daylight, sunlight and microclimate, they should provide a good mix of facilities, including play and exercise equipment, be well located close to neighbourhoods and provide multiple functions (biodiversity, SuDS, play, connectivity, and shade).
- Provision of significantly more publicly accessible open space than identified within the illustrative masterplan in the draft Local Plan.
- Conservation and enhancement of Sites of Borough Importance for Nature Conservation, in particular Wormwood Scrubs and the Grand Union Canal.
- Major applications to be accompanied by an Ecological Statement.
- Establishment of the Grand Union Canal Linear Park forming the main east-west walking and cycling route and an important part of London's Blue Ribbon Network.
- Explore the feasibility of creating valuable public open space on the large roof of the HS2 station and by decking over the tracks either side of North Acton Station.
- Provide a green bridge directly connecting Old Oak Park to the north of the canal with Wormwood Scrubs in order to significantly improve accessibility and provide additional linear public open space.
- Wholescale and widespread installation of integrated sustainable drainage within streets and open spaces to ensure flood resilience is fully integrated across the development (required amount to be determined).
- Require all major development to undertake post-construction monitoring to demonstrate compliance with OPDC policies.

ATKINS

Headline Targets

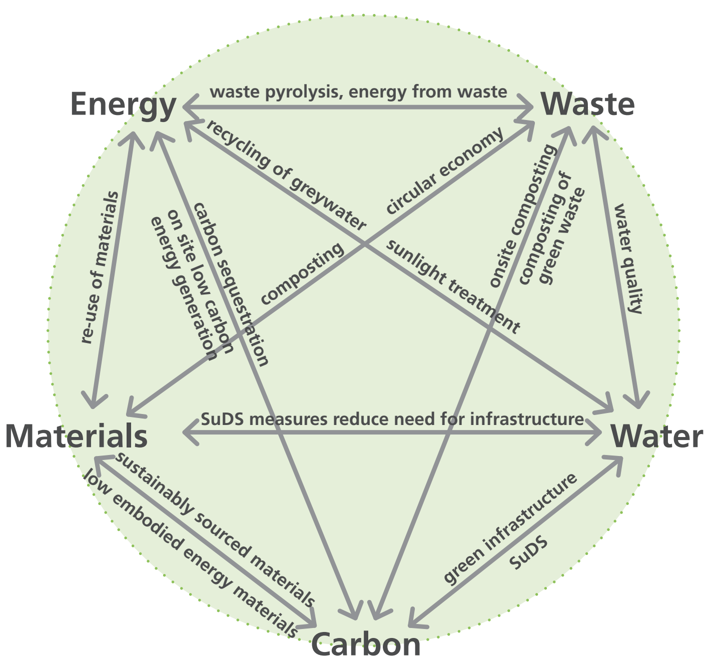
- Old Oak: operationally zero carbon in the short term and overall operationally carbon positive in the long term (C40 CCPF definition). Park Royal: short term 10% and long term 25% carbon reduction (from 2016 levels).
- All new development: 35% reductions in carbon emissions beyond Building Regulations 2013 Part L in short term, Passivhaus standards for residential in long term. Park Royal: short term 15% overall demand reduction for industrial uses, long term 25% (from 2016 levels).
- Onsite zero / low carbon energy generation, 15% (short term) to 20% (long term) of onsite demand.
- Zero waste with a low and decreasing percentage of construction and operational waste sent to landfill over short to long term.
- Old Oak: percentage of organic waste processed by anaerobic digestion or composting: short term 50% and long term, 70% (targets for Park Royal less 10%). Percentage of dry recyclable waste recycled: short term 60% and long term 70% (Old Oak), short term 70% and long term, 75% (Park Royal).
- Percentage reduction in overall embodied carbon against site-specific benchmarks: 15% in short term, 20% (Old Oak) and 15% (Park Royal) in long term.
- 100% by value of wood from certified sustainable sources.
- 80% of materials by value from suppliers participating in responsible sourcing schemes such as BRE BES 6001.
- Targets to achieve water neutrality. Potable water consumption (l/person/day), residential: short term <=105lpd and long term 90-80lpd. Percentage of within-plot rainwater collected and used onsite: short term 50%, long term 60%. Percentage of greywater recycled onsite: short term 30%, long term 80%.
- Percentage of trips in to or out of Old Oak by combustion engine private vehicles: short term 15%, long term 10%.
- Percentage reduction in freight trips in to or out of Park Royal resulting from consolidated delivery: short term 60%, long term 75%.
- NO_x and PM_{10} average emissions (g/m^2/annum) 5% below air quality neutral benchmarks in Mayor's Sustainable Design and Construction Supplementary Planning guidance.
- Our initial work suggests that a minimum of 30% (29.3ha) of Old Oak's total area should be allocated to accessible open space including civic spaces and Green Streets. In addition, financial contributions should be directed to enhancing the facilities on Wormwood Scrubs (subject to the findings of a full open space strategy).

Environmental Themes and Objectives

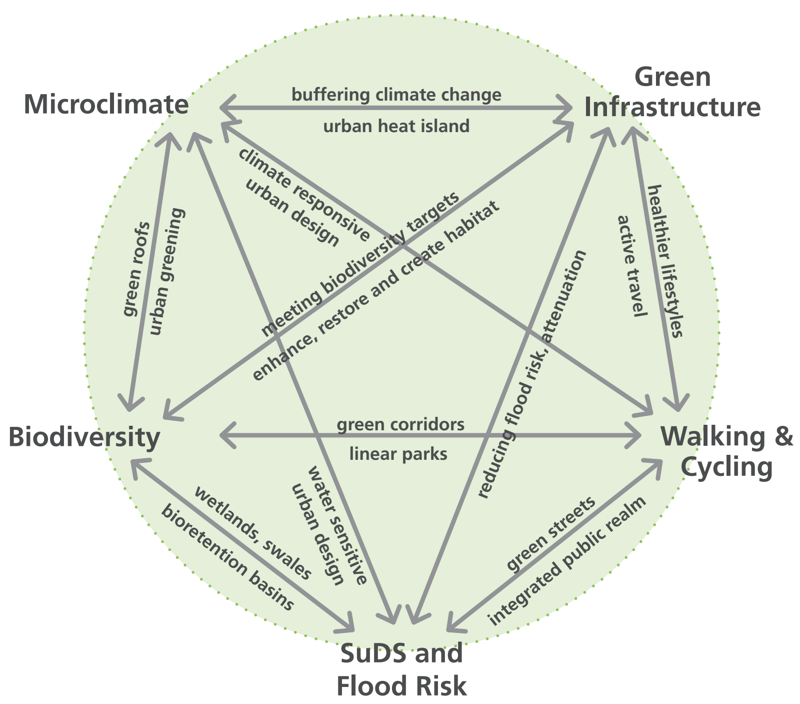
The core themes of Environmental Performance and Environmental Quality provide a framework for developing and testing appropriate environmental objectives and targets for development of this site.

We have developed some challenging but focussed objectives in relation to the two themes. These objectives represent the outcomes that are required to achieve the environmental vision and have been used to guide the development of indicators, targets and guidance.

Environmental Performance



Environmental Quality



Adapted from Shaping Neighbourhoods, Hugh Barton, Marcus Grant & Richard Guise

		Environmental Objectives
Environmental Performance	**Energy**	• Minimise energy demand • Maximise onsite zero / low carbon energy generation
	Waste	• Zero waste • Resource and carbon efficient solid waste disposal
	Materials	• Optimise use of low carbon, sustainably sourced, healthy materials
	Carbon emissions	• Overall Carbon Positive
	Water	• Maximise efficient use of water • Maximise use of alternative sources for non-potable water • Minimise surface run-off and wastewater discharge
	Air quality	• Enhance local ambient air quality • New buildings and transport to be at least air quality neutral • Enhance indoor air quality
Environmental Quality	**Green infrastructure & biodiversity**	• Maximise multi-function, multi-benefit green infrastructure • Restore natural habitats and enhance biodiversity • Promote high quality, liveable built environment for diversity of residents, employees and visitors
	Microclimate & public realm	• Light, comfortable, healthy, vibrant open space / public realm • Light, comfortable, healthy building internal environments • High quality, liveable built environment for diversity of residents, employees and visitors
	Climate resilience	• Mitigate the urban heat island (UHI) effect • Prevente overheating of outdoor areas and indoor spaces • Minimise flood risk
	Noise	• Plan for comfortable and healthy homes and open space / public realm • Reduce the negative effects of dense urban environments • Reduce exposure to infrastructure / industrial generated noise
	Sustainable transport	• Maximise low / zero carbon movement • Strong walking and cycling networks: integration with green infrastructure • Restricted parking • Encourage zero/ultra low carbon vehicles

Computer generated image of the proposed development at Old Oak Park as shown in the Draft Local Plan

Key Issues, Recommendations and Targets

The analyses undertaken have provided the evidence to support the following high level recommendations and targets for new development which have informed the policy recommendations within Chapters 4 and 5 of the main report.

Energy

Key Issues

- Low energy residential and non-residential buildings mandated.
- Potential for exceeding the current Mayoral requirement for 25% of energy demand from localised distributed energy systems (renewables and energy from waste), for both Old Oak and Park Royal.
- Carbon savings from fossil fuelled Combined Heat and Power (CHP) based systems for heating likely to become negative relative to heat pumps as grid decarbonises.
- Onsite renewable energy target of 20% of demand could be met or exceeded with expected demand reductions.

Key Recommendations

Need for close collaboration required between OPDC, developers, energy service providers, utility companies and regulators to support use of onsite low carbon energy infrastructure including:

- An onsite 'virtual power plant' using modern smart grid technology capable of integrating electrical supply from a range of local sources, including CHP plant, energy from waste plant, solar PV arrays and energy storage.
- Onsite multi-source, lower temperature heat and higher temperature cooling networks.
- A high proportion of renewables.

Targets

- All new development to be operationally zero carbon in respect of regulated energy loads in the short term. Zero carbon is defined as at least 35% reduction in carbon emissions beyond Building Regulations 2013 Part L. Passivhaus standards for residential in the long term.
- Park Royal: short term 15% overall demand reduction, long term 25% (from 2016 levels).
- Onsite zero / low carbon energy generation: Old Oak, short term 15% of demand, long term 20% and for Park Royal, short term 10%, long term 15%.

ALL NEW **DEVELOPMENT** TO BE **OPERATIONALLY ZERO CARBON**

ATKINS

Stockholm Royal Seaport

The development has set an objective to be fossil-free by 2030, ahead of the city wide goal of 2050. To achieve this, the urban district has integrated environmentally sustainable systems that aim to encourage responsible behaviour and lifestyle changes, by making sustainable choices ‘easy’. This target will also be achieved through the installation of an intelligent electricity grid, self-generated energy within buildings and a bio-fuel fired bus system. Resilience to future climate change issues, such as increased precipitation, has been built into the masterplan and design processes for example through use of the Green Space Index. The index allocates points for green infrastructure and environmental interventions including deep layers of soil, green roofing and tree planting.

Waste

Key Issues

Achieving the current mayoral targets will be very challenging for the new development at Old Oak. This will require:

- Rapid and substantial decline in the proportion of waste sent to landfill.
- High uptake in recycling and reuse of wastes.
- Percentage of residual waste (after recycling) treated via combustion to be substantially and rapidly increased, compared to the current baseline, and linked to high efficiency Combined Cooling, Heat and Power (CCHP) or CHP energy from waste (EfW) plant.
- Progressive decline in residual waste, as is implied in meeting or exceeding the current Mayoral municipal waste recycling targets.

Key Recommendations

Need for a very strong focus from the outset in master planning and urban design on ensuring that:

- Facilities necessary to achieve required segregation and capture rates, in particular with regard to food waste, are fully designed in.
- Sufficient space, access and infrastructure is provided for onsite storage and either transfer or, preferably, local treatment of waste.
- Need for onsite integrated construction, demolition and excavation waste consolidation, storage and processing facilities is addressed.
- Need for onsite energy from waste/anaerobic digestion facilities capable of handling existing and potential waste streams from both Park Royal and Old Oak is addressed.
- Need for onsite waste management facilities to recycle operational waste (organic and dry recyclable) generated from development at Old Oak and industrial activities at Park Royal is addressed.

Promotion of opportunities for development of industrial activities which can make direct use of locally recycled waste outputs should also be prioritised, enhancing the local circular economy.

Targets

- Zero Waste: low and decreasing percentage of construction and operational waste sent to landfill over short to long term.
- Old Oak: Percentage of organic waste processed by anaerobic digestion or composting: short term 50% and long term 70%. Park Royal: Short term 40%, long term 60%.
- Old Oak: Percentage of dry recyclable waste recycled: Short term 60% and long term 70%. Park Royal: Short term 70%, long term 75%.

ZERO WASTE
LOW AND DECREASING
PERCENTAGE OF CONSTRUCTION AND OPERATIONAL WASTE SENT TO LANDFILL OVER SHORT TO LONG TERM

Materials

Key Issues

- The high density, high rise development proposed at Old Oak will entail more dense material use per area unit. Steel, concrete and glass equate to a significant proportion of the total embodied carbon.
- Enhancing the overall carbon efficiency of use of these materials, such as via increasing recycled content, will form a particular challenge.
- The focus on materials has tended to be around themes such as recycled content, certification (e.g. FSC for Timber) and also the use of high specification / performance criteria, especially on glazing and cladding.
- Focus is placed on those aspects which help to sell a scheme – recycled content, energy efficiency – and health issues such as low VOCs and non-toxic materials.
- Ensuring all materials are responsibly sourced is an increasing area of focus.

Key Recommendations

Developers to submit a Sustainable Materials Plan comprising:

- Embodied Carbon Reduction Strategy.
- Supplier accreditation details: BRE BES 6001, ISO 14001; EMAS; FSC / PEFC, as appropriate.
- Local Materials Sourcing Strategy.
- Details of compliance with responsible sourcing and healthy materials targets.

Targets

- Percentage reduction in overall embodied carbon ($kgCO_2e/m^2$ GFA) against site-specific benchmarks: 15% in short term), 20% (Old Oak) and 15% (Park Royal) in long term.
- 100% by value of wood from certified sustainable sources.
- 80% of materials by value from suppliers participating in responsible sourcing schemes such as BRE BES 6001.
- Percentage by weight of materials which are toxic: 0%.

20%

EMBODIED CARBON

REDUCTION IN

OLD OAK

Carbon Emissions

Key Issues

- Substantial building energy reduction from business as usual (BAU) likely.
- Potential for low carbon onsite energy generation systems, plus implications of decarbonising grid.
- Transport and waste related carbon emissions significantly reduced from BAU with public transport and limited private fossil fuelled vehicles, plus strong emphasis on waste diversion from landfill and energy recovery.

Key Recommendations

- Adopt the C40 Cities Climate Positive Framework (C40 CCPF) for all or part of the site.
- OPDC to work with the GLA, regulators, infrastructure services providers and developers to develop an appropriate Carbon Planning and Management Framework (CPMF) for defining and implementing exemplar zero carbon development.
- Developers to submit Carbon Reduction Strategies with planning applications which comply with CPMF.
- Residual emissions offset by support for designated carbon reduction projects and/or financial contributions.

Targets

- Old Oak: operationally zero carbon in the short term, overall operationally carbon positive in the long term (C40 CCPF definition).
- Park Royal: short term 10% and long term 25% overall operational carbon reduction (from 2016 levels).

OLD OAK

OPERATIONALLY
ZERO CARBON
IN SHORT TERM

OPERATIONALLY
CARBON POSITIVE
IN LONG TERM

Elephant Park

£1.5 billion regeneration of Elephant and Castle by Lendlease. Formally recognised by C40 Cities as 1 of 18 globally recognised projects. Set to be Climate Positive by 2020.

Water

Key Issues

- Substantially reducing water demand and using alternative (reclaimed) water sources, beyond current Mayoral standards and current best practice, is essential for Old Oak to meet the objective of water and discharge neutrality.
- Major issues for water / discharge neutrality at Old Oak: concentration of water demand, the impermeable clay based local geology, the lack of planned green space, and the several barriers across the site.

Key Recommendations

- Substantial reduction in potable water demand.
- Substantial storage of stormwater, on or offsite, required.
- Use of sustainable drainage systems (SuDS) wherever feasible within both Old Oak and Park Royal to help realise associated multi-function benefits from on-site green infrastructure (see Green Infrastructure section below).
- Rainwater harvesting and greywater recycling.

Targets

- Potable water consumption (litres/person/day – l/p/d), residential: short term <=105lpd and long term 90-80lpd.
- Percentage of within-plot rainwater collected and used onsite: short term 50%, long term 60%.
- Percentage of greywater recycled onsite: short term 30%, long term 80%.

RESIDENTIAL POTABLE WATER CONSUMPTION **REDUCED** TO **90-80 LITRES** PER PERSON / PER DAY IN LONG TERM

ATKINS

Air Quality

Key Issues

- There are currently exceedances of the Air Quality Objectives (AQO) for NO_2 and PM_{10} and exceedances of NO_2 annual mean AQOs are likely to still occur in future.
- Road traffic is the most important source of air pollution in the OPDC area.
- Reducing emissions associated with freight vehicles is a particular focus for Park Royal, and also Old Oak.
- PM_{10} exceedances appear to be associated with operation of industrial and waste management activities in the area.
- Internal air quality is less frequently prioritised in new schemes, ventilation requirements and issues can be a challenge when designing at higher densities.

Key Recommendations

- Designate the entire OPDC area as a Low Emission Neighbourhood.
- Support development of on-site energy generation and waste management plant and facilities which produce either zero or very low air emissions.
- Strong focus on transport related measures to reduce overall emissions.
- Support zero/low emission 'last mile' deliveries and implementation of Freight Consolidation Centres.
- Development proposals to include low/zero VOC emissions materials, fittings and fixtures strategy as well as a ventilation, air filtration and air cleaning systems design clearly demonstrating compliance with site-wide CO_2 indoor air quality targets.

Targets

- Incidences of exceedance of national air quality objectives per annum: Zero
- Percentage of trips in to or out of Old Oak by combustion engine private vehicles: short term 15%, long term 10%.
- Percentage reduction in freight trips in to or out of Park Royal resulting from consolidated delivery: short term 60%, long term 75%.
- NO_x and PM_{10} average emissions (g/m^2/annum) 5% below air quality neutral benchmarks in Mayor's Sustainable Design and Construction Supplementary Planning Guidance.
- Targets to enhance indoor air quality.

OLD OAK TRIPS BY **COMBUSTION VEHICLES** REDUCED TO **10%** IN LONG TERM

Green Infrastructure & Biodiversity

Key Issues

- Green infrastructure (GI) should be considered as a valuable multi-functional and multi-benefit resource and is important in improving health outcomes by increasing physical activity, reducing stress and removing pollutants.
- The current level of public open space, shown in the illustrative masterplan, is insufficient to meet the recreational needs of the future population of Old Oak and Park Royal (both workers and residents).
- The site's existing biodiversity will need to be enhanced and complemented with new areas of biodiversity value.
- Wormwood Scrubs will be required to fulfil the role of a District Park in particular provision of sufficient good quality outdoor sports facilities and playing fields.
- The importance of green roofs in providing adaptation to climate change, aiding energy, efficiency and enhancement of biodiversity.
- The anticipated increase in surface water runoff across the Old Oak and Park Royal site will be substantial and current green areas insufficient to attenuate.

Key Recommendations

- Provision of significantly more publicly accessible open space.
- Conservation and enhancement of Sites of Borough Importance for Nature Conservation, in particular Wormwood Scrubs and the Grand Union Canal.
- Major applications to be accompanied by an Ecological Statement.
- Open spaces to be connected by safe and direct, car-free, pedestrian and cycle routes, set within a 'green-grid'.
- Establishment of the Grand Union Canal Linear Park forming the main east-west walking and cycling route and an important part of London's Blue Ribbon Network.
- All major new buildings to incorporate green roofs (intensive or extensive).
- Create valuable public open space on the roof of the HS2 station and by decking over the tracks either side of North Acton Station.
- Provision of a green bridge directly connecting Old Oak Park to the north of the canal with Wormwood Scrubs.
- A 'Green Space Factor' to be adopted for the provision of GI within new residential areas in Old Oak.
- Wholescale and widespread installation of integrated sustainable drainage within streets and open spaces to ensure flood resilience is fully integrated across the development.

Targets

- A minimum of 30% of Old Oak's total area should be allocated to accessible open space including civic spaces. In addition, financial contributions should be directed to enhancing the facilities on Wormwood Scrubs. This equates to approximately 4.14sqm per resident and 1sqm per worker, a standard which could be used across the whole OPDC area.
- The additional public open space should be used to provide 3 Local Parks within 400m of homes.
- A minimum of 10sqm of dedicated play space per child.
- A minimum of 5sqm of private outdoor space should be provided for all 2 person dwellings and an extra 1sqm for each additional occupant.

BIODIVERSITY POSITIVE

A MINIMUM OF **30%** OF OLD OAK SHOULD BE **PUBLICLY ACCESSIBLE** OPEN SPACE

Microclimate & Public Realm

Key Issues

- The modelling of solar exposure within the highest density area of Old Oak South has shown that the internal residential courtyards within street blocks would receive very little sunlight.
- BRE guidance recommends that at least half of amenity areas should receive at least two hours of sunlight on 21 March. This target will be difficult to achieve in the highest density parts of Old Oak.
- The urban design of Old Oak should carefully consider microclimate when selecting the optimum street geometry. The height-to-width (H/W) ratio of the street is a key factor in maximising solar access into the street, creating calm wind conditions and maintaining good air quality.
- 3D microclimate modelling of the overall urban design, and in particular the effect on streets and the public realm, should be an essential part of the masterplanning process.

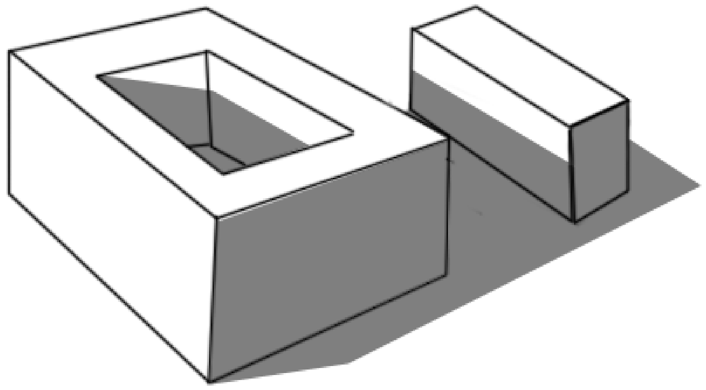
Key Recommendations

- The development should promote climate responsive urban design to create high quality, comfortable open spaces and buildings.
- Maximise quality and availability of sunlight and natural light in outdoor spaces, particularly in winter.
- Minimise winter overshadowing between buildings, which can compromise naturally-lit buildings and reduce solar gain
- Avoid building sunlight reflection in open spaces and streetscapes that can generate discomfort.
- Minimise excessive winter wind speeds induced by canyon and other building related effects.
- Promote localised air movement particularly in summer to encourage dispersion of air pollution.
- Minimise Urban Heat Island effects to reduce summer overheating.

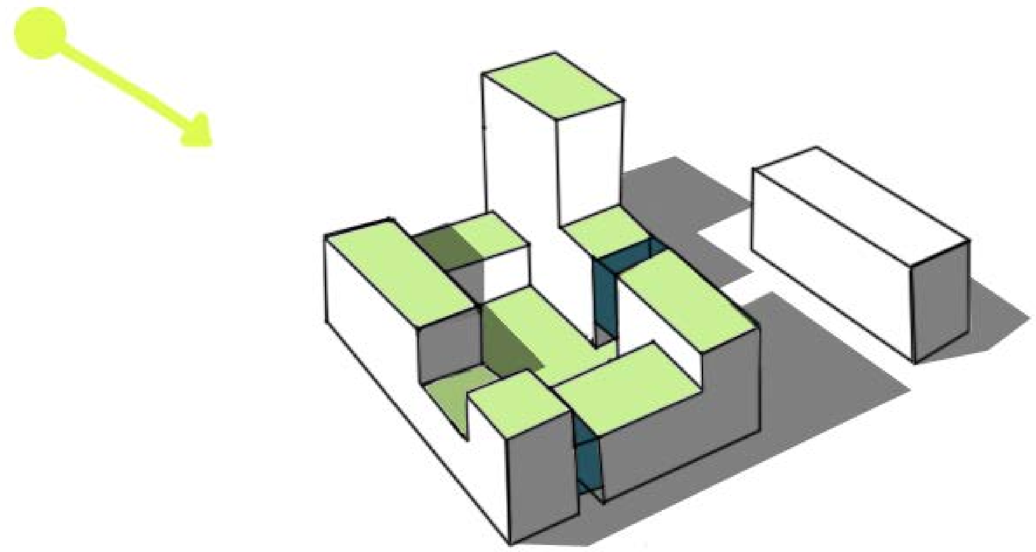
Targets

- Public spaces should benefit from good light and microclimate (at least 2 hours of daylight on 21st March into 50% of space) in line with BRE guidance.

Conventional street block



Street block after applying principles of climate responsive urban design



PUBLIC SPACES TO
HAVE AT LEAST
2 HOURS OF DAYLIGHT
ON 21ST MARCH

Climate Resilience

Key Issues

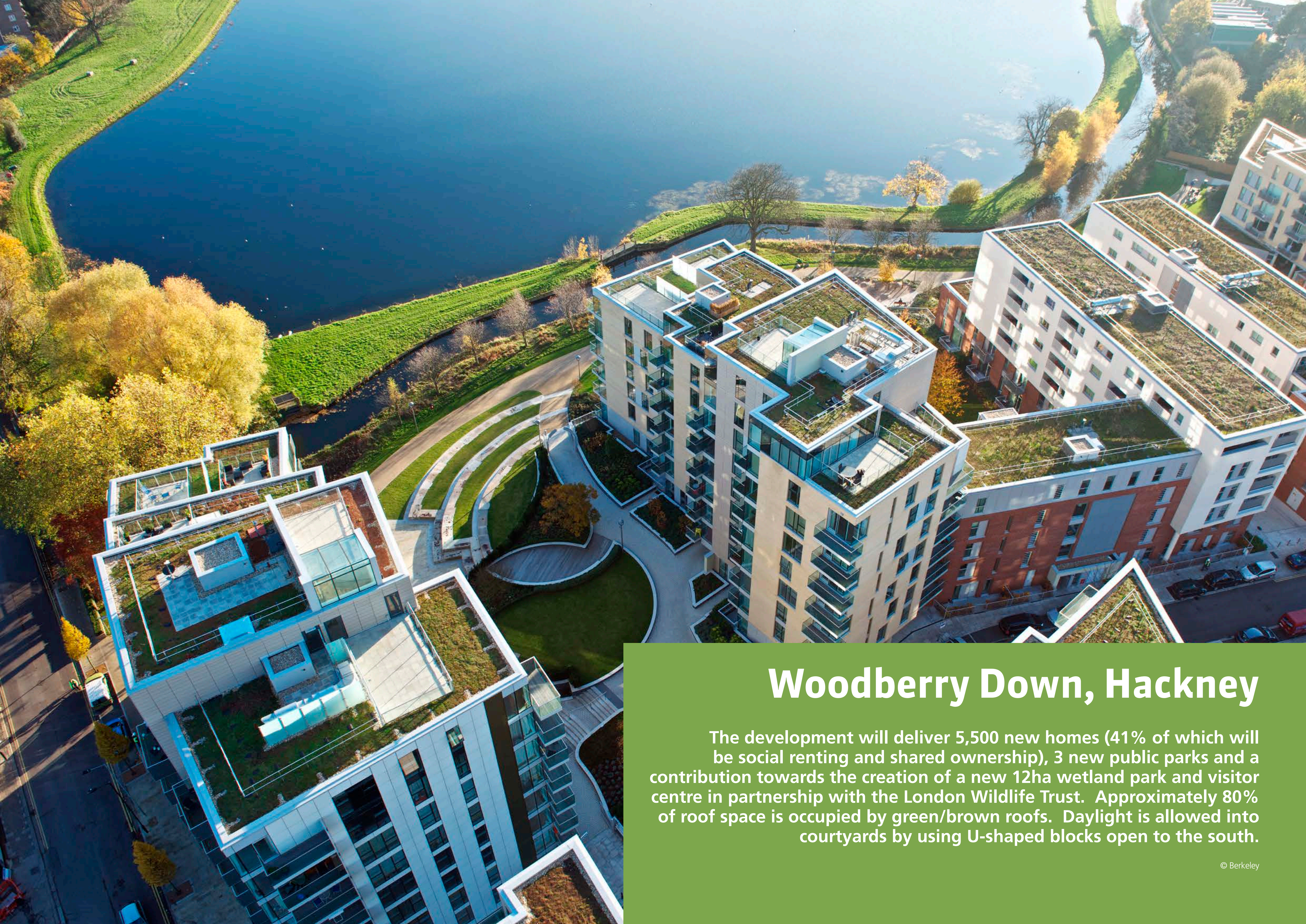
- As summers become hotter, the overheating of buildings and the outdoor environment is expected to become an increasingly serious health and wellbeing problem.
- The high density proposed in Old Oak will very likely lead to enhanced urban heat island (UHI) effect in the outdoor spaces and increased surface water run-off, which will exacerbate flood risk during heavy storms. Lack of greenspace in the draft masterplan and the current urban form in Park Royal also presents potential for enhanced UHI and flood risk.
- The low natural drainage capacity and the constrained sewer network present a particular risk of surface water flooding on the site.
- As the OPDC site is clay based infiltration is not possible, which means that surface water will need to be stored onsite in open water features such as ponds and wetlands and then released at a controlled rate.
- One of the most effective ways to address UHI and flood risk is maximising green infrastructure across the site.
- A preliminary Urban Heat Island study has been performed for the Old Oak Common area by Imperial College London using the Modified Town Energy Balance (MTEB) model. The study indicates that:
  - In the high-rise area, green roofs reduce the maximum temperatures in the surface layer and canyon by 2.1^{0}C and 0.8^{0}C, respectively. For reflective paints, the maximum temperature reduction for the surface layer and canyon is approximately 1^{0}C and 0.4^{0}C, respectively.
  - These temperature reductions, in particular those in the canyons which is where the people live, are significant given the concerns of UHI effects for the high density sections of Old Oak Common.
  - Green roofs and reflective paints can reduce significantly the roof temperature and the energy requirements for the building.

Key Recommendations

- Overheating of outdoor areas: variety of measures including enhancing green infrastructure, enhancing air movement and shading, avoiding reflection and heat absorbing surfaces, and reducing combustion engine vehicles.
- Overheating of indoor spaces: incorporation of design measures including green roofs, optimal building orientation controlling solar gain, shading, mixed mode and cross ventilation strategies.
- The Mayor's Climate Change Adaptation Strategy also sets out a number of other measures for reducing outdoor overheating, all of which will be particularly important in Old Oak.
  - Create breeze pathways that enhance natural ventilation
  - Orientate streets and buildings to provide shade in summer and passive solar gain in winter
  - Optimise the street width to allow for appropriate scale deciduous street trees
  - Use high-albedo (pale and reflective) and permeable paving materials.
- Where feasible, existing roofs within Park Royal to be painted with high-albedo paint to create 'white' (or cool) roofs which reflect solar radiation.
- All major new buildings to incorporate green roofs (intensive or extensive).
- Maximise green surfaces for evapotranspiration.

Headline Targets

- Addressed under Green Infrastructure and Microclimate.



Woodberry Down, Hackney

The development will deliver 5,500 new homes (41% of which will be social renting and shared ownership), 3 new public parks and a contribution towards the creation of a new 12ha wetland park and visitor centre in partnership with the London Wildlife Trust. Approximately 80% of roof space is occupied by green/brown roofs. Daylight is allowed into courtyards by using U-shaped blocks open to the south.

Noise

Key Issues

- A preliminary review of the scheme, which takes into account the policy to deliver a car-free development, suggests that the rail corridors will be the key generators of noise pollution on site.

Key Recommendations

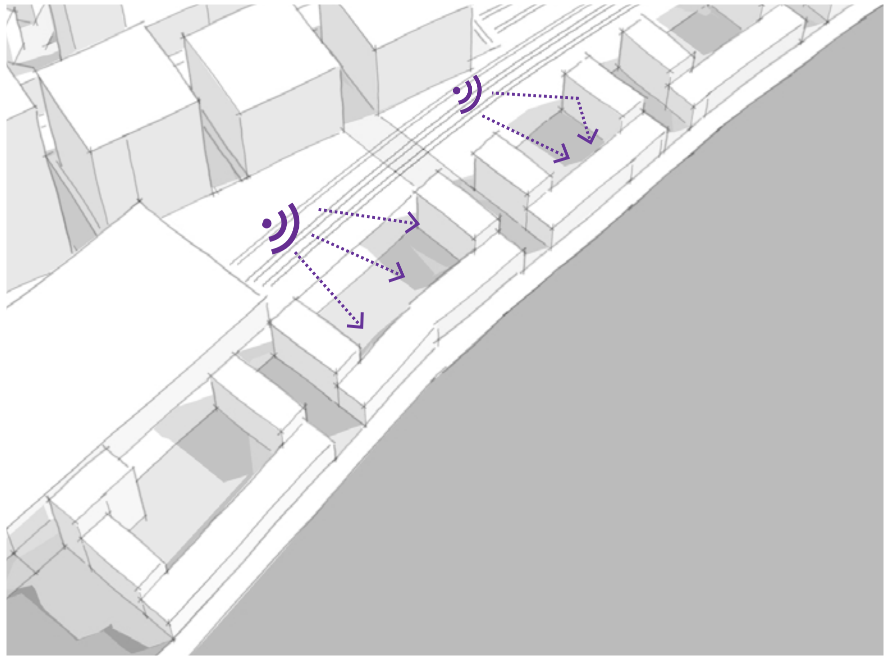
- Development proposals should submit a noise and vibration assessment that demonstrates:
    » How design has minimised adverse noise impacts from both surrounding and internal uses on future occupants. In high density development noise attenuation measures will be of particular importance, and
    » Where development is proposed close to existing noise generators such as waste sites, cultural facilities, strategic roads or uses within Strategic Industrial Locations, how it will ensure the continued effective operation of those uses.
- Possible design and mitigation strategies include:
    » The design of mixed use developments should seek to minimise noise to residents
    » The use of circulation space to act as a sound buffer between land uses where sound transmission could be an issue
    » Sound proofing of transport infrastructure
    » Use of sound barriers and mounding with vegetation to act as a buffer.
    » Decking or boxing of rail corridors.

Targets

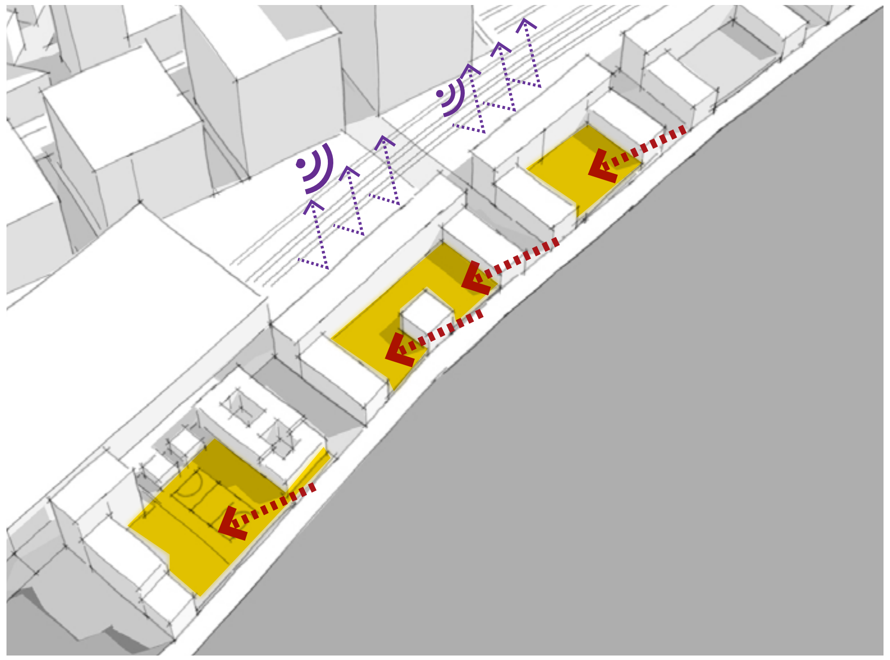
- Recommended noise targets are taken from BS8233:2014.

Example of noise mitigation applied to illustrative masterplan layout

Existing Layout



Proposed Layout



Sustainable Transport

Key Issues

- Old Oak Common HS2 station presents a once in a lifetime opportunity to deliver a step change in public transport across Old Oak and Park Royal and provide the catalyst for regeneration.
- The OPDC area will be one of the best connected locations in the UK with the new stations for High Speed 2 (HS2) and Crossrail. This major new transport hub provides the catalyst for a Transit Oriented Development (TOD). TODs are a major solution to climate change by creating low-carbon lifestyle, sustainable communities.
- The scale of development at Old Oak and Park Royal offers an opportunity to deliver transport improvements that are at the forefront of sustainability and innovation.
- Intelligent Mobility (IM) should be anticipated and provided for in the design of the street network at Old Oak.

Key Recommendations

- Prioritise sustainable transport modes and support modal shift from private cars.
- Provide high quality, safe, direct and accessible walking networks.
- Support and provide infrastructure for the Legible London scheme.
- Provide state of the art cycling infrastructure.
- Promote and help to deliver cycle hire schemes within the OPDC area.
- Incorporate electric charging points for electric vehicles at all new parking spaces.
- Include and promote provision for car club vehicles and car sharing.
- Secure Delivery and Servicing Plans (DSPs) through planning agreements.
- Implement and safeguard for future innovative and smart technologies.
- Undertake a 'Healthy Street' survey, using the TfL methodology, for Park Royal to identify opportunities to positively enhance the existing street network.
- Adopt a 'Whole-Street' approach, using the TfL methodology, for the design of the new street network in Old Oak.
- Incorporate a second pedestrian and cycle crossing of the major rail corridor to connect the new communities in Old Oak with Wormwood Scrubs.
- Encourage the use of the Grand Union Canal for transport and freight movement.
- Explore the delivery of new bridge crossings over the canal.

Targets

- Cycle parking should meet the requirements set out in the London Cycling Design Standards (2014) with provision in excess of London Plan minimum standards.
- Old Oak
  - » Promotion of car free development close to public transport hubs.
  - » Securing zero car parking for non-residential developments, except for Blue Badge holders.
- Park Royal
  - » Allowing limited car parking for non-residential developments taking into account access to public transport and operational or business needs.

CAR FREE
DEVELOPMENT CLOSE TO
PUBLIC TRANSPORT HUBS

Case Study Analysis

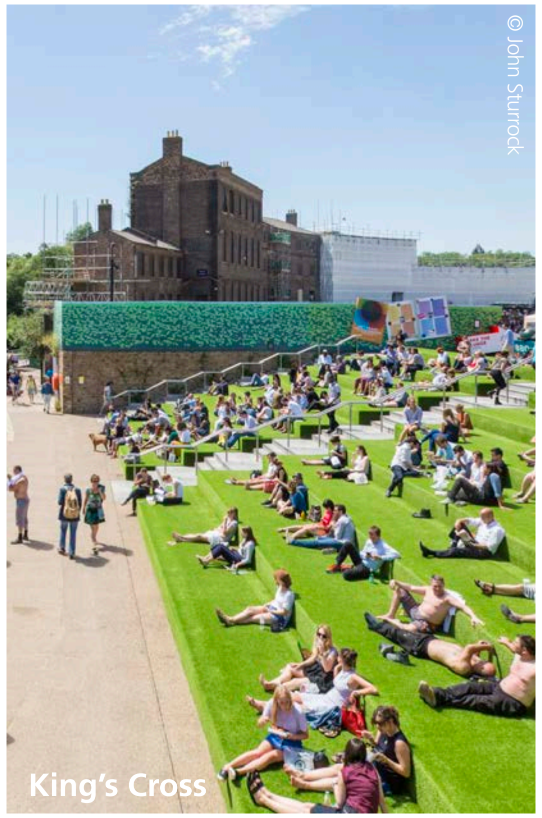
London Case Studies

A review of comparable high density residential and mixed use schemes in London has been carried out in order to identify examples of best practice and to see how ambitious environmental targets have been achieved and delivered in the capital. The 12 projects range in density from 230-600 dwellings per hectare.

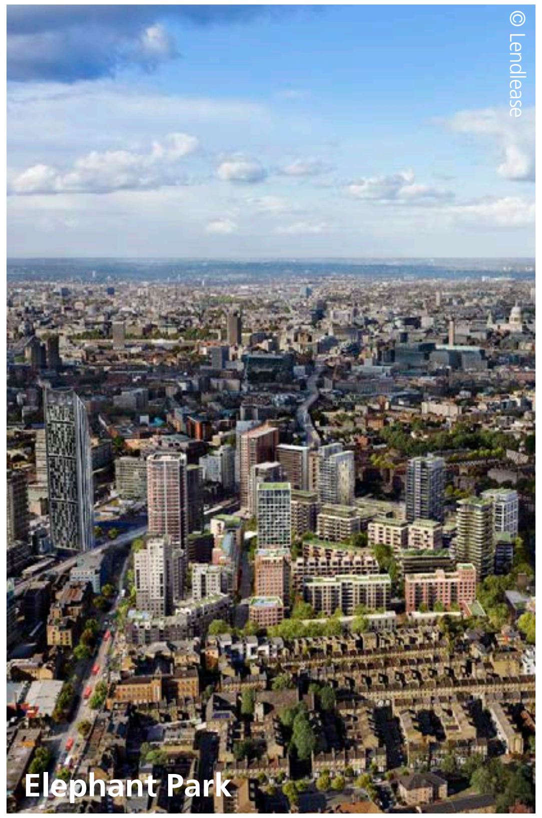
- Woodberry Down, Hackney
- Elephant Park, Southwark
- Hale Village, Tottenham
- East Village
  (Former London 2012 Athletes Village)
- King's Cross Central, Camden
- Bermondsey Spa, Southwark
- St Andrew's, Phase 3, Bromley-by-Bow
- The Library Building, Clapham High Street
- Regent's Place, Euston Road, Camden
- Arundel Square, Islington
- Central St Giles, Camden
- Wood Wharf, Tower Hamlets
  (Canary Wharf's new phase)

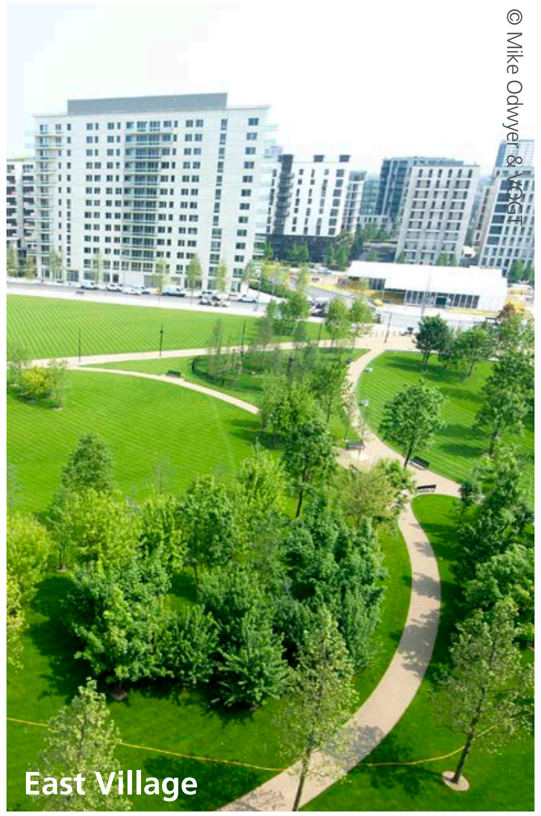

Woodberry Down


Hale Village

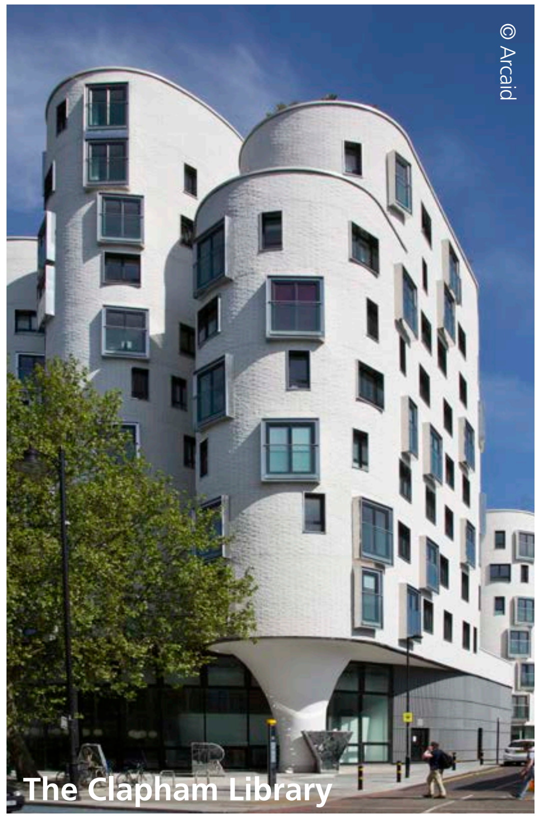

King's Cross


St Andrew's


Elephant Park


East Village


Bermondsey Spa


The Clapham Library

Regent's Place

Central St. Giles

Arundel Square


Wood Wharf

Conclusions

This review of case studies has shown that there are very distinctive 'trends' which can be seen operating at the different densities and scale of scheme. The largest schemes (by area) provide the best opportunities to improve environmental performance, as systems such as district energy and integrated sustainable transport become viable. However, they have also shown that at the highest densities, the relative environmental performance may begin to drop off, with the most dense buildings potentially requiring more energy to heat, cool and light them, and greater embodied carbon per unit of floor space, and that there is a level at which schemes can be seen as reaching 'optimal sustainability' both in terms of environmental and social factors.

Fortunately, this optimal density seems to correlate to the type of urban forms that also create the most socially sustainable places, with the greatest sense of place and an environment which encourages health and wellbeing. Density ultimately becomes the driver for the environmental approach taken – high density perimeter block models will achieve 300-450dph, then to increase that further taller elements are required – perhaps on the corners – to take that up towards the 600dph level.

At this point pressure on open space grows, and the roofs / podium spaces can become more valuable as open space than as surfaces for energy generation, heat rejection equipment or biodiversity mitigation, so developments then tend to move to a district level energy systems, with a dedicated energy centre, and it becomes more essential to have a varied mix of uses to help balance the load demands on the energy networks. In turn, this mix of uses promotes street life and helps to support small businesses by driving demand over a greater time horizon. It also helps promote co-location of housing and employment uses and associated active local travel.

Once densities start to go even higher, the building form changes to be more individual towers, potentially with some mixed use podium levels, but these typically require more mechanised systems – not just to operate high-rise lifts, but to deal with heating, cooling and ventilation. The pressures on space at ground level grow more intense, as greater levels of servicing are required to support the buildings, and more space is required for transport and leisure.

Typically all these cannot be catered for at ground level, so roof gardens and intermediate servicing floors have to be introduced. There is also less frequent entrances, and it is more difficult to activate ground floors. Some of the case studies have shown how this can be accomplished, but this is typically through mixing uses and building types.

Overall, the case studies direct the future development of Old Oak towards a certain type of higher density mixed use scheme which seeks to deliver at that optimum level, in order to balance all of the environmental criteria, support health and wellbeing, and create the quality of place that is aspired to.

Analysis of Public Open Space Provision

A review of the level of publicly accessible open space allocated within the illustrative masterplan in the Draft Local Plan was undertaken. At 9ha (9.2%) it was considered to be insufficient to meet the leisure and recreational needs of the future resident and worker population. The very limited level of coverage is also likely to be insufficient to help address the other benefits of the green open space including: reducing flood risk, improving air quality, heat amelioration and biodiversity.

It is recognised within London that a high level of onsite open space provision is not always achievable especially where there is considerable planning policy impetus to deliver mixed use development comprising commercial, residential and other uses at optimum densities. However, based on an analysis of the illustrative masterplan and comparison with other high density mixed use schemes in London, it is recommended that at least 30% of publicly accessible open space (including pedestrian priority streets and squares) is provided within the re-development of Old Oak. This is 29.3ha of the Old Oak area (not including Park Royal) and equates to approximately 4.14sqm per resident and 1sqm per worker.

Increasing the provision from 9% to 30% would help to provide a more comfortable environment to live, work and play in. It takes account of the very high density of the proposed development and the need for significant multi-functional green infrastructure, the need for large civic squares to serve the new HS2/Crossrail station and commercial development, the opportunity to create a linear park along the Grand Union Canal and the need to ensure that the new population does not put unacceptable pressure on the capacity of Wormwood Scrubs.

A more detailed Green Infrastructure/Public Open Space Strategy is required to confirm this level of provision, considering open space deficiencies and capacity in the wider area, and identify where facilities and open space on Wormwood Scrubs could be enhanced through developer contributions.

Woodberry Down - 25.1% open space

Source OPDC

East Village - 24.5% open space

Source OPDC

King's Cross Central - 28.2% open space

Source OPDC

St Andrew's, Bromley-by-Bow - 32.8% open space

Source OPDC

Elephant Park - 34.9% open space

Source OPDC

Wood Wharf - 33.5% open space

Source OPDC

Opportunities to increase the amount of publicly accessible open space

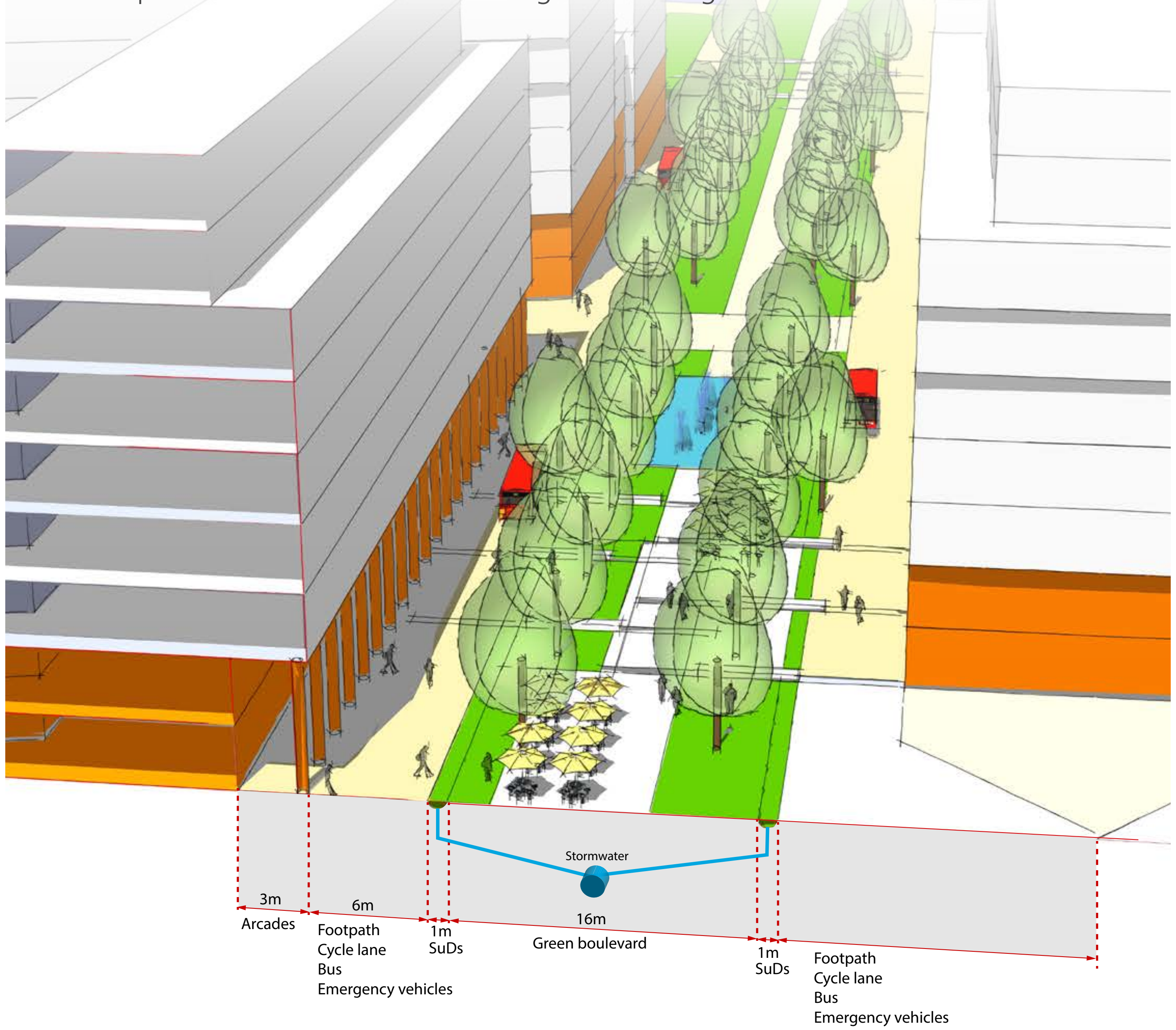
Application of Guidance

Main Station Square

Thousands of people will arrive at, or cross, Station Square every day and it will form the first impression and gateway to Old Oak. It will be the hub serving the HS2 and Crossrail stations and will have prominence in the hierarchy of new open spaces. High rise buildings to be placed on the northern slide of the block to allow more daylight into the space. Large raised table crossings to accommodate large pedestrian flows and desire lines. At least 30% of square to be green space/ soft landscape. Squares used for temporary storm water storage and underground water storage.

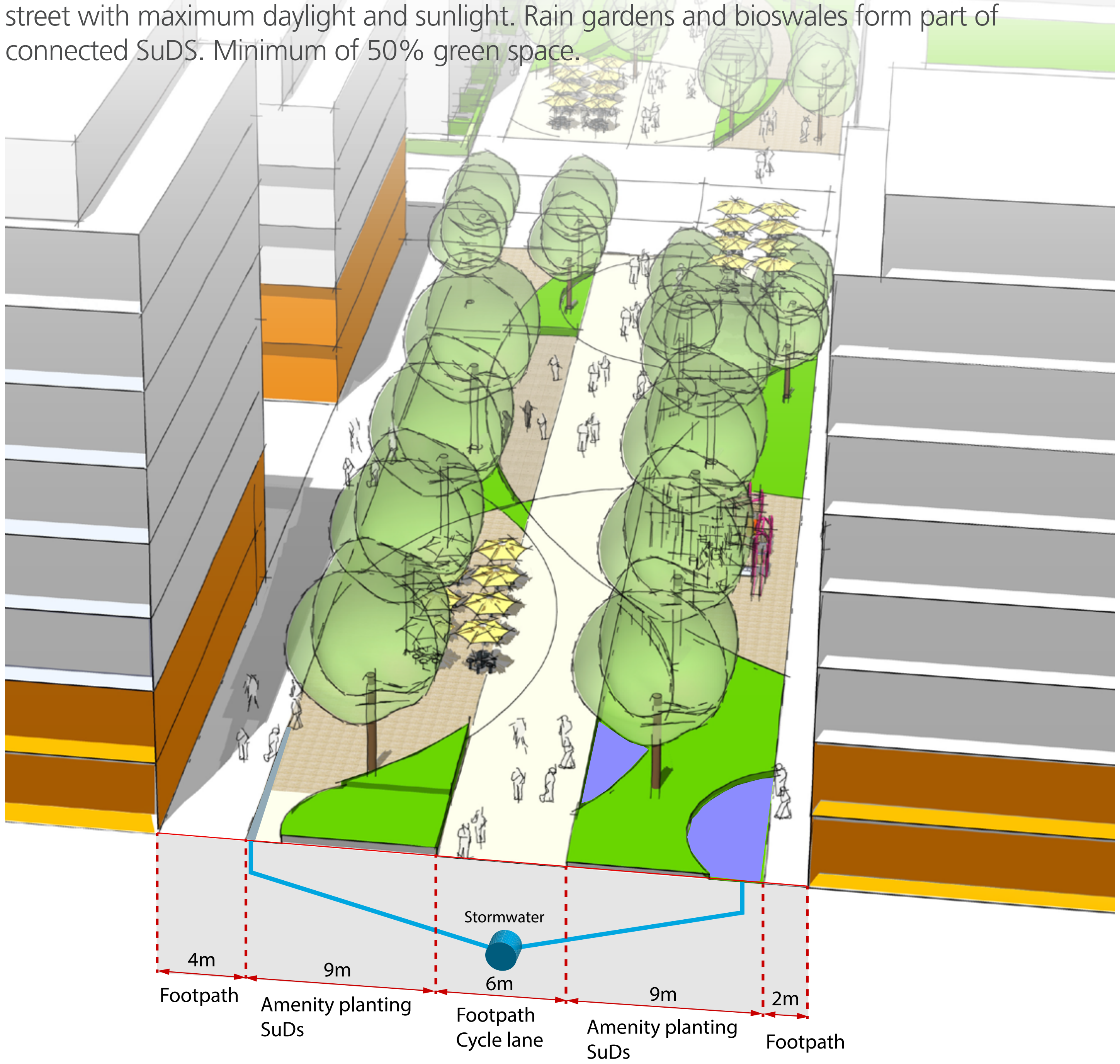
The High Street

The most important street in the new development will be Old Oak High Street. The street will create a new link connecting Harlesden and Willesden Junction in the north, through Old Oak Park, to the HS2 Old Oak Common Station. The green corridor will be designed primarily for pedestrians and cyclists with vehicles restricted to buses and emergency vehicles. The opportunity exists to create a linear green boulevard along the centre of the street. The trees and high proportion of planted space will help mitigate the heat island effect and provide a more comfortable living and working environment.



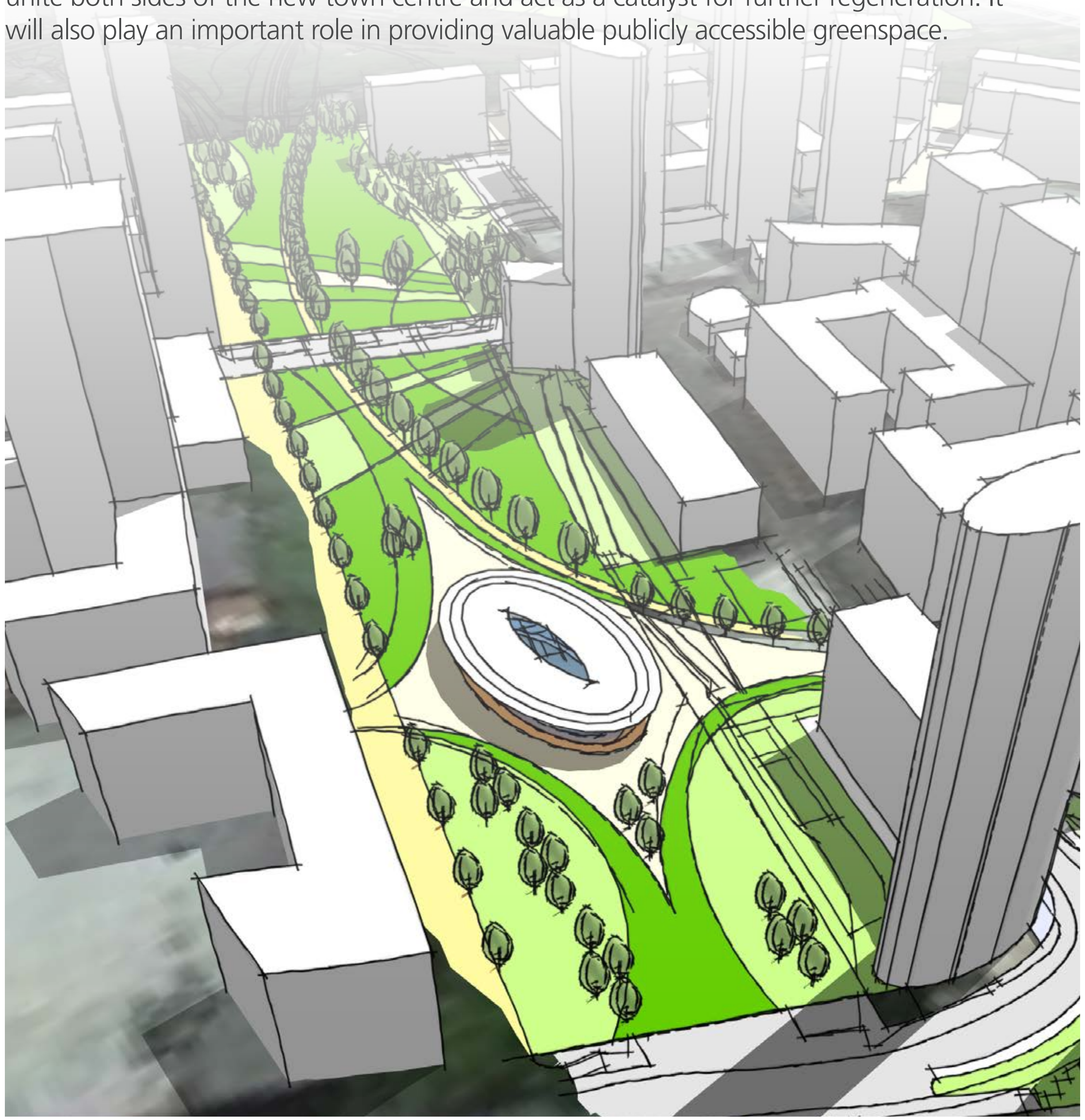
Green Streets

The opportunity exists to create a Green Grid of pedestrian and cycling routes set within continuous green corridors providing safe and convenient access between residential areas and stations, schools and community facilities. Street section to ensure street is adequately sunlit throughout the year. Outdoor seating and children's play to be sited in areas of the street with maximum daylight and sunlight. Rain gardens and bioswales form part of connected SuDS. Minimum of 50% green space.



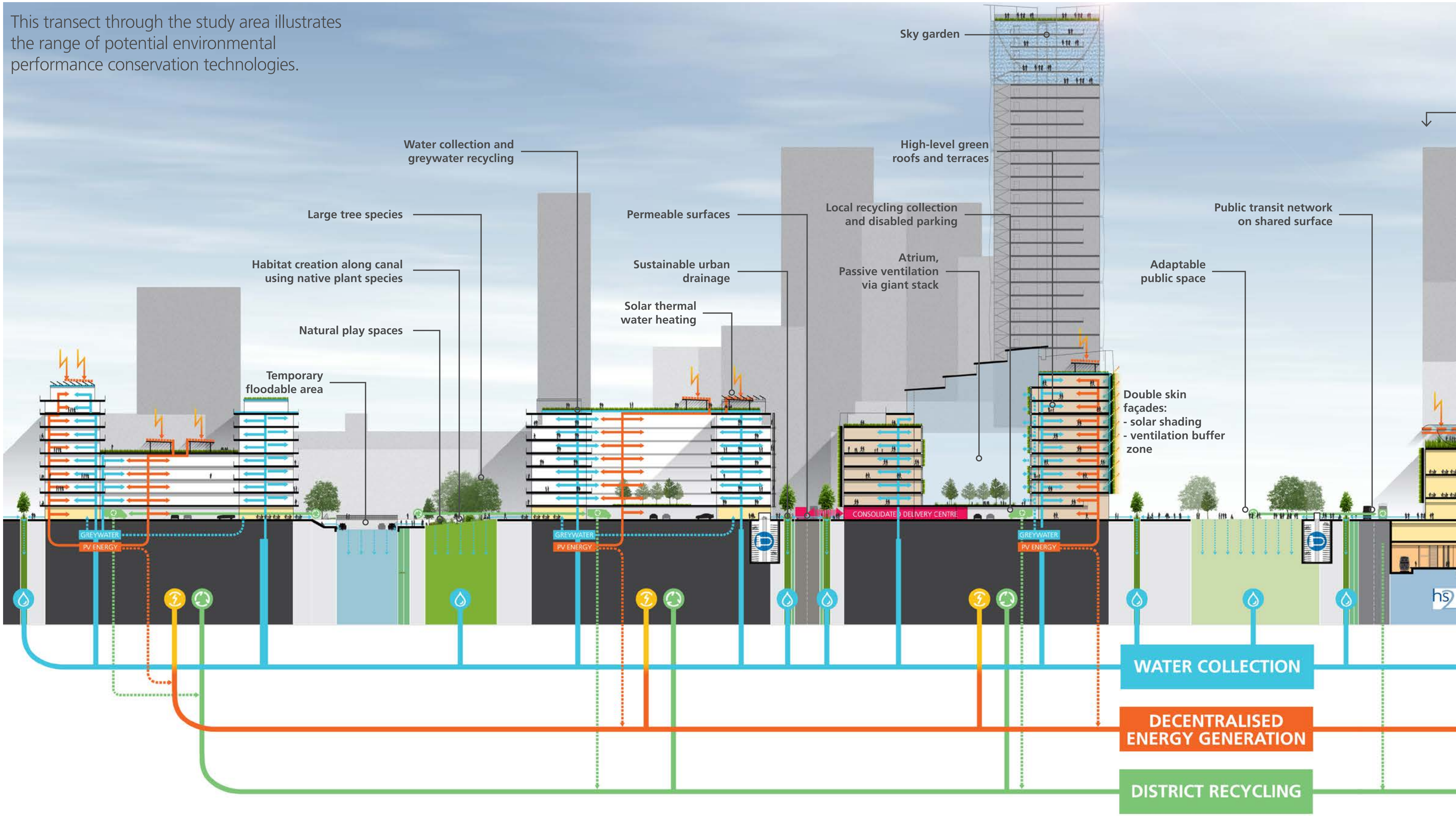
North Acton - Rail Deck Park

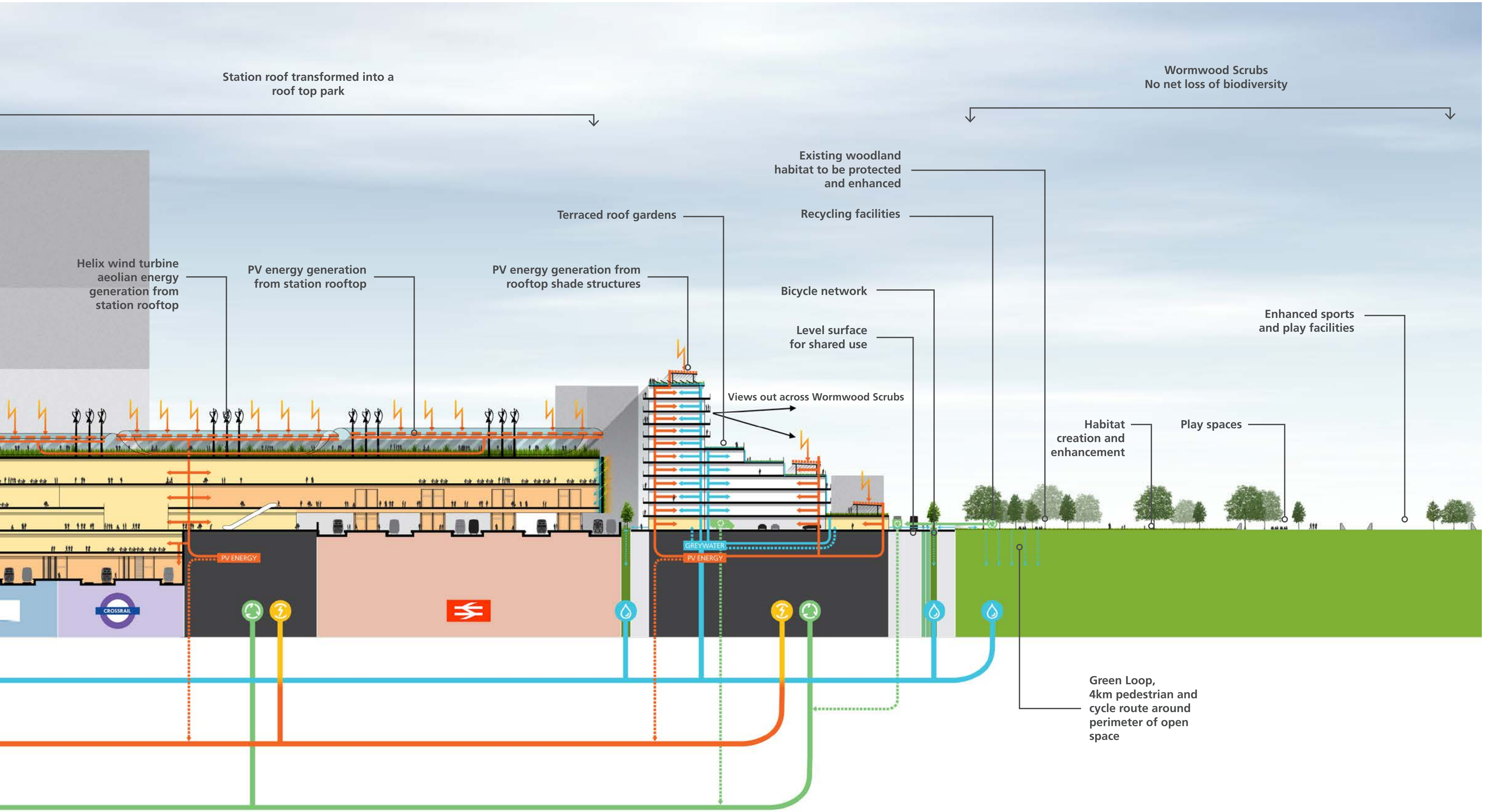
Rail Deck Park: creation of a new local park by decking over the railway cutting. This will unite both sides of the new town centre and act as a catalyst for further regeneration. It will also play an important role in providing valuable publicly accessible greenspace.



Study Area Transect Old Oak South

This transect through the study area illustrates the range of potential environmental performance conservation technologies.




Station roof transformed into a roof top park
Wormwood Scrubs
No net loss of biodiversity
Existing woodland habitat to be protected and enhanced
Terraced roof gardens
Recycling facilities
Helix wind turbine aeolian energy generation from station rooftop
PV energy generation from station rooftop
PV energy generation from rooftop shade structures
Bicycle network
Level surface for shared use
Enhanced sports and play facilities
Views out across Wormwood Scrubs
Habitat creation and enhancement
Play spaces
PV ENERGY
GREYWATER
PV ENERGY
CROSSRAIL
Green Loop, 4km pedestrian and cycle route around perimeter of open space

Conclusion – An Integrated Approach

We have proposed an environmental Vision which looks beyond the environmental impacts of developments and considers the need to address wellbeing:

> To be a flagship zero carbon, resource efficient development which is resilient to climate change and promotes smart and healthy behaviours, environmental health and mental and physical wellbeing.

An approach which promotes wellbeing and healthy living closely balanced with environmental sustainability

ATKINS

The Vision informed the two environmental themes which have provided a framework for developing and testing objectives and targets for development of the site. The first theme, **Environmental Performance**: relates to improving the overall environmental sustainability performance of the built environment. Old Oak and Royal Park should be a neighbourhood that is carbon and resource efficient and helps enhance air quality. The second theme is **Environmental Quality**: we need to balance environmental performance with quality of life issues and promote climate responsive urban design to create high quality, attractive, open spaces and streetscapes as well as healthy, comfortable and energy efficient buildings, and biodiversity positive ecological assets. We also need to plan and design for the predicted effects of climate change over the next several decades, particularly in terms of increasing flood risk and enhanced Urban Heat Island effect.

There will inevitably be crossover between the themes and topics which lie within each theme and the report seeks to capture this within the cross-cutting policy recommendations and the illustrative application of guidance. The recommendations for significantly more green space will support provision of opportunities for recreation, improve health and wellbeing, create an attractive place to live and work in, help to mitigate flood risk and the Urban Heat Island effect, and enhance biodiversity. Achieving the proposed Carbon targets will depend on joined up thinking around waste, energy and materials and a mechanism such as the C40 Cities Climate Positive Framework can support the creation and implementation of this new community and help it grow in an environmentally sustainable and economically viable way. A shift to more carbon efficient energy generation, materials and travel will also improve air quality. New smart grid technology will facilitate the integration of infrastructure, we've emphasised the need for close collaboration between OPDC, developers, energy service providers, utility companies and regulators to support use of onsite low carbon energy infrastructure. There is also a need for a very strong focus from the outset in masterplanning and urban design on ensuring that appropriate areas are allocated for onsite waste facilities, SuDS, stormwater storage, water recycling, freight consolidation centres, car clubs and cycle parking. And finally the future masterplanning process will need to define a street layout and hierarchy which takes into account the microclimate and climate responsive design principles.

Hammarby Sjöstad, Stockholm

Environmental sustainability has been built into the development on a district level through the installation of the innovative 'Hammarby Model', an efficient 'closed loop' system for water, energy and waste streams. The system was the product of rigorous masterplanning that has helped the area meet its stringent environmental targets of reducing water and energy usage by 50% of the typical 1990 level usage in Sweden. The district uses the ENVAC waste system, which collects separated waste centrally via an underground pipe network. Solid waste is then recycled and used for agriculture and forestry, biogas is produced for cooking, whilst heat produced from incineration is used to heat homes. The development has emphasised reduced car usage through improving sustainable transport links to the city and has restored natural ecosystems, such as the waterways in and around the development.

OPDC
OLD OAK AND
PARK ROYAL
DEVELOPMENT
CORPORATION

OPDC Environmental Standards Study

June 2017

MAYOR OF LONDON

ATKINS

Contents

Energy

Waste

Materials

Carbon

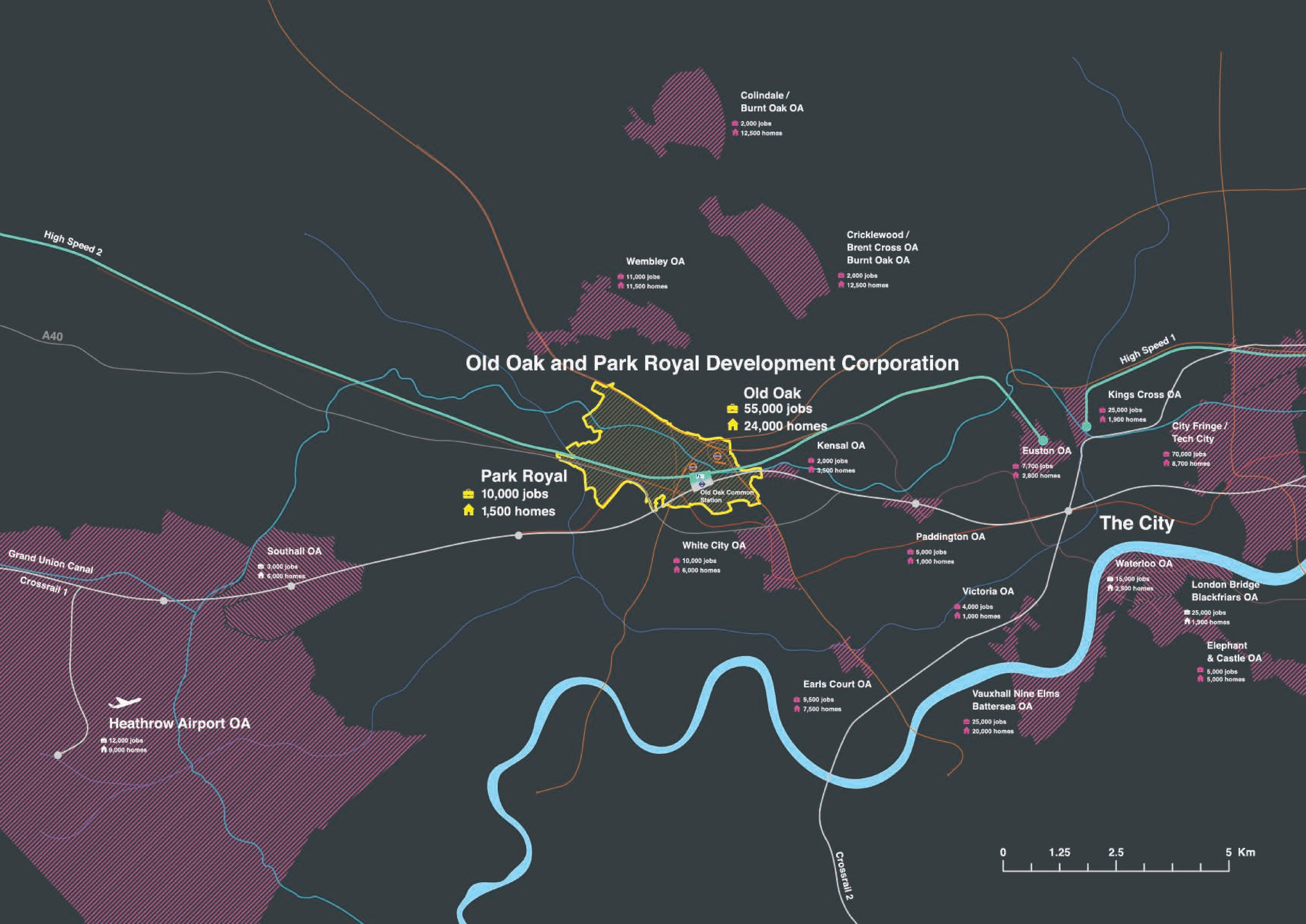
Water

Air

Green Infrastructure & Biodiversity

Resilience

1. Introduction



Old Oak and Park Royal Development Corporation
Old Oak
55,000 jobs
24,000 homes
Park Royal
10,000 jobs
1,500 homes
Old Oak Common Station
Colindale / Burnt Oak OA
2,000 jobs
12,500 homes
Cricklewood / Brent Cross OA Burnt Oak OA
2,000 jobs
12,500 homes
Wembley OA
11,000 jobs
11,500 homes
High Speed 2
A40
High Speed 1
Kings Cross OA
25,000 jobs
1,900 homes
City Fringe / Tech City
70,000 jobs
8,700 homes
Euston OA
7,700 jobs
2,800 homes
Kensal OA
2,000 jobs
3,500 homes
The City
Paddington OA
5,000 jobs
1,000 homes
White City OA
10,000 jobs
6,000 homes
Southall OA
3,000 jobs
6,000 homes
Grand Union Canal
Crossrail 1
Waterloo OA
15,000 jobs
2,500 homes
London Bridge Blackfriars OA
25,000 jobs
1,900 homes
Victoria OA
4,000 jobs
1,000 homes
Elephant & Castle OA
5,000 jobs
5,000 homes
Earls Court OA
9,500 jobs
7,500 homes
Vauxhall Nine Elms Battersea OA
25,000 jobs
20,000 homes
Heathrow Airport OA
12,000 jobs
9,000 homes
Crossrail 2
0
1.25
2.5
5 Km

1. Introduction

Purpose of Study

Atkins was awarded a contract to help make Old Oak and Park Royal, London's largest Opportunity Area, one of the most sustainable urban developments in the UK.

It is the aspiration of the Old Oak and Park Royal Development Corporation (OPDC) to deliver a new part of London that is an exemplar in environmental sustainability, and realise the wider investment potential from the HS2 and Crossrail transport infrastructure projects.

Atkins was tasked with developing a set of aspirational but deliverable environmental sustainability targets that are aimed at ensuring future development across the Old Oak and Park Royal sites will be exemplar in construction and operation. The purpose of the study is rooted in the need to develop robust, defendable planning policy for the OPDC area to take forward the ambitious development envisioned.

The study outcomes will be used as evidence in OPDC's policy formulation, notably its emerging Local Plan. The targets will also guide future development, including associated infrastructure, in addressing challenges and taking advantage of opportunities presented across energy provision, water management and waste management to deliver carbon dioxide reduction, good air quality and resource efficiency.

The environmental sustainability targets for the OPDC area seek to go beyond targets in the London Plan and Mayoral strategies, pushing the boundaries and shaping exemplar design, construction and operation for this new area of London. The environmental targets will be adopted in the Local Plan and inform the new development at Old Oak and the urban intensification and regeneration of Park Royal.

The process of developing standards is iterative and has been tested by Stakeholders (including GLA, local authorities, Environmental Agency, industry and universities) and refined in response to their input.

The Study Area and Local Plan Proposals

The OPDC area covers the Old Oak and Park Royal Opportunity Areas in the Mayor's London Plan (2015), which is situated within the three London Boroughs of Brent, Ealing and Hammersmith & Fulham. It is bounded by National Rail, Overground and Underground lines to the north, south and east, while the North Circular (A406) and Western Avenue (A40) form additional boundaries to the west and south.

The area has been identified to have the capacity to deliver a minimum additional 26,000 homes and indicative 59,000 jobs (supersedes figures in plan opposite), representing London and the UK's largest regeneration project. The OPDC itself was established to maximise the regeneration benefits generated by the new stations for High Speed 2 (HS2) and Crossrail and potentially two new London Overground Stations to be located within the OPDC area.

The OPDC area covers 650 ha, over twice the area of the City of London Corporation. At over 120 ha of developable land, Old Oak provides particular opportunities for a range of supporting uses. Although most of the land is industrial, there are a handful of residential pockets, a hospital and supermarket in addition to land for the railway lines and their embankments crisscrossing the area. Park Royal is Europe's largest industrial estate and is a vital component of the London economy, accommodating over 1,500 businesses employing over 36,000 people.

Approach

Our approach has been to provide strategic, smart and conceptual thinking that defines what OPDC is trying to achieve and provides the rationale and high level evidence to support the adoption of goals and objectives in the emerging Local Plan.

1. The output aims to be strategic and holistic, setting out a clear vision, goals and key objectives supported by clear outcomes and targets that will be relevant over the life of the project and across the different components of the project.
2. Recommendations are supported by relevant, high level evidence informed by our analyses and best practice around the world with the key challenges identified.
3. The key recommended targets and guidance will inform the brief for other infrastructure and masterplanning studies. High level ambitions have been set but the actual targets will only be determined once feasibility has been undertaken.
4. Feasibility will be undertaken as part of future studies, the guidance we have provided will inform options for meeting the targets and a review of deliverability including cost.
5. The process of arriving at an agreed framework, vision, goals and targets will be ongoing and informed through a stakeholder engagement process.

Structure of Report

Within the following chapter, 'Vision and Objectives', we have proposed an environmental vision which looks beyond the environmental impacts of developments and considers the need to address wellbeing.

To be a flagship zero carbon, resource efficient development which is resilient to climate change and promotes smart and healthy behaviours, environmental health and mental and physical wellbeing.

The Vision has informed two environmental themes which have provided a framework for developing and testing objectives and targets for development of the site. The first theme, Environmental Performance, relates to improving the overall environmental sustainability performance of the built environment. The second theme is Environmental Quality, which is about promoting a high quality, attractive and comfortable place to live and work in.

The report is structured around the two environmental themes. Following a discussion of key issues and opportunities (Chapter 3) relating to each theme which are specific to Old Oak and Park Royal, Chapter 4 covers Environmental Performance and Chapter 5, Environmental Quality.

Chapter 4, Environmental Performance, adopts a topic based approach and covers energy, waste, materials, carbon emissions, water and air quality. This reflects the Local Plan structure, the other studies which are being undertaken and ensures that all these major topics are appropriately assessed. These topics demand a predominantly performance-based approach with indicators and targets which can be incorporated into the Local Plan, measured and monitored.

Chapter 5 on Environmental Quality focuses on quality of life issues for people living, working and visiting the development and demands a predominantly guidance-led approach, illustrating how the site should be planned to ensure high quality and energy efficient buildings, open space and the public realm to promote a healthy and comfortable environment. This chapter also addresses Climate Change Resilience and reflects the Mayor's Climate Change Adaptation Strategy, identifying measures required to mitigate flood risk and the urban heat island effect. Each of these chapters is divided into sections for each topic area.

There will inevitably be crossover between the themes and topics and the report seeks to capture this within the cross-cutting policy recommendations within each section.

Each topic (section) within chapters 4 and 5 is structured to provide:

- Planning policy context
- Site context
- Proposed objectives and policy recommendations
- Associated evidence: site analysis and case study analysis
- Indicators where appropriate defining intended outcomes to be measured
- Time-bound initial targets based on quantifiable evidence (chapter 3 only)
- High level financial and technical feasibility of delivering recommendations and targets (for chapter 3 only)

Chapter 6 illustrates the spatial application of the environmental performance recommendations and environmental quality guidance to the streets and the public realm in Old Oak and Park Royal.

The Case Study Analysis in Chapter 7 provides a review of comparable high density residential and mixed use schemes in London to identify best practice and understand how ambitious targets have been achieved and delivered. These case studies, along with other international ones, are also used throughout the document to illustrate best practice.

Chapter 8 includes the conclusions and this is followed by appendices which include more detail on the case studies, the environmental performance analyses, the Imperial College Urban Heat Island Study and references.

Stakeholder Consultation

A series of meetings and discussions were held with key stakeholders. These took the form of one-to-one meetings, telephone conversations and presentations. We also held a number of workshops.

The first stakeholder workshop was held on 6th May 2016. The aim of this workshop was to discuss scope of the study, site issues and opportunities, best practice, an environmental vision and targets. Attendees included representatives from:

- OPDC and GLA
- London Boroughs of Ealing, Brent, Hammersmith and Fulham and Royal Borough of Kensington and Chelsea
- Natural England
- Environment Agency
- London Waste and Recycling Board (LWARB)
- Thames Water
- HS2
- Transport for London (TfL)

Four groups were formed to discuss current environmental and sustainability targets: Urban Planning, Transport, Energy, Water and Waste and Green/blue Infrastructure. The opportunity to go beyond these targets was also discussed and helped to inform the environmental vision and objectives for the proposed development.

A presentation of initial findings and assessment of the key issues and options was held with the OPDC, GLA, the UK Green Building Council (UKGBC) and UCL on 11th August 2016. The subsequent discussion helped to steer the focus of the study, identifying the need to include sustainability issues related to daylight and sunlight, the extent of green open space and green roofs, maintenance of amenities, connectivity and examples of best practice.

A second stakeholder workshop was held on 19th October. The first part in the morning was with officers within the OPDC and the afternoon session was with representatives from the organisations listed above. The aim of these workshops was to present key findings, recommendations and targets for discussion. This was followed up by sending all attendees copies of the draft topics papers which they were able to review and provide more detailed comments on.

OPDC also held a study tour and workshop on 8th February 2017 attended by Atkins to seek industry feedback on the draft strategies and policies for Old Oak and Park Royal.

We have used case studies throughout the report to illustrate best practice and help inform the evidence base. Towards the end of the study, we held one to one meetings with the developers and/or architects who were responsible for some of these schemes to ensure the case study information was accurate, discuss the environmental standards which guided their schemes and whether they were achieved and to get feedback on the key recommendations and targets we had developed for the OPDC site.

We spoke to representatives from:

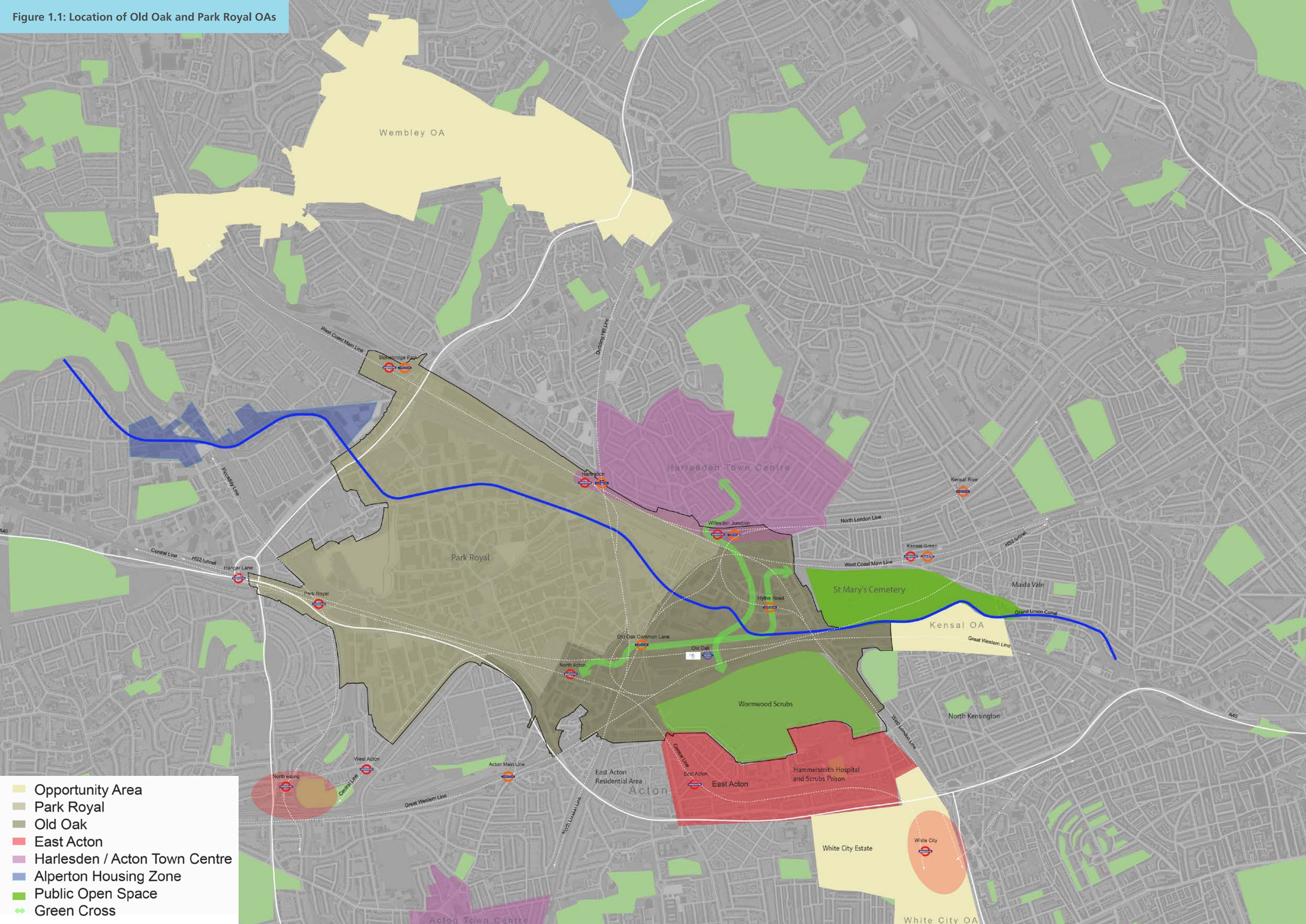
- Argent
- Berkeley Group
- British Land
- Canary Wharf Group
- Lend Lease
- Stockholm Royal Seaport
- Farrells
- Fletcher Priest Architects
- Legal & General
- Levitt Bernstein Architects
- Pollard Thomas Edwards Architects

Further consultations were held March-April 2017 regarding specific topics and targets, in particular regarding use of sustainable materials. We spoke with representatives of the following additional organisations:

- BAM International
- Conways
- Skanska
- Tarmac

We thank the stakeholders, developers, architects and contractors / suppliers for their valuable time and inputs.

Figure 1.1: Location of Old Oak and Park Royal OAs



Current Environmental Targets in London Plan / Mayoral Strategies

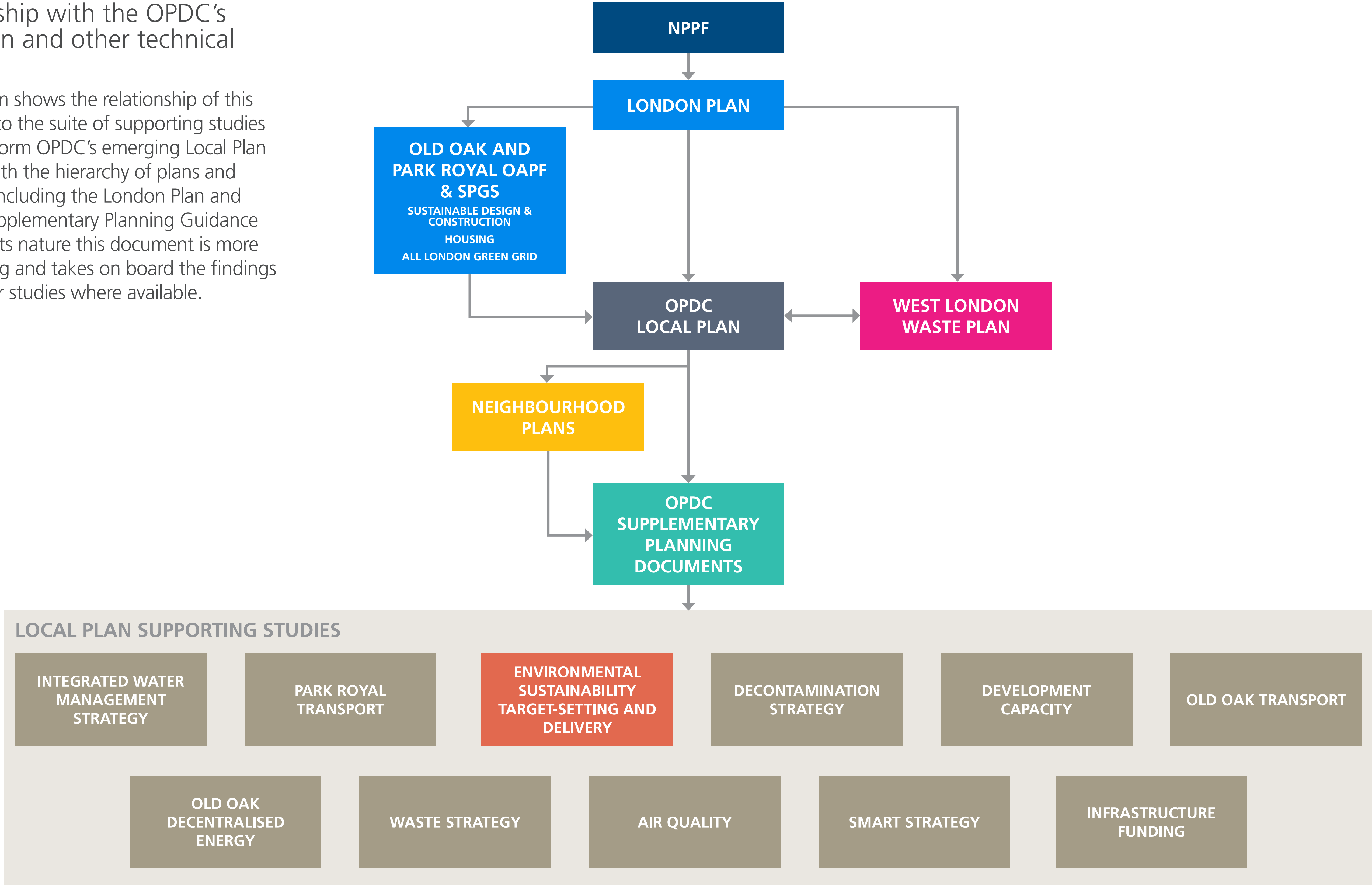
The current Environmental Targets in the London Plan and Mayoral Strategies are summarised by key environmental sustainability topic in the adjacent table and set out for each topic in Chapters 4 and 5.

Topic Area	Current targets in London Plan / Mayoral Strategies
Energy	• 25% of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025. • From October 2016, buildings of all types are expected to show substantial energy demand reductions, using a combination of both passive and active design measures, contributing to the overall target of zero carbon buildings.
Waste	• Work towards zero biodegradable/recyclable waste to landfill by 2026 • 90% reuse re-cycling/re-purposing of construction materials • Recycling 70% of commercial/industrial waste by 2020 • Recycling of 50% of municipal waste per capita per annum
Materials	• Use low embodied energy, sustainably sourced materials • Use durable materials and maximise use of pre-fabricated elements. • Use 'healthy' materials: minimise the harmful effects on human health. • Use existing resources and materials; design for deconstruction rather than demolition
Carbon emissions	• Reduce $C0_2$ emissions by 60 per cent from 1990 levels by 2025, and 80% by 2050 • All new homes forming part of a major development to be zero carbon; all non-domestic buildings to be zero carbon by 2019 • Reduce London's waste management to save one mega tonne of $C0_2$ equivalent per year by 2031 • Application of the Energy (and cooling) Hierarchy in the London Plan. • All major development proposals to seek to reduce carbon dioxide emissions by at least 20 % through use of onsite renewable energy generation
Water	• Minimising use of mains water • Use SuDS to achieve run-off rate equivalent to a greenfield • Water efficiency of 105 litres per household per day to match higher requirements of Building Regulations • New developments to aim for water neutrality: limiting new demand and using alternative water sources • Developers should aim for a greenfield runoff rate from their developments
Air quality	• Meet EU values for air pollutants • Seek to achieve Air Quality Neutrality • Developments should be designed to minimise the generation of air pollution, and minimise and mitigate against increased exposure to poor air quality
Green infrastructure & biodiversity	• Increase tree coverage by at least 25% to 30% • All major buildings to include a green, solar or cool roof and a minimum of 50% of the built environment footprints to include urban greening measures • Achieve net gains for nature

Relationship with the OPDC's Local Plan and existing OPDC technical studies

Relationship with the OPDC's Local Plan and other technical studies

The diagram shows the relationship of this document to the suite of supporting studies that will inform OPDC's emerging Local Plan together with the hierarchy of plans and guidance, including the London Plan and relevant Supplementary Planning Guidance (SPG's). By its nature this document is more cross-cutting and takes on board the findings of the other studies where available.



ATKINS

2. Vision and Objectives

2. Vision and Objectives

Environmental Vision

To be a flagship zero carbon, resource efficient development which is resilient to climate change and promotes smart and healthy behaviours, environmental health and mental and physical wellbeing.

As we developed our environmental vision for the site we asked: what makes this place and this opportunity unique? What does the site offer that cannot be provided in other places? Can super high density living create a healthy environment? What makes the site a compelling answer to present and future needs and desires?

The site will accommodate one of the biggest new stations in a century, it will be one of the best connected sites in London, a major interchange which creates the opportunity for very high density development.

It is the biggest and most ambitious opportunity area and development site in London that is largely owned by the public sector and there is a desire to create an exemplary sustainable regeneration project based on Transit Orientated Development principles that will connect to and enhance local natural blue and greenspace assets. That means delivering a place that supports a thriving, healthy and low carbon community, fully connected with the fastest IT connections.

Both **Old Oak** and **Park Royal** will endeavour to set new standards in environmental place making that is resilient and flexible to change whilst setting new standards of high density and mixed use development that has appropriate levels of social infrastructure, is affordable, inclusive and is properly serviced with a mix of transport systems.

To balance the aspirations and challenges, new thinking and approaches are needed to planning, transport, infrastructure provision, building standards especially tall buildings, provision and design of green space. High density development requires a high quality environment if it is to have a positive impact on the health and wellbeing of the local population and business community.

Old Oak

Old Oak will be an **exemplar model of high density, compact, mixed use** human scale development, with land use, densities and urban form efficiently organised to support low carbon, resource efficient buildings and movement.

A key attraction for residents, workers and visitors alike will be high quality, liveable, vibrant public open space and highly permeable urban form rooted in **climate responsive design** principles, with a diversity of local services, encouraging a strong sense of place, identity and community.

It will be a **fossil fuelled-car free neighbourhood,** served by a smart and reliable public transport network, attractive and safe walking and cycling routes, with extensive infrastructure to support zero emission vehicles.

A dense network of **multi-function, multi-benefit green infrastructure** will permeate both public and private open space, closely integrated with Park Royal green infrastructure and the London green grid.

Over the long term the neighbourhood will be **carbon positive, zero waste, and biodiversity positive;** the development will be water neutral, with enhanced water and air quality.

Park Royal

Park Royal will evolve into a high value, **low carbon high performance business park,** with strong mutually supportive economic and resource efficient interlinkages between businesses and activities.

It will provide flexible and affordable business spaces, **rapidly adaptable** to the future economy and environment and high value jobs.

Attractive, greener public open space, and local service provision in activated frontages along key movement corridors, linked to parking and flow controls and enhanced public transport, will **promote walking and cycling**, vibrancy and high quality of life.

Deliveries and company logistics will be co-ordinated, with strong support for **zero/low emission freight vehicles.**

The area will undergo **extensive greening** with connected public and private green space linking parks, street vegetation, verges/setbacks, drainage areas, landscaping, green roofs and green walls.

Long term, Park Royal will be **low carbon, low waste and biodiversity positive;** the area will be water neutral, with enhanced water and air quality.

Environmental Themes

The vision has informed the following two core themes which provide the framework for developing and testing appropriate environmental objectives and targets for development of this site:

Environmental performance

We urgently need to improve the environmental sustainability performance of the built environment. Old Oak and Royal Park should be a neighbourhood that is carbon and resource efficient and helps enhance air quality.

Environmental quality and resilience

We need to balance environmental performance with quality of life issues and promote climate responsive urban design to create high quality, attractive, open spaces and streetscapes as well as healthy, comfortable and energy efficient buildings and biodiversity positive ecological assets.

We need to plan and design for the predicted effects of climate change over the next several decades, particularly in terms of increasing flood risk, enhanced Urban Heat Island effect, and protecting and enhancing biodiversity.

Environmental Themes	
Environmental Performance	**Environmental Quality**
Energy	Green infrastructure & biodiversity
Waste	Microclimate & public realm
Materials	Climate resilience
Carbon emissions	Noise
Water	Sustainable transport
Air quality	

Environmental Objectives

We have developed some challenging but focused objectives in relation to the two themes above. These objectives represent the outcomes that are required to achieve the environmental vision and have been used to guide the development of indicators, targets and guidance which are identified and tested in Chapters four, five and six.

			Environmental Objectives
Environmental Performance		**Energy**	• Minimise energy demand • Maximise onsite zero / low carbon energy generation
		Waste	• Zero waste • Resource and carbon efficient solid waste disposal
		Materials	• Optimise use of low carbon, sustainably sourced, healthy materials
		Carbon emissions	• Overall Carbon Positive
		Water	• Maximise efficient use of water • Maximise use of alternative sources for non-potable water • Minimise surface water run-off and wastewater discharge
		Air quality	• Enhance local ambient air quality • New buildings and transport to be at least air quality neutral • Enhance indoor air quality
Environmental Quality		**Green infrastructure & biodiversity**	• Maximise multi-function, multi-benefit green infrastructure • Restore natural habitats and enhance biodiversity • Promote high quality, liveable built environment for diversity of residents, employees and visitors
		Microclimate & public realm	• Light, comfortable, healthy, vibrant open space / public realm • Light, comfortable, healthy building internal environments • High quality, liveable built environment for diversity of residents, employees and visitors
		Climate resilience	• Mitigating the urban heat island (UHI) effect • Preventing overheating of outdoor areas and indoor spaces • Minimising flood risk
		Noise	• Plan for comfortable and healthy homes and open space / public realm • Reduce the negative effects of dense urban environments • Reduce exposure to infrastructure / industrial generated noise
		Sustainable transport	• Maximise low / zero carbon movement • Strong walking and cycling networks: integration with green infrastructure • Restricted parking • Encourage zero/ultra low carbon vehicles

The Car Giant site at Old Oak with Park Royal in the distance

3. Key Issues and Opportunities

Computer generated image of the proposed development at Old Oak Park as shown in the Draft Local Plan

3. Key Issues and Opportunities

Introduction

The key issues and opportunities in terms of setting aspirational environmental targets for Old Oak and Park Royal have been summarised under the following key environmental / sustainability cross-cutting themes:

- Achieving Zero Carbon
- Achieving Zero Waste
- The Challenge of Super Density
- Tall Buildings
- Competing Demands for Space
- Connections and Open Space
- Wormwood Scrubs: Biodiversity and Greenspace
- Park Royal: Sustainable Retrofit
- Resilience
- Future Proofing

Achieving Zero Carbon

Zero Carbon

The scale of development at Old Oak has the potential to generate very substantial operational emissions associated with building use, transportation and waste disposal. The development will also generate a large embodied carbon footprint associated with the materials and equipment used in construction.

The UK is the world's eighth largest emitter of carbon dioxide (CO_2e), and London is responsible for 8.4% of these emissions (the latest annual estimate is 44.71 million tonnes). London also has the lowest domestic CO_2e emissions per person per year, at 2.26 tonnes, and the joint lowest transport emission rate per person, at 1.38 tonnes, of all the UK regions. This is largely due to the higher use of public transport and the density of development in London[1].

The Mayor seeks to achieve an overall reduction in London's CO_2e emissions of 60% (below 1990 levels) by 2025. The London Plan sets out staged targets for reducing carbon emissions from buildings, with both residential (from 2016) and non-residential (from 2019) buildings expected to eventually be zero carbon.

Most recent available data from the London Energy and Greenhouse Gas Inventory (LEGGI) covers only Scope 1 and 2 emissions, as defined in international reporting guidelines and Defra's Guidance on Measuring and Reporting Greenhouse Gas Emissions. This includes direct and indirect emissions from energy consumption in buildings and transport, but excludes waste disposal. Figures from a GLA report of 2014[2] (see Figure 3.1), which includes Scope 3 emissions, indicate that buildings accounted for 50% of emissions, with surface transport accounting for another 13% (road based transport accounted for 11%), while emissions associated with waste disposal amounted to only around 1%. It should be noted that the latter figure does not include emissions embodied in the waste itself.

Clearly, the highest priority for achieving operational zero carbon development in London is reducing and offsetting building related emissions, followed by road based transport related emissions. The unprecedented high densities and associated tall buildings within Old Oak will make both energy demand reduction and ultra low carbon onsite energy generation additionally challenging. The high current and planned provision of rail transit, however, will make transport related carbon reduction easier. These unusual features, together with proximity to the major employment area at Park Royal, offer an extraordinary, unmatched opportunity for creating a new model of low/zero carbon development in Old Oak, with the potential to be a ground-breaking exemplar for London and the UK.

Reducing energy consumption in high density, tall development will require very close attention to both passive and active design approaches to optimise electrical and thermal performance whilst retaining good internal lighting and comfort levels. Retrofitting buildings in Park Royal with energy saving technologies may be expected to yield lower improvements in performance and over a longer timeframe. There is a major opportunity to optimise deployment of distributed renewables across the site, including photovoltaic, solar thermal and multi-source heat pump technology, and potentially energy from waste, to provide a very significant zero carbon local energy generation capacity.

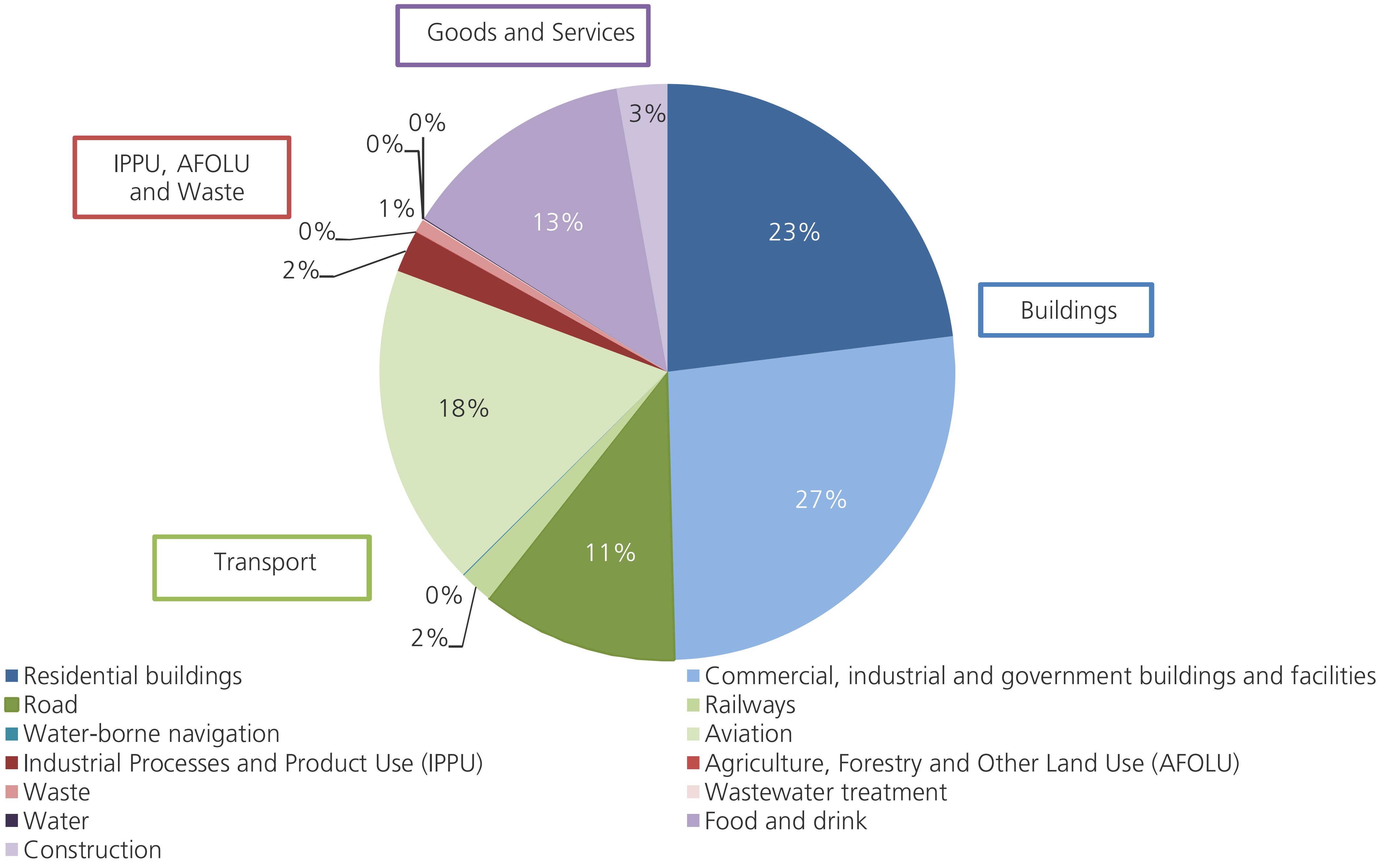
Substantial reductions in transport related emissions are achievable with a fully integrated approach to urban form, movement, open space, green infrastructure and microclimate across the site, rooted in Transit Oriented Development (TOD) principles, with the aim of optimally maximising non freight movement by public transport, non-motorised modes and zero/low emission vehicles (ZEV/LEV). This approach will also have many other benefits, including reducing other air pollutants and promoting a high quality, healthy, liveable built environment, both in Old Oak and Park Royal. Freight consolidation centres and lorry holding areas, together with provision of facilities for low/zero carbon vehicle deliveries within residential, commercial and industrial areas, will need to be incorporated in order to minimise freight / goods movement related emissions.

Reducing emissions from waste disposal will centre on minimising waste sent to landfill and maximising recycling and composting, with low carbon energy generation from incineration of the remainder.

To achieve an ambition of operational zero carbon for Old Oak and Park Royal, in the short-medium term there is likely to be a need to offset significant net carbon emissions, either through onsite or offsite sequestration, other designated offsite carbon reduction initiatives, or carbon pricing. In the longer term, as the carbon intensity of grid electricity is expected to fall and energy efficiencies increase, it may be possible to achieve net operational zero carbon with substantially lower offsetting.

1 Delivering London's Energy Future - The Mayor's Climate Change Mitigation and Energy Strategy, GLA, October 2011.
2 Assessing London's Indirect Carbon Emissions, GLA, July 2014.

Figure 3.1 – Breakdown of London's CO_2e Emissions in 2010 from DPSC Methodology



Source: Assessing London's Indirect Carbon Emissions, GLA, July 2014
Note: DPSC means 'Direct Plus Supply Chain', one of two methodologies for measuring city wide emissions provided under the BSI PAS 2070 standard, 2014.

Achieving Zero Waste

Zero Waste

In 2009/10, London produced 3.8 million tonnes of municipal waste, a significant decrease from the 4.4 million tonnes produced in 2003/04, while London's population increased from 7.39 million to 7.76 million[3]. Organic waste, paper and card, mixed waste and plastics make up more than three quarters of London's municipal waste (see Figure 3.2). London's recycling and composting rate in 2009/10 of 27% was the lowest of all the English regions, and considerably lower than some of the best performing international cities such as Berlin (41%). The figure for recycling and composting in London includes anaerobic digestion, which in 2009/10 accounted for less than 1% of London's municipal waste treatment. Of the municipal waste not recycled or composted in 2009/10, nearly half was sent to landfill and the majority of the remainder was incinerated, producing energy from waste.

Approximately 40% of municipal waste produced in London comes from flats and estates where recycling is challenging. Nearly half of London's households are flats. Lack of space for recycling storage and difficulties in transporting materials to a collection point represent key barriers. A further 21% of municipal waste is collected from small and medium-sized businesses, adding to the complexity of the municipal waste management picture.

Diverting waste from landfill, via recycling, composting, and energy-from-waste incineration, is key to reducing carbon emissions from waste disposal. It is also important in terms of reducing the overall cost of waste management, due to the increasing cost of landfill disposal. However, with the heat making up two thirds of energy generated from incineration not being captured, current energy-from-waste incineration is not very energy or carbon efficient. This could be improved with the use of Combined Heat and Power (CHP) technology with incineration. Reusing, recycling and composting represent the most carbon as well as resource efficient form of management overall for most types of waste, with recycled materials able to displace use of virgin materials.

Current Mayoral targets include increasing municipal waste recycling to 50% by 2020, rising to 60% by 2031, as well as zero organic/recyclable waste to landfill by 2026. Recycling of non-municipal commercial/industrial waste recycling is targeted to reach 70% by 2020. Reuse/recycling/re-purposing of construction materials is targeted to reach 95% by 2020.

The scale of new development and regeneration at Old Oak and Park Royal will result in very substantial amounts of municipal waste being generated and of materials and resources being used in construction and operation.

There is already a tradition of waste recycling in the OPDC site. A number of waste recycling facilities exist in Old Oak and Park Royal. Those in the Old Oak area will need to be re-located in order to allow for the re-development of this area. The Opportunity Area Planning Framework (OAPF) for Old Oak and Park Royal, published in 2015, states that the Powerday waste site, a relatively new facility built in 2006 which predominantly deals with construction waste, could act as the onsite construction waste management centre for the redevelopment of the Old Oak site and could be refurbished over the lifetime of the development so that its focus could switch to municipal waste management and district-scale energy generation.

There is a huge opportunity at Old Oak and Park Royal to promote a local economy based on circular economy principles, which is waste free and which through recycling and re-processing resources ensures that products and materials are kept at their highest utility for as long as possible with minimal associated carbon emissions.
To achieve this zero waste ambition, the focus will be on maximising recycling and composting of recyclable/compostable waste, and maximising carbon efficient generation of energy from the residual waste. This will require a strong focus on efficient separation and sorting of waste streams, both at the user side and within processing facilities, together with effective collection methods optimised for high density, high rise development.

3 Source: London's Wasted Resource – The Mayor's Municipal Waste Management Strategy, GLA, November 2011.

Figure 3.2 - Municipal Waste by Material

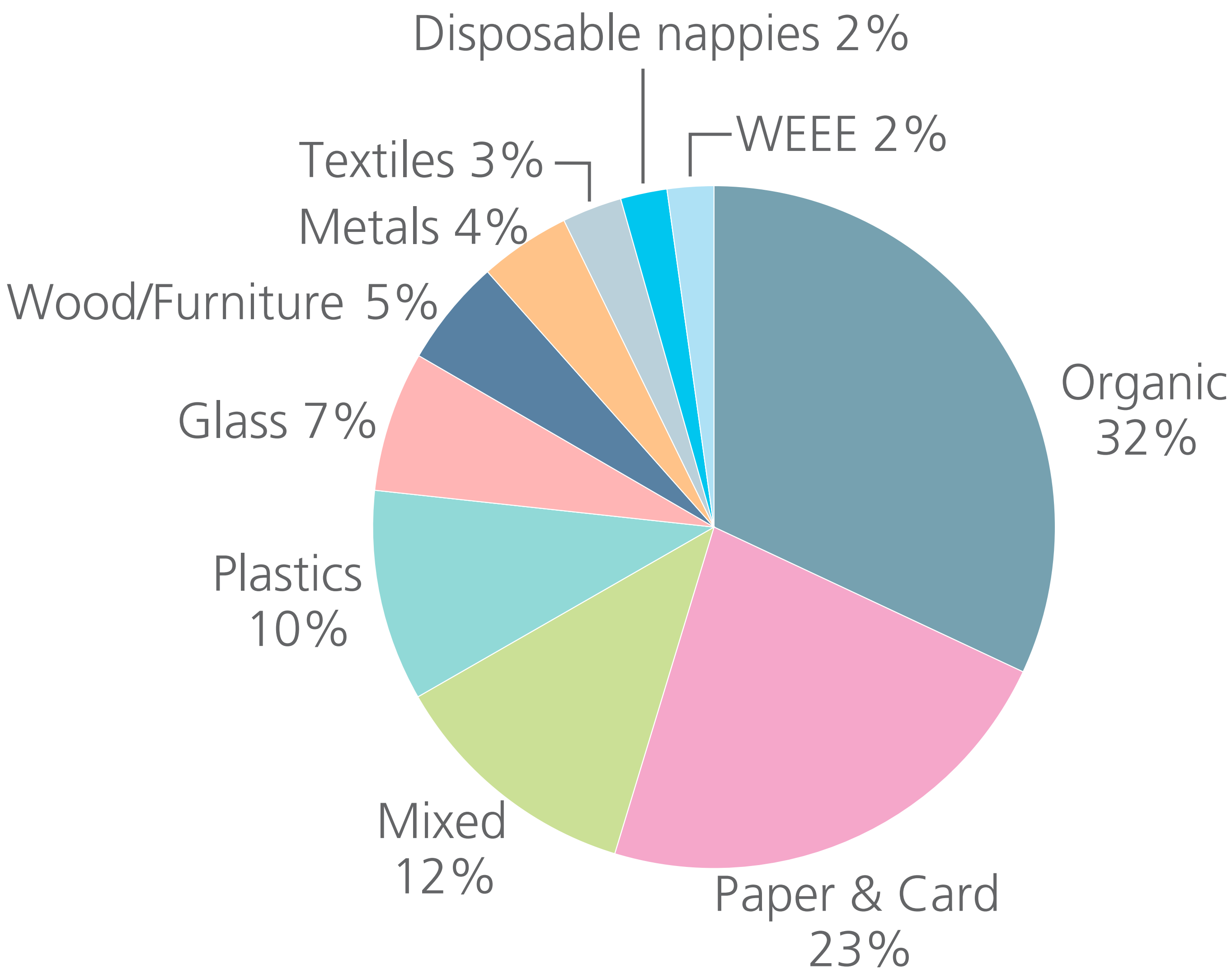


Diagram source: London's Wasted Resource – The Mayor's Municipal Waste Management Strategy, GLA, November 2011.
Data source: Defra, 2010 www.defra.gov.uk.
Notes: 'Mixed' waste includes household sweepings and soil. WEEE refers to Waste Electrical and Electronic Equipment.

The Challenge of Super Density

OPDC has developed a draft Development Capacity Study (DCS) for review and comment alongside the draft Local Plan. This sets out OPDC's draft housing trajectory and shows how the area could accommodate the targets set out in the London Plan. The capacity analysis in the DCS identifies areas that could accommodate different densities. Suggested density levels that may be appropriate in different locations are:

- **Highest -** Old Oak Common Station and surrounds: in the region of 600 units per hectare;
- **High -** Stations and key destinations: in the region of 550 units per hectare;
- **Medium -** Residential led areas: in the region of 405 units per hectare; and
- **Lower -** Sensitive edges: in the region of 300 units per hectare.

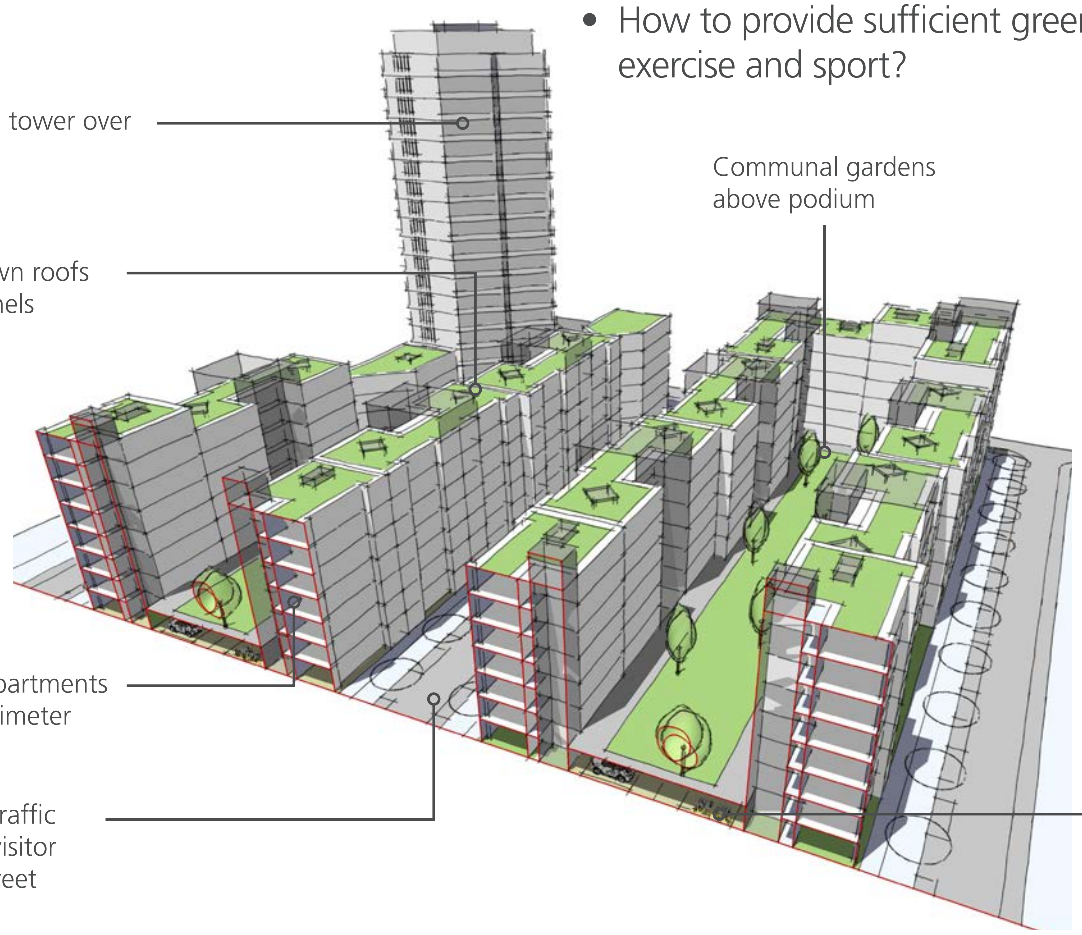
The density range proposed 300-600 dwellings per hectare (dph) will make the area one of the densest in London, other comparable areas are Greenwich Peninsula, Vauxhall / Nine Elms / Battersea and the future extension to Canary Wharf. These densities are referred to as Superdensity 250-350 dph and Hyperdensity 350-600 dph.

Chapter 7 provides case study examples of residential and mixed use developments in London that fall within the 300-600 dph density band proposed at Old Oak.

Providing high quality and sustainable housing at these very high densities presents a number of interrelated challenges, in particular, how to provide: homes for families, sufficient outdoor space, accommodate bikes and bins and effective management and maintenance.

Super Density Housing

The sketch below shows the typical architectural response evolved in London over the last decade for providing 'Super Density' housing at 250-350 dwellings per hectare. These typically take the form of 7-10 storey apartments enclosing a perimeter street block. The addition of a tall tower over 20 storeys will further increase the density.



Issues

- How to provide housing for families with children above ground level?
- How to provide sufficient private open space with adequate outlook, privacy and shelter?
- How to reconcile the competing demands (parking, servicing, delivery access and amenity) on the public realm around the base of buildings?
- How to create comfortable, safe and attractive communal spaces that have sufficient daylight and shelter?
- How to provide space for large canopy trees and urban greenery to reduce heat island effect?
- How to provide sufficient greenspace for exercise and sport?

Opportunities

- Use two storey duplexes and maisonettes at the base of flat blocks to provide family accommodation.
- Maximise available rooftops for private and semi-private open space. Provide winter gardens and atriums to create spaces that can be used throughout the year.
- Innovative design of the public realm around the base of buildings to achieve the optimum balance between the competing demands for space.
- Communal amenity spaces to be located in areas with best daylight and sunlight. Other uses (cycle storage, bins etc) in poor performing areas.
- Careful arrangement and orientation of residential accommodation to prevent overlooking. Ensuring adequate noise insulation and buffers between noise generating activities.

The publication **Super Density: The Sequel**[4] based on research by four architectural practices: (HTA, Pollard Thomas Edwards, Levitt Bernstein and PRP) who specialise in housing and neighbourhood planning provides a series of short essays and best practice case studies highlighting the issues around Super Density housing between 150 and 350 homes per hectare and the difficulties faced in achieving Hyper Density schemes over 350 homes per hectare.

4 http://www.pollardthomasedwards.co.uk/download/SUPERDENSITY_2015_download.pdf

Catering for families

Serious consideration needs to be given to housing families with children above ground level. Families should have their own access or front door, with door-step play space for children under five close to the home.

To work effectively in the long term, family dwellings above ground need to offer levels of amenity approaching those provided by single family houses at ground level. This requires private open space of sufficient size for the whole family and guests to gather, and with adequate outlook, privacy and shelter.

Appropriate levels of dedicated play space for younger children can be provided in shared courtyards together with a safe and child friendly street environment in traffic-calmed Home Zones.

Two and three-storey duplexes work well at the base of flat blocks with individual street entrances and small gardens, and function much as houses.

St Andrew's, Bromley-by-Bow

© Atkins

Outdoor space and the public realm

Design of the public realm requires an analysis of the servicing needs of the surrounding buildings. The success of the public realm can be undermined by failing to accommodate access for parking, refuse requirements or the need for adequate cycle storage. The base of high density buildings, if not carefully considered, can become cluttered with ventilators, planters, ramps and service access.

Where the ground space is in intense demand, for example around transport hubs, it is important to provide a sufficient allocation of comfortable sheltered space, safe from traffic and removed from noise and fumes.

The challenge is to create more high quality outdoor space to accommodate pedestrian movement and provide a suitable environment for people to sit and rest, free of noise and pollution. Courtyards, arcades, canopies and terraces are useful elements to achieve this.

East Village

© Mike O'Dwyer and VOGT

Management and maintenance

As density increases and becomes multi-tenure, there is a need to ensure there is more focus on the long term management and maintenance costs at the design stage of a development. Cost effective and efficient management arrangements in superdense development are essential to minimise services charges and aid affordability.

Very dense developments, with tall towers, create more intense pressure on shared space and infrastructure and have higher management and maintenance costs than other typologies. Service charges need to be projected in order to ensure that dense developments do not become unaffordable for future occupiers.

The opportunity exists to extend the role of estates management beyond buildings maintenance, grounds maintenance and waste collection to embrace a host of lifestyle services including:

Regent's Place, Euston

© Atkins

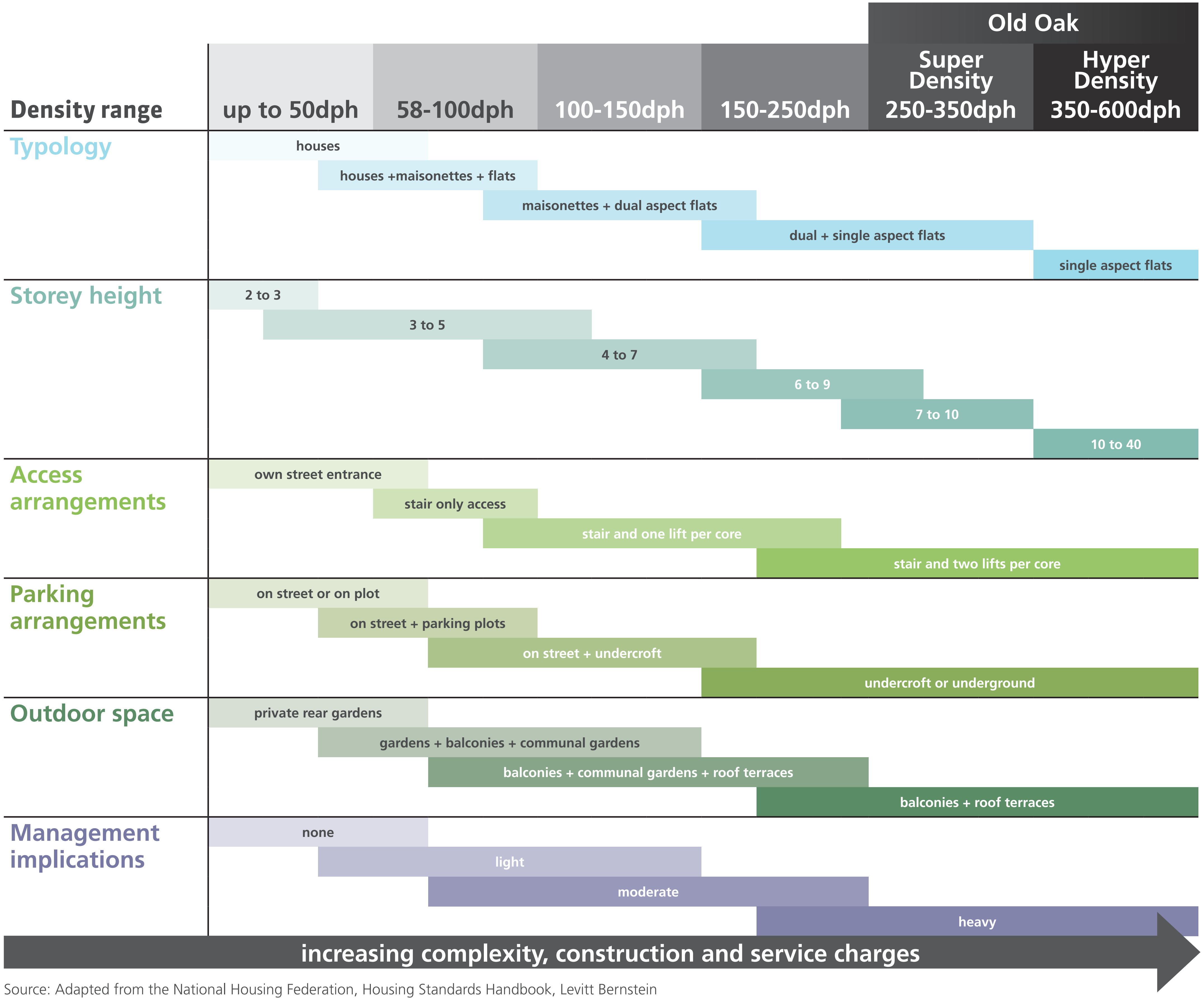
- Providing transport services such as car clubs, cycle clubs and travel information;
- Promoting local food links and receiving deliveries of local food;
- Supplying renewable energy;
- Advising residents on energy saving and green choices;
- Promoting community spirit and community events;
- Providing on site composting and food growing facilities;
- Managing leisure facilities such as gyms and office space; and
- Managing a community centre

For successful long-term management, the interface between residents and the community management service becomes critically important. British Land's mixed use campus at Regent's Place provides a good example of an intensively used and well managed space.

Regent's Place, Euston

© Atkins

Diagram illustrating typical characteristics at a range of densities



Source: Adapted from the National Housing Federation, Housing Standards Handbook, Levitt Bernstein

ATKINS

© Jimmy Wu Photography

East Village (Former London 2012 Athletes Village) is an example of the form of the lower to medium density residential development expected within Old Oak.

© Shutterstock

Canary Wharf is an example of the form and density of commercial development expected close to the main transport interchange.

Competing Demands for Space

A key issue with Super Density residential schemes is how to reconcile the competing demands for space, particularly at podium and rooftop level.

Sustainability objectives to encourage both cycling and recycling requires the provision of significant storage space at ground floor level for bikes and bins. Cycle storage areas need to be covered, secure, integrated and accessible.

Small, secure cycle stores (ideally serving 10-15 flats) are best provided either close to cores, within secure courtyards or within undercroft parking areas. Where feasible, cycle storage should be provided in a form that is suitable for storing other 'outdoor' items including prams/buggies, sports/camping equipment etc.

Refuse storage, including green waste, needs to be accessible to residents, sufficiently ventilated and located within reasonable distance from vehicle access points for collection by refuse trucks. In high density apartments these facilities are space hungry at podium level and are challenging to integrate in ways that ensure the creation of attractive and safe entrance areas.

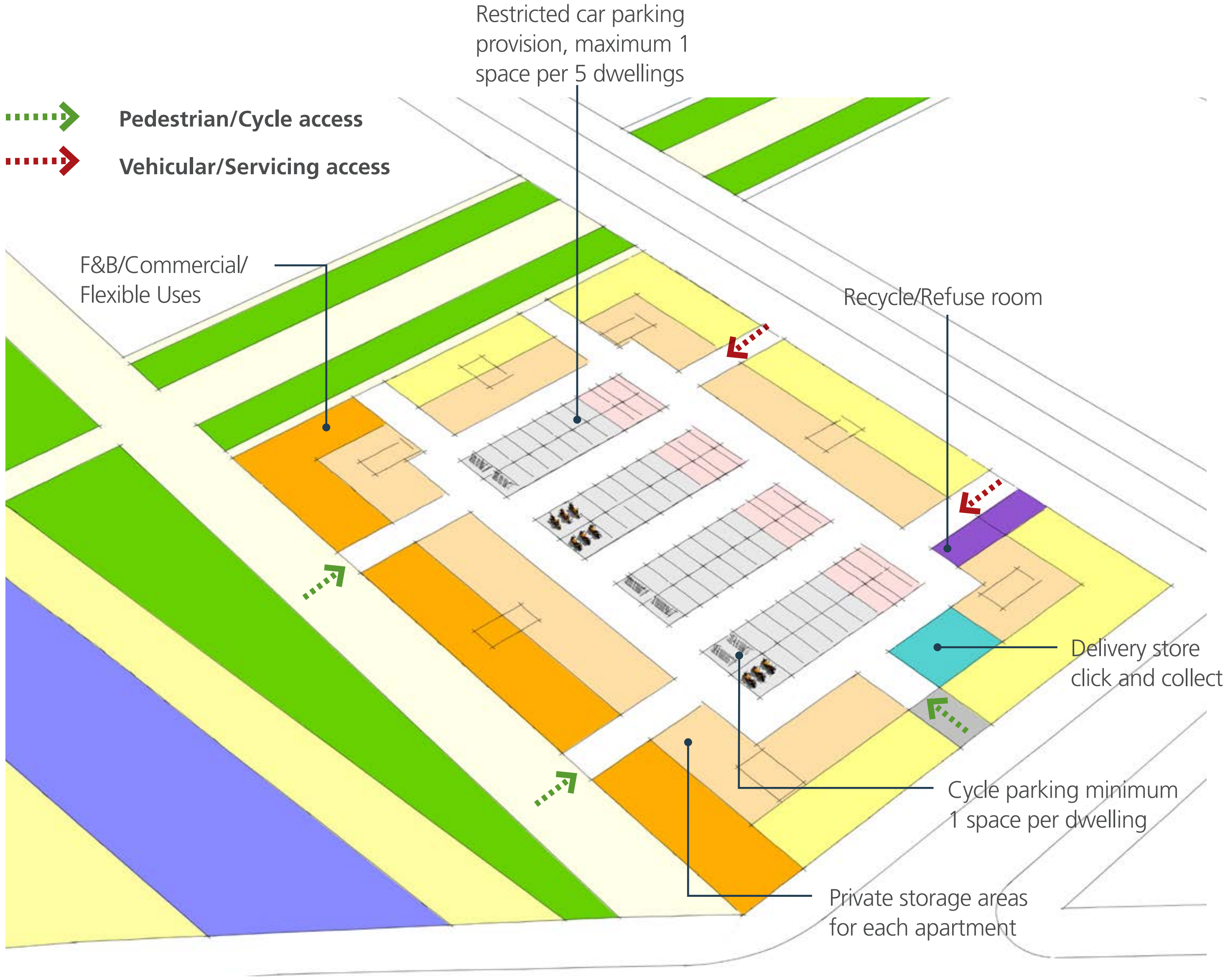
An important management consideration relates to refuse storage and recycling facilities. The frequency of collection and the form of storage can have a significant impact at ground and below ground levels.

Changes to on-line purchasing and deliveries have significant implications for ground level delivery, storage and servicing arrangements.

Podium Level

At podium level there is a need to balance the demands for:

- Car parking, this is typically restricted to 1 space per 5 dwellings with priority given to, electric vehicles, blue badge holder and car clubs with electric vehicle charging points.
- Secure cycle parking, typically at least 1 space per dwelling.
- Private storage for outdoor items such as prams and sports equipment.
- Delivery vehicles, this is rapidly increasing due to internet shopping.
- Refuse collection vehicles, waste storage and recycling.
- District energy facilities and plant rooms.
- Provide for small scale retail, cafés and restaurants together with employment to provide an active frontage to the street.



ATKINS

Roof Spaces

At rooftop level there are competing demands, particularly if rooftops experience high levels of daylight. There is a need to balance the demands for:

- Private open space in the form of terraces and roof gardens. These are best located to enjoy views and daylight without overlooking.
- The roof gardens are integral to the rain surface water drainage strategy by absorbing peak rainfall, providing habitat for wildlife and allow for increased bio-diversity.
- Rooftop mini-allotments and local food production, including bee hives.
- Semi-private communal roof gardens with 'intensive' planting.
- 'Green' roofs with restricted access and 'extensive' planting of low maintenance vegetation such as sedums blankets providing habitat for birds, butterflies and invertebrates.
- 'Brown' roofs, with low maintenance gravels and aggregates used to recreate brownfield habitats, which attract Black Redstarts.
- 'Blue' roofs which can store rainwater and form part of a rainwater harvesting system with greywater used for toilet flushing and irrigation.
- 'White' (or cool) roofs which reflect solar radiation due to the albedo effect without raising the urban air temperature.
- Solar thermal collectors used to generate hot water. These can be combined with 'brown' roofs.
- Electricity generating photovoltaic (PV) panels, these are best sited to maximise solar radiation.
- Plant rooms, lift shafts and building maintenance facilities.

Regent's Place, British Land

© Farrells

© BSG Ecology

© Scott Shigley

© greenroofers.co.uk

Tall Buildings

Tall Buildings

Old Oak Common is set to become one of London's new clusters of tall buildings largely based on Transit Orientated Development models (TOD), where tall building clusters are located on, or in the vicinity of public transport nodes. Other such clusters are emerging at Vauxhall/Nine Elms/Battersea (VNEB), Elephant and Castle, Paddington Basin, Greenwich Peninsula and Bankside/ Waterloo.

These clusters of tall buildings are a relatively new addition to London's skyline which has traditionally been a low-rise city. The hyper densities proposed in these height clusters ranges between 350-600 dwellings per hectare. Building heights typically vary between 20-60 storeys. This unprecedented form of urban development in London brings with it a number of environmental issues and opportunities.

SketchUp Model of tall building cluster around HS2 in Old Oak South showing the number of building storeys

Issues

Some of the environmental issues associated with taller buildings are:

- Tall buildings can overshadow smaller adjacent development and inhibit the process of solar energy gathering on surrounding buildings.
- Tall buildings can generate accelerated wind speeds at their bases, wind can be funnelled from high up down to the street level.
- Opening or using balconies at higher levels is prohibitively dangerous.
- The public spaces adjacent to tall buildings require more careful consideration to ensure that they are comfortable and safe.
- Traditionally materials used in the construction of tall buildings result in high levels of embodied energy.
- Tall buildings have a high surface area to volume ratio, which can mean they generally require more energy to control the internal climate.
- High glazing ratios particularly in tall office buildings combined with the large number of occupants can result in high heating loads in summer which require significant amounts of cooling.
- Clusters of tall buildings can result in highly pollutant concentrations and stagnant air at street level.
- As height increases, the ratio of roof-mounted energy generation to building demand reduces.

Opportunities

Tall buildings provide the following advantages and opportunities:

- A step change in relative density provides the catalyst for increased public transport efficiency.
- Tall buildings can occupy a smaller footprint than other forms of development providing the potential for larger areas of public space.
- Tall slender buildings, because of the relationship of total floor area to building depth, provide better daylight penetration and thermal mass.
- Opportunities to provide a vertical mix of uses can extend the use and enjoyment of streets and squares.
- Tall buildings provide opportunities for efficient access through centralised cores.
- Savings can be made in the provision of buildings services when focused on a single larger building.
- Tall buildings offer larger economies of scale and can therefore potentially represent better value in terms of construction.

ATKINS

Emerging Trends

The conventional view of tall buildings as large scale energy consumers with little regard for sustainable architecture is now changing. The new generation of buildings are being designed with energy conservation and sustainability as their principal criteria. Increased emphasis on the use of green and sustainable building materials and technologies is creating a paradigm shift in the way the new generation of tall buildings are being designed. Energy efficiency has become the core issue for the acceptance of any design solution that advocates long-term economy.

The design and construction of tall buildings should make a positive contribution to their urban context, raise the profile of sustainable technology, and improve existing benchmarks for energy efficiency and resource management. Emerging trends over the last decade relate to:

- Innovative structural systems.
- Unusual configurations.
- High performance materials.
- Provision of high level green space.
- Energy efficiency and dematerialization.
- Smart, Nano and Green Technologies.
- Reduction in embodied energy of materials.
- Disaster mitigation measures.
- Building management systems.
- Greater durability
- Design for deconstruction

New Technologies and Construction Practices

Smart technology already has a major role to play in the sustainability of buildings. Such systems aim to integrate all of the electronic and information systems of the building with the ultimate goal of improving work practice and energy efficiency. Tall buildings represent significant opportunities for exploring, developing and utilising sustainable design and construction practices.

Recently emerging technologies and design approaches that have been incorporated into the latest generation of tall buildings have significantly increased the sustainability of tall buildings:

- Improving day lighting / internal air quality.
- Alternative energy generation such as solar and wind.
- Energy efficiency.
- Provision of high level open space in the form of sky gardens.
- Waste reduction and recycling.
- Improved efficiency of lifts.

International Best Practice

A number of international cities have successfully managed the introduction of tall buildings. New York and Chicago were the first cities to develop the skyscraper with clusters of tall buildings forming the skyline of their central business districts. New York developed sophisticated urban design codes to allow daylight to reach lower storeys. More recently Vancouver and Frankfurt have developed three-dimensional height frameworks to locate clusters of tall buildings at transport nodes.

The relationship of tall buildings to each other and their environmental impact requires climate responsive urban design to ensure the optimum balance is achieved between creating high quality, liveable built environments and an architecturally stunning skyline.

Frankfurt central business district skyline

Singapore 'Biophilic City'

Globally one of the most developed models of the high-rise city is the island state of Singapore. The island has limited room for expansion, land is at a premium and space standards are low in terms of the size of dwellings. Minimum standards are maintained by the intervention of the state in providing a significant proportion of social housing.

Highly efficient public transport is needed to make such high density cities work. These networks are based on multi-modal systems providing frequent and rapid transit for both short and long distances. In compensation for the limitations of living space, public intervention ensures a high level of communal open space both in terms of the urban realm and green parkland.

Singapore is the best example of a vertical green city. More than 47% of the city - state's land area is dedicated to public green space and nature plays an integral role in urban life.

Connections and Open Spaces

Open Space Deficiency

The majority of the Old Oak site and all of Wormwood Scrubs falls within the London Borough of Hammersmith and Fulham. Wormwood Scrubs is the largest publicly accessible space in the borough and acts as a Metropolitan Park as defined in the Mayor's Public Open Space Hierarchy, with a catchment of 3.2km.

The Borough's Parks and Open Spaces Strategy 2008 – 2018[5] predicts that the demand for open space will rise as the borough's population increase. This would reduce the ratio of public open space from an already low 1.35ha per 1000 people to 1.22ha per 1000. With the exception of a few small pockets most areas of the borough have access to less than 1ha per 1000 people. Across the borough, there is approximately 0.3ha of outdoor sports space per 1000 people.

The Borough's figure of 1.22ha per 1000 population is just half of the minimum provision recommended by Fields in Trust (formerly the National Playing Fields Association) in their Six Acre Standard which recommends 2.4ha of outdoor sport and play per 1000 population.

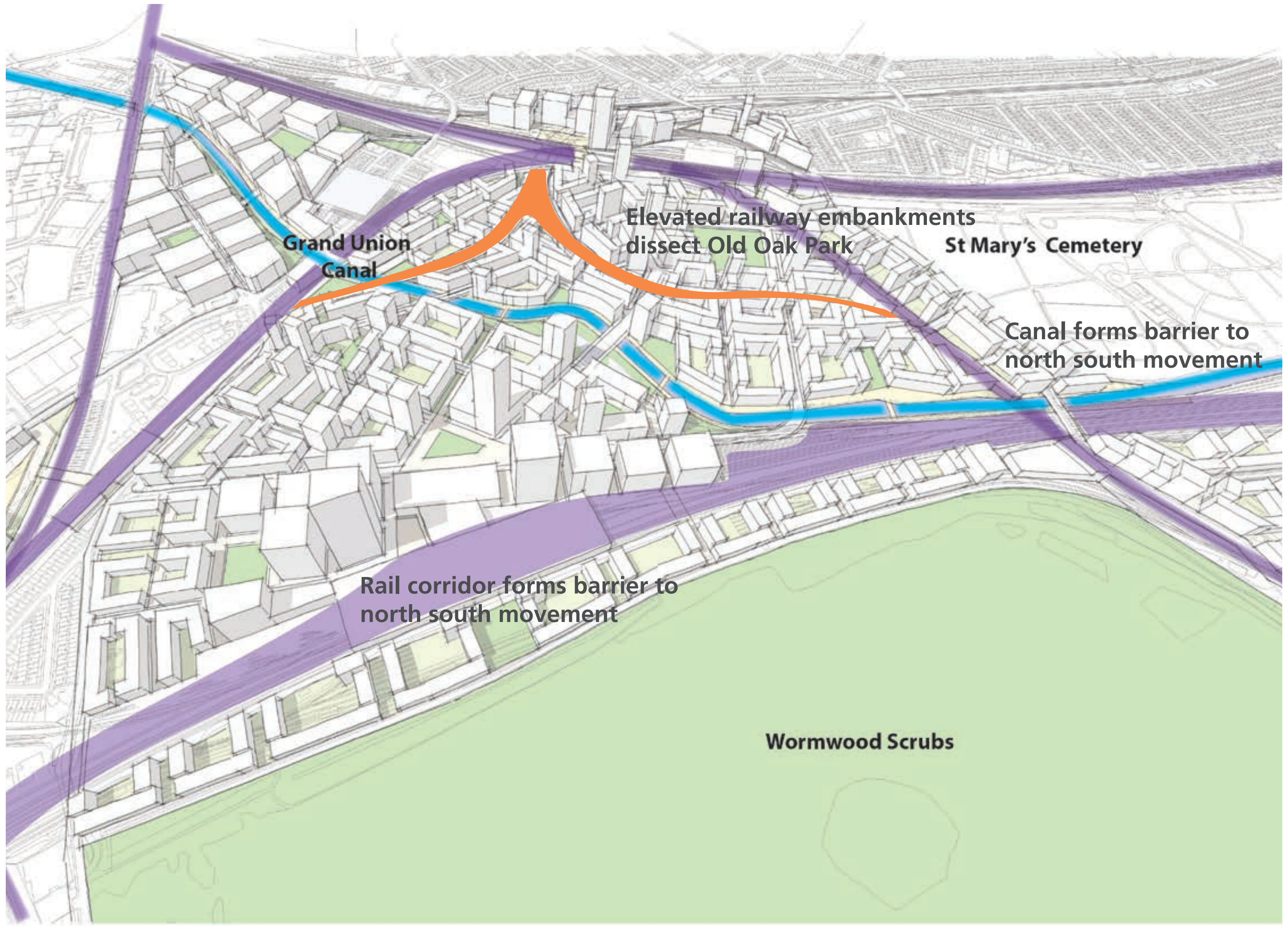
The current indicative masterplan that accompanies the draft local plan does not provide for any local parks and open spaces over 2ha and provides only 2.6ha of open space within the categories of Small Open Spaces and Pocket Parks. A further 4.1ha of open space falls within the category of Linear Open Spaces, mainly along the Grand Union Canal. There are seven squares proposed next to stations in the masterplan, if these are included a further 2.3ha is provided. This gives a total of 9ha. This figure excludes approximately 10ha of semi-public open spaces within the courtyards of residential street blocks.

The lack of publicly accessible open space within Old Oak is a key issue not just in terms of children play, active and passive recreation but the permeable natural surfaces will be required for SuDS and the urban greening for the biodiversity and mitigation of the urban heat island effect. These issues are addressed in more detail under Green Infrastructure in Chapter 5.

Wormwood Scrubs will be needed to fulfil the role of a Metropolitan and District Park for Old Oak with a large area of open space that provides a natural landscape setting for a wide range of activities, including outdoor sports facilities and playing fields, children's play for different age groups and informal recreation pursuits.

The corridor of open space along the Grand Union Canal will also act as a Linear Open Space as defined in the London Plan categorisation.

Barriers to movement and connectivity



Grand Union Canal

© OPDC

5 https://www.lbhf.gov.uk/sites/default/files/section_attachments/hf_parks_and_open_spaces_strategy_2008-2018.pdf

ATKINS

Wormwood Scrubs: Biodiversity and Greenspace

Wormwood Scrubs covers almost 70 hectares and is the largest open space in the London Borough of Hammersmith & Fulham. It acts as an important green lung that provides people and wildlife with the opportunity to enjoy green open space. It is managed by the Wormwood Scrubs Charitable Trust and protected by the Wormwood Scrubs Act 1879, the Commons Act 2006 and as Metropolitan Open Land in the London Plan. This protection will continue.

Portions of Wormwood Scrubs are designated as Local Nature Reserves and Sites of Borough Importance. Over half of the Scrubs comprises a mix of young and established woodland, scrub, grassland and tall herbaceous vegetation, which gives the Scrubs a sense of wildness that is particular valuable given it's proximity to central London.

The mosaic of habitats support a diverse range of native plants, breeding birds and insects, including species not usually found in more formal parks and open spaces. There are a number of legally protected animals, plants and fungi resident on the Scrubs.

Vision (as set out in Draft Local Plan)

Wormwood Scrubs will continue to be a cherished public open space and important ecological asset. New sensitive connections to the north and carefully considered improvements will bring Old Oak and White City together and make the Scrubs more accessible to all Londoners. These would be carried out in agreement with the Wormwood Scrubs Charitable Trust, the London Borough of Hammersmith and Fulham and in discussion with the local community.

Issues

- How to accommodate the significant number of residents and workers in Old Oak wanting to access the natural greenspace in Wormwood Scrubs without any net loss in biodiversity?
- How to balance the competing demands for active recreation and sport from new residents and workers with the requirements of existing communities surrounding Wormwood Scrubs?
- How to provide safe and convenient access for the new residents and workers in Old Oak across the major railway corridors?
- How to secure sufficient financial resources for the conservation, restoration and enhancement of Wormwood Scrubs and its long-term management and maintenance?

Opportunities

- The need to prepare a long term management plan that ensures the conservation and protection of natural habitats and legally protected wildlife.
- The enhancement of existing sports and play facilities to accommodate the increase in number of users, together with new green infrastructure that facilities healthy lives.
- Establish new crossings over the railway corridors for pedestrians and cyclists to provide a seamless connection between Old Oak and Wormwood Scrubs.
- Ensure the capital and maintenance costs required for the enhancement of Wormwood Scrubs are properly calculated and projected into the long term. The responsibility between the public and private sectors for meeting these costs to be agreed at the outset.
- Improving access to and from Old Oak, Little Wormwood Scrubs, North Kensington, Old Oak Common estate and other areas to the south.
- Addressing current surface water flooding issues experienced along its edge and in locations in the eastern and western areas.
- Carrying out sensitive enhancements.

Wormwood Scrubs

Park Royal: Sustainable Retrofit

Existing Situation

Park Royal is one of Europe's largest and most thriving industrial estates. Since the 1903 Royal Agriculture Show – which gave the area its name – Park Royal has supported a range of world renowned businesses such as Guinness, Heinz and McVities who continue their world leading operation from the site today.

The ***Park Royal Atlas***[6], commissioned by the Mayor of London, reveals the continued importance of Park Royal as a motor for our economy. With over 2000 workplaces mapped and analysed, it helps make the case for attracting investment to stimulate growth and improve the working environment for the 30,000 plus people based here. The Atlas estimates that 75% of all the known workplaces in Park Royal are micro businesses. These are businesses with less than ten employees, although many have no more than one or two. The vehicle sale and repair category alone constitutes 15% of all micro businesses. Small businesses make up 20% of all workplaces, while only 4% of workplaces are medium-sized businesses. The 1% of workplaces that are large businesses is made up only 19 businesses. These include a number of large food manufacturers like Bakkavor, a ready meal manufacturer, and several industrial bakeries like McVitie's, perhaps the largest household name to be based in Park Royal. Other noteworthy employers are Royal Mail distribution centre, and the UK headquarters of Carphone Warehouse, currently Park Royal's largest employer (1200 employees).

Vision (as set out in Draft Local Plan)

Park Royal will continue to grow, evolve and intensify to accommodate 10,000 additional jobs and to strengthen its position as a global leading location for industrial and economic innovation that actively supports London's economy.

Supported by resilient and innovative physical and green infrastructure, the area will continue to be home to an array of diverse industries and a strong business community, where innovation and start-up businesses can develop and thrive.

Transport improvements and the use of emerging transport modes, will support businesses in efficiently delivering services and goods while new and improved business services will support the functioning of the area.

The design of industrial buildings will likely have changed, responding to the need for making optimum use of existing land, as values rise and new technologies support structural change.

The residential pockets and open spaces will be better connected by safe and inviting routes to allow existing and future residents in these areas to access the range of new services available in Old Oak.

Issues

- How to create a high value, low carbon diversified industrial cluster?
- How to reduce dependency on the private car?
- How to move towards a circular economy and low waste in the long term?
- How to reduce building energy consumption?
- How to achieve water neutrality?
- How to provide improved green infrastructure and a more attractive public realm?

Opportunities

- Provide flexible and affordable business spaces, rapidly adaptable to the future economy and environment.
- Priority access given to non-car modes, and parking limited to essential uses. Incentives provided to employers and employees to travel by sustainable modes. Car sharing incentivised and co-ordinated between businesses. Deliveries and company logistics co-ordinated.
- Measures to reduce building energy consumption to operationally low carbon in the medium / long term. Some onsite generation in Park Royal will offset consumption in Old Oak.
- Achieve low waste in the long term, with virtually all construction / retrofit and a substantial proportion of operational waste being processed to create valuable resources. New buildings and structures will be designed for reuse or dismantling.

© OPDC

© OPDC

6 https://www.london.gov.uk/sites/default/files/Park%20Royal%20Atlas%20Screen%20Version%201.1_0.pdf

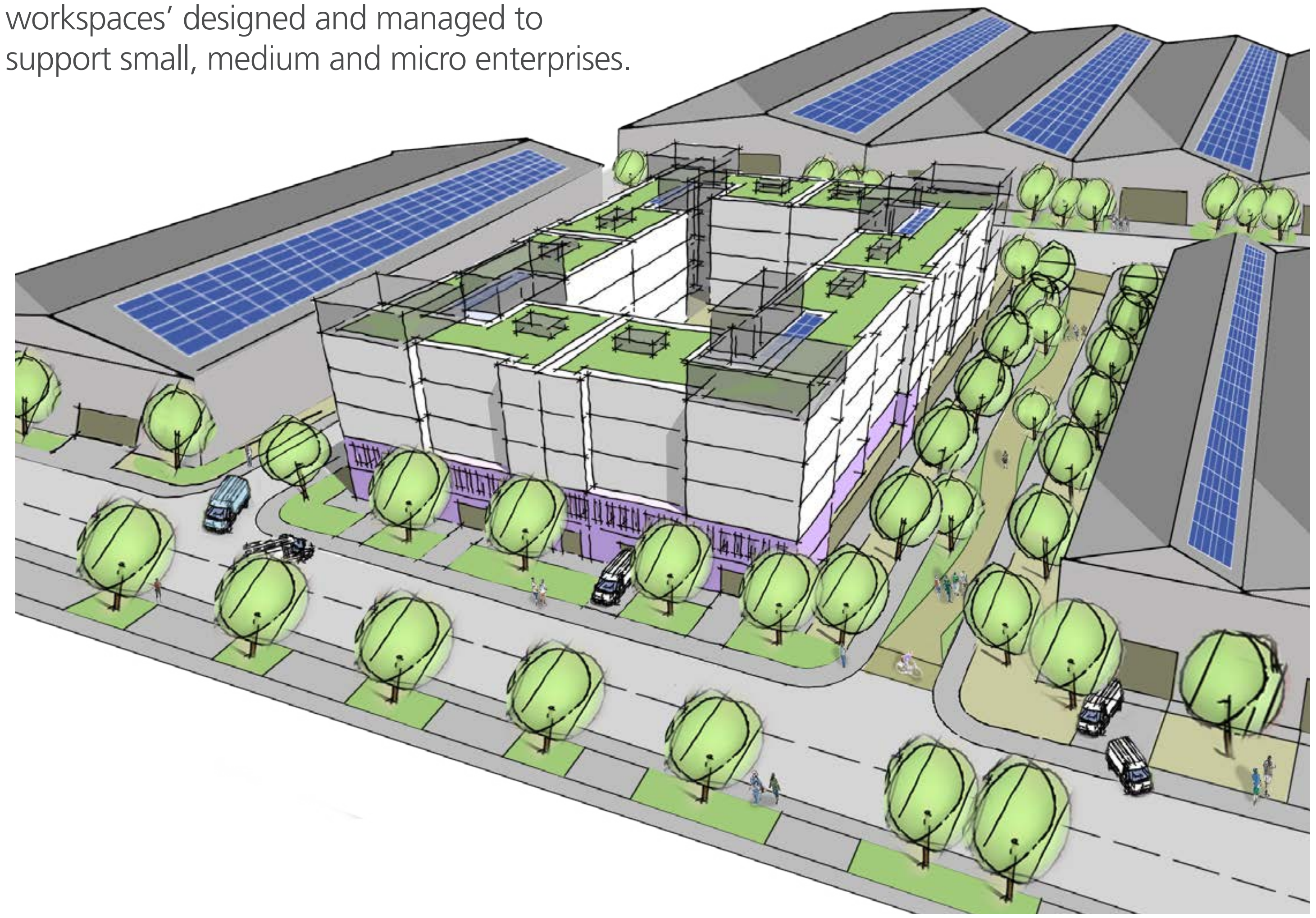
New Workspace Typologies

It is important that Park Royal functions efficiently as a reservoir of industrial land. The OPDC seeks to ensure that the remaining stock of land is utilised as efficiently as possible through intensification, including modernisation and improvements to existing stock and sites.

The opportunity exists to introduce new workspace typologies that create more intensive forms of development with higher plot ratios. This may include multi-storey warehousing, and the provision of 'open workspaces' designed and managed to support small, medium and micro enterprises.

These typologies should provide flexible access to affordable co-working spaces with shared facilities, and flexible rental terms.

The illustration below shows the intensification of sites by the provision of multi storey open workspaces above traditional light industrial uses, together with the greening of the industrial area and the retrofit of solar panels onto the large expanses of roofspaces. A street has also been transformed into a pedestrian priority 'green street'.



Food Innovation District

Innovation Districts bring together leading research institutions such as universities and R&D companies with large firms and small start-ups in well connected, mixed-use, urban locations that are attractive places to live, work and play. In many countries, including the UK, this marks a shift away from the past few decades where companies chose to, or were encouraged to, locate in out-of-town business parks. Barcelona, Spain is credited with creating the first innovation district with its 22@Barcelona Project that began in 2000. (See adjacent panel)

The innovation district model could be introduced into Park Royal as part of a wider programme of environmental renewal and sustainability retrofit. The aim would be to create a working area that is also liveable, walkable, bikeable and has good transport links. The dominance of food and beverage industries on Park Royal could provide the catalyst. The Park Royal Partnership (PRP) opened its food innovation centre in 2009 to provide support to small and medium enterprises (SMEs).

22@ Barcelona

The regeneration project involved the redevelopment of 200 hectares of abandoned industrial land into an innovation district, with the goal of concentrating and building knowledge-intensive activities and companies.

22@ is perceived as a success and has become the pioneering model for other innovation districts, 70% of the industrial land in El Poblenou has been refurbished. The private sector, has built 700,000 square metres of renewed facilities and close to 2,000 new housing units in the area.

Since 2000, 4,500 companies employing 56,000 workers have started in or relocated to 22@. Approximately 72% of the total employees in 22@ are university-educated.

Many universities have also established a presence in 22@ such as Pompeu Fabra University. Several incubators and accelerators have been created such as Biomedical Park, the MediaTic building and Barcelona Activa.

Resilience

Climate Change

The same trend can be seen in heavy rainfall events, where the frequency of heavy rainfall days (defined as more than 45mm of rainfall in a day) occurred, on average, once every 30 years before 1960 and once every six years after 1960. Temperatures are projected to rise all over the UK, but most of all in the south and more so in summer than in winter. UK climate projections for London[7] up to the middle of this century indicate summers are expected to be progressively hotter and drier, winters warmer and wetter.

The Mayor's Climate Change Adaptation Strategy[8] identifies three key risks for London from the effects of predicted climate change: flooding, drought and overheating. The sections below look at the implications of each of these risks, together with wider future proofing issues, for Old Oak and Park Royal.

Flood Risk

Climate change is expected to increase flood risk through greater runoff to surface watercourses arising from wetter winters, causing river levels to rise more quickly and higher river flows. More frequent and intense extreme rainfall events are expected to give rise to greater fluctuations in soil moisture content, leading to greater amounts of soil movement, placing greater stresses on flood defences, the mains water network and the drainage network.

Current fluvial flood risk in Old Oak and Park Royal is assessed by the Environment Agency as low (Flood Zone 1) over most of the site. There are small areas categorised as Flood Zone 2 and 3 in the north-western corner of the area associated with proximity to the River Brent. The site lies almost solely on a bedrock of London Clay, with limited superficial deposits of Alluvium and Gravel in the north-west corner of the development area boundary associated with the River Brent. London Clay is a low permeability geological stratum.

The area's sewer network is old and has insufficient capacity in places to serve the planned growth and regeneration for the purposes of foul-water and surface water drainage.

The low natural drainage capacity and the constrained sewer network present a particular risk of surface water flooding on the site. The current Mayoral target to maximise opportunities to achieve 'greenfield' runoff rates in developments is echoed in the OPDC Draft Plan, which also places strong emphasis on achieving water neutrality, i.e. no net increase in mains demand or discharge to the sewer network. The water management strategy proposed in the OPDC Draft Plan includes an emphasis on capturing rainwater, recycling greywater and deploying sustainable drainage systems (SuDS), which together are expected to greatly reduce both surface water and discharge to the sewer system, thus reducing the risk of surface water flooding. SuDS should also help alleviate fluvial flood risk.

The density of the proposed development at Old Oak leaves little room for the green spaces required to implement SuDS, which represents a key challenge for managing climate change resilience.

Drought

Drought means a lack of water available to meet current demands from people and the environment, a summer phenomenon in the UK caused by lack of rainfall. Climate change is expected to affect water availability by reducing river flows and groundwater replenishment, increasing evapotranspiration and increasing demand for water from people and wildlife.

A key means to reduce drought risk is reducing overall water demand. Per capita water use in London in 2009/10 was 167 litres per day, an increase of around 50 litres per person per day since the 1970s, and significantly higher than the national average of less than 150 litres per person per day. Increasing demand in London has largely been driven by affluence and lower occupancy rates (smaller household units, such as flats, each with water consuming devices). Analysis suggests that the peak demand in London in 2006 (a drought year) was nearly double that in 2007 (a comparatively cool and wet summer).

The current London Plan requires that all new homes should be built to enable the inhabitants to use, on average, 105 litres of water per person per day. The substantial reduction from the current average this represents would provide an important contribution to reducing drought risk. This is especially significant for Old Oak and Park Royal, given the proposed development will contain a large proportion of smaller household units. A per capita water consumption target of 105 litres per day or less would also help to achieve overall water neutrality.

Overheating

As summers become hotter, the overheating of buildings and the outdoor environment, i.e. to point where temperature rises affect human health and wellbeing, is expected to become an increasingly serious problem. The risk of overheating has only recently been recognised and is therefore relatively poorly understood and managed. The August 2003 heatwave provided a dramatic example of how vulnerable London is to heat. It is estimated that at least 600 people died in London because of the heatwave. The impact of the 2003 heatwave on Londoners appears to have been greater than anywhere else in the UK.

7 UK Climate Projections 2009 (UKCP09). http://ukclimateprojections-ui.defra.gov.uk.
8 Information in this section is from Managing Risks and Increasing Resilience: The Mayor's Climate Change Adaptation Strategy, October 2011.

Future Proofing

In addition to the predicted effects highlighted in the sections above, planning and designing for resilience to climate change encompasses a number of other broader issues. The implications of these for Old Oak and Park Royal are briefly outlined in this section.

Climate change is anticipated to have variable effects on air quality. In winter increased precipitation and greater air movement is likely to result in faster dispersion of air pollutants. In summer, however, higher temperatures, less rainfall and less cloud cover are projected to increase the formation of ground level ozone. Additionally, periods of little or no wind usually associated with heatwaves may mean that pollution in the city - including particulate matter which is particularly harmful to health - will be less easily dispersed. The high density, high-rise development proposed for Old Oak is likely to exacerbate both these trends.

Transport infrastructure, in particular public transit systems, is expected to be impacted in variety of ways by climate change, including passenger comfort, deterioration in plant and equipment from higher temperatures, as well as flood risk to both lines and stations. The expected high reliance on transit movement to/from and within the site make these particularly significant issues for Old Oak and Park Royal which will need careful consideration in planning and design.

Climate change effects are also expected to impact waste management, both in terms of changes in the volume and composition of waste streams, and impacts on waste collection, storage and treatment processes. The large proportion of organic waste arisings projected for Old Oak may present challenges in terms of impacts on collection, storage and treatment under higher average temperatures, drier summers and wetter winters.

Climate change will affect the amounts and types of energy used, and when it used, resulting in changing load balancing requirements for energy infrastructure. Increasing cooling and reducing heating requirements may make highly energy efficient Combined Cooling, Heating and Power (CCHP) plant more cost effective for district energy systems. Renewable energy systems are likely to become more cost effective as solar radiation and potentially windier weather increase. Greater decentralisation of energy generation, and a wider mix of generation types, represent a key opportunity from climate change adaptation, which can be expected to improve overall resilience and increase carbon efficiency. The high concentration of demand in high rise buildings presents particular challenges in realising this opportunity in Old Oak and Park Royal.

The high density, high rise development proposed for Old Oak, currently with relatively few areas of public green space, presents a particular challenge in terms of risks of overheating. There will be a need to find an optimal balance between measures designed to reduce building overheating and those aimed at reducing winter heating demand, as well overall low carbon and energy efficiency measures. With regard to outdoor overheating, the key factor identified in research and now incorporated in Mayoral policy is provision of green infrastructure. There is a strong relationship between the ratio of greenspace to buildings and the intensity of the UHI effect. Increasing and enhancing greenspace is thus an effective mechanism to manage both flood risk and overheating.

Future Proofing London

Atkins' Future Proofing London report was produced in partnership with Centre for London and Oxford Economics in 2015. It identified that London is significantly underestimating the level of development required to keep up with the city's growth over the coming decades. The report highlights key risks to London's competitive advantage and puts forward four integrated proposals for the city's planners and policy makers:

1. Prioritising infrastructure investment to be more inclusive - adapting how we choose to invest in infrastructure so that the social and environmental benefits are just as important as the economic benefits.
2. Revitalising outer London through a major strategic programme - to deliver much needed housing and a diverse range of jobs, improve on social equity and create a better quality of life.
3. Reimagining opportunity areas as 'curated clusters' – to nurture economic growth sectors and create diverse communities that last.
4. Developing a strategic approach to green infrastructure - to make the best use of the city's green infrastructure whilst creating opportunities for housing delivery and environmental improvements.

Elephant Park

£1.5 billion regeneration of Elephant and Castle by Lendlease. Formally recognised by C40 Cities as 1 of 18 globally recognised projects. Set to be Climate Positive by 2020.

4. Environmental Performance

Stockholm Royal Seaport

The development has set an objective to be fossil-free by 2030, ahead of the city wide goal of 2050. To achieve this, the urban district has integrated environmentally sustainable systems that aim to encourage responsible behaviour and lifestyle changes, by making sustainable choices ‘easy’. This target will also be achieved through the installation of an intelligent electricity grid, self-generated energy within buildings and a bio-fuel fired bus system. Resilience to future climate change issues, such as increased precipitation, has been built into the masterplan and design processes for example through use of the Green Space Index. The index allocates points for green infrastructure and environmental interventions including deep layers of soil, green roofing and tree planting.

4. Environmental Performance

Introduction

This chapter covers the first core study theme: environmental performance. The chapter is organised under six topics: energy, waste, materials, carbon emissions, water and air quality. Under each topic the overall approach, site and policy context are first described. Proposed objectives, policy recommendations, associated evidence and cost implications for proposed objectives and policy recommendations are then set out. Each topic section is completed with a set of proposed environmental performance indicators and targets under the proposed objectives, together with the rationale for these.

Details on the strategic site analyses underpinning the development of environmental performance policy recommendations and proposed objectives, indicators and targets are set out in relevant sub-sections of Appendix B.

Objectives

Energy
- Minimise energy demand
- Maximise onsite zero / low carbon energy generation

Waste
- Zero waste
- Resource and carbon efficient solid waste treatment / disposal

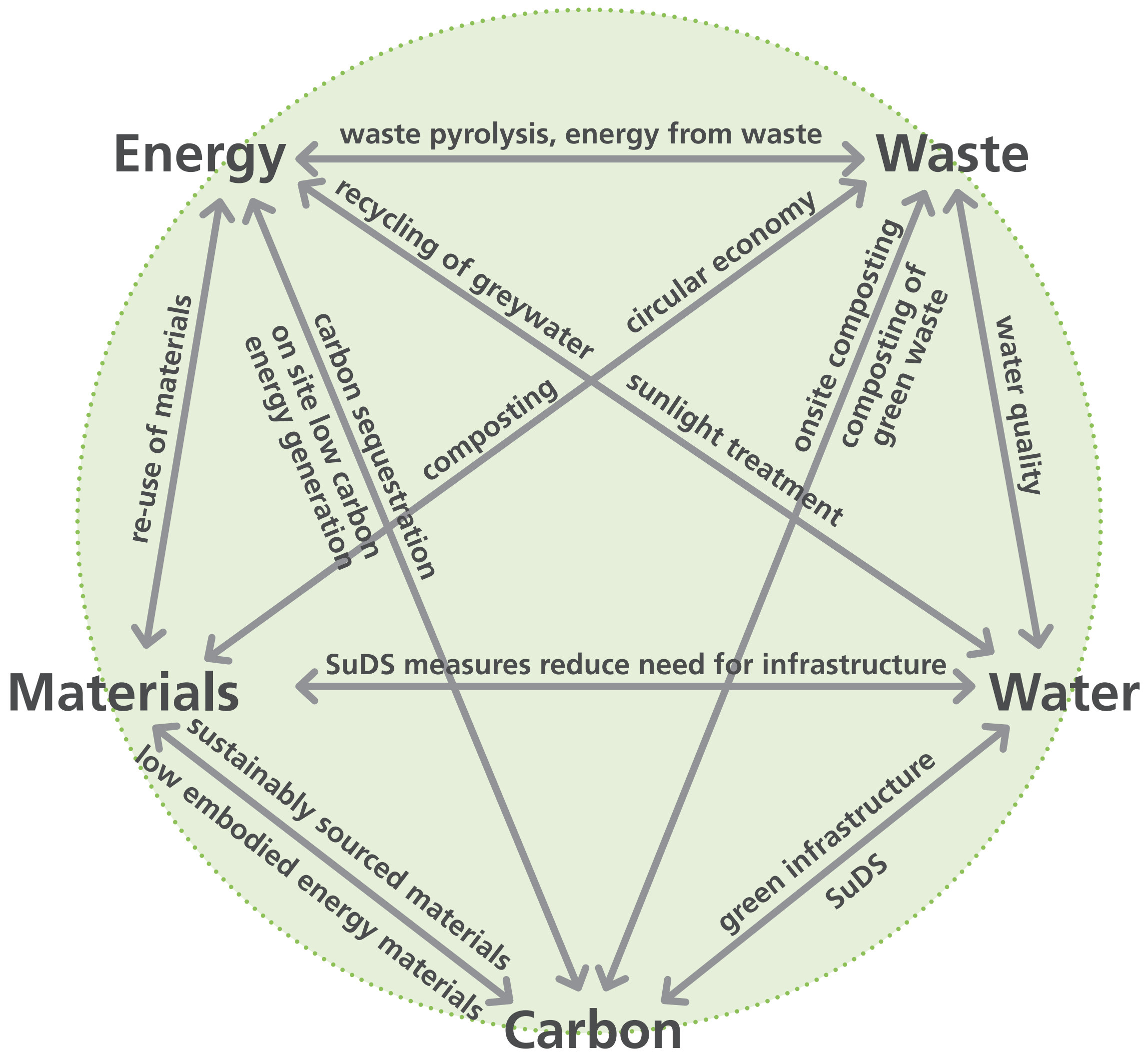
Materials
- Optimise use of low carbon, sustainably sourced, healthy materials

Carbon emissions
- Overall Carbon Positive

Water
- Maximise efficient use of water
- Maximise use of alternative sources for non-potable water
- Minimise surface water runoff and wastewater discharge

Air quality
- Enhance local ambient air quality
- New buildings and transport to be air quality positive
- Enhance indoor air quality

The web of resource management



Adapted from Shaping Neighbourhoods, Hugh Barton, Marcus Grant & Richard Guise

ENERGY

Energy demand, onsite generation, low carbon supply

Introduction

In his vision 'A City for All Londoners', the Mayor has set the ambitious goal for London to become a zero-carbon city by 2050. To achieve this goal the Mayor has indicated his intention for London to lead the shift to a more affordable, lower carbon system and more energy efficient buildings. The Mayor's strategy emphasises making better use of locally produced energy, with more coordination and integration of energy systems and infrastructure, and the use of smart technology.

New, innovative ways to deliver low carbon distributed energy, in terms of both power and heating / cooling, enabled by rapid advances in smart technology and substantial and continuing reductions in low carbon energy technology costs, are giving rise to the need for a major rethink in energy strategy. This is expected to drive fundamental shifts in the design, financing and management of energy supply infrastructure, buildings and building energy systems.

Site Context

Current energy demand in both Old Oak and Park Royal is dominated by industrial and other non-residential uses, with some areas of existing residential use. This will change significantly as the planned new homes, businesses and infrastructure transform the area

The majority of the Old Oak core area falls within UK Power Network's London Power Network (LPN), Willesden Regional Area. The LPN EHV networks supplied from Willesden 275/132kV and 275/66kV Grid Supply Points (GSPs) have an aggregated demand of approximately 390MW. Willesden 132kV additionally supplies the EPN Leicester Road Grid substation increasing the demand on the GSP by a further 60MW. There is a network of low pressure gas distribution mains crossing the Old Oak development area which are owned and operated by National Grid. These generally follow the route of the public highway network and provide supplies of gas to residential and commercial properties, particularly for domestic purposes and for heating[1].

In order to provide the planned new development major investment in new infrastructure will be needed. Whilst there is currently no district heating/cooling network within the OPDC area, there is an opportunity to generate and distribute low carbon energy through a local smart network.

Policy Context

The importance of energy production and consumption in achieving sustainability is acknowledged within the National Planning Policy Framework (NPPF), which has as one of its core planning principles support for the transition to a low carbon future in a changing climate and encourages the reuse of existing resources, including conversion of existing buildings, and the use of renewable resources. To support the move to a low carbon future, it encourages local planning authorities to:

- plan for new development in locations and ways which reduce greenhouse gas emissions;
- actively support energy efficiency improvements to existing buildings; and
- when setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards (para 95).

It also states that developments should be expected to comply with adopted Local Plan policies on local requirements for decentralised energy and take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption (para 96.) Local planning authorities should have a positive strategy and policies to maximise renewable and low carbon sources and consider suitable sites for these sources supporting community-led initiatives (para 97).

London Plan

Chapter 5 of the London Plan sets out extensive policies on energy, climate change and sustainability. The London Plan is supported by Building regulations and The Mayor's Sustainable Design and Construction SPG.

Policy 5.2 of the London Plan sets out an 'energy hierarchy' as follows:

1. Be lean: use less energy
2. Be clean: supply energy efficiently
3. Be green: use renewable energy

The overarching requirement of Policy 5.2 is that all new development will comprise zero carbon residential buildings from 2016 and zero carbon non-domestic buildings from 2019. Recently issued mayoral guidance on housing and energy planning has confirmed that, for all major new developments, the residential building requirement will apply from 1 October 2016 and all new commercial development will also be required to be 35% below Building Regulations Part L 2013. The Building Regulations Part L 2013 include an assessment of regulated energy loads only, ignoring, for example, kitchen appliances, computer use and other 'plug loads' which can amount to around 40% or more of a building's total energy load.

1 Source for information on electrical and gas infrastructure in this section: OPDC Development Infrastructure Funding Study, supporting study for the OPDC Draft Local Plan, February 2016.

Greater London Authority (GLA) guidance on preparing energy assessments sets out the demand reduction (Be Lean) requirements for development energy assessments. These include passive design measures, including optimising orientation and site layout, natural ventilation and lighting, thermal mass and solar shading; active design measures, including high efficiency lighting and efficient mechanical ventilation with heat recovery; and effective building automation. Building design should prioritise passive measures. Developers should aim to achieve Part L 2013 Building Regulations requirements through design and energy efficiency alone, as far as is practical.

Policy 5.5 of the London Plan requires 25% of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025. In order to achieve this target the Mayor prioritises the development of decentralised heating and cooling networks at the development and area wide levels, including larger scale heat transmission networks. The policy requires developers to prioritise connection to existing or planned decentralised energy networks where feasible. The policy anticipates that future district heating networks will evolve from natural gas CHP to low and zero carbon fuel sources such as energy from waste (EfW).

London Plan Policy 5.6 requires that development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also examine opportunities to extend the system beyond the site boundary to adjacent sites. CHP systems must be designed to run efficiently and be optimally sized to maximise carbon dioxide savings. Opportunities to incorporate energy from waste or, where technically feasible, renewable energy should be investigated.

Policy 5.7 of the London Plan expects projections for installed renewable energy capacity outlined in the Climate Change Mitigation and Energy Strategy and in supplementary planning guidance will be achieved in London. Boroughs are expected to identify broad areas where specific renewable energy technologies, including large scale systems and the large scale deployment of small scale systems, are appropriate. There is a presumption that all major development proposals will seek to reduce carbon dioxide emissions by at least 20% through the use of onsite renewable energy generation wherever feasible.

London Plan Policy 5.8 supports and encourages the more widespread use of innovative energy technologies, including electric and hydrogen fuel cell vehicles, hydrogen infrastructure, and advanced waste conversion technologies such as anaerobic digestion, gasification and pyrolysis.

In summary, current Mayoral policy and guidance indicates, as a minimum, the following requirements for all major new developments:

- From 1 October 2016, buildings of all types are expected to show substantial energy demand reductions, using a combination of both passive and active design measures, contributing to the overall target of zero carbon homes and 35% carbon reduction below Building Regulations Part L requirements for non-residential development. Specific unitised targets (e.g. kWh/m²/year) are not set, but there is a presumption that as much of the Part L reductions as possible should be achieved through energy efficient design (Be Lean), i.e. demand reduction.
- 25% of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025.
- Innovative new energy technologies are encouraged and supported. In particular, carbon efficient waste to energy technology offers an important means of transferring CHP systems away from gas.

OPDC Objectives and Policy Recommendations

Based on review of mayoral policies and guidance, review of best practice case studies and initial site energy analysis exploring onsite demand reduction and low carbon energy generation potential (see sections below), energy policy recommendations for Old Oak and Park Royal have been developed and are set in Table 4.1 below. Policy recommendations are grouped under the two core objectives developed for OPDC energy policy, which also form the basis of the recommended targets:

1. Minimise energy demand
2. Maximise onsite zero / low carbon energy generation

Table 4.1 – Old Oak and Park Royal Energy Objectives and Policy Recommendations

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Minimise energy demand			
Building energy demand - reducing demand	• All new development will be required, as a minimum, to be operationally zero carbon in respect of regulated energy loads. Zero carbon is defined as at least 35% reductions in carbon emissions beyond Building Regulations 2013 Part L requirements onsite, with remaining regulated emissions to be off-set by a cash in lieu payment to OPDC. Developers should aim to achieve zero carbon development by maximising design and energy efficiency measures as far as possible. Developers should aim to meet or exceed guideline performance targets for regulated energy demand for all land use types. • As part of planning applications, developers will be required to submit strategies to monitor, manage and reduce unregulated energy demand. These should set out how the developer will support occupiers to minimise their energy demand. • OPDC will work with developers, energy service providers, utility companies and regulators to support use of onsite low carbon energy infrastructure to achieve zero carbon development. As part of planning applications, developers will be required to include strategies for use of lower temperature building heating systems with high flow/return delta, to take advantage of lower temperature heat supply networks whose sources will operate more efficiently as a consequence of the lower heating water temperatures. Strategies for use of higher temperature building cooling systems will also be required as part of planning applications.	• In line with the first step in the Mayor's energy hierarchy, 'Be Lean', minimising energy demand in buildings of all types should be central design of new development. Recent Mayoral guidance requires all new large scale development in London to be zero carbon from 2019. Previously issued Mayoral guidance emphasises maximising design and energy efficiency measures as far as possible in meeting the zero carbon requirement. Based on analysis of current best practice design approaches, initial guideline energy performance targets have been provided. These will require review and updating as the OPDC Plan progresses. • As regulated loads are progressively reduced, the importance of reducing unregulated loads increases. Growing use of ICT and other 'small power' electronic equipment will exacerbate this. Clear strategies to monitor and manage unregulated loads will be key to reducing this element of demand. New technology that supports demand management and reduction in peak demands is expected to become increasingly cost effective to adopt. • The energy and carbon efficiency of building loads can be enhanced with buildings designed from the outset to accommodate more energy and carbon efficient site-wide infrastructure. The overall costs of energy supply, both within buildings and site-wide infrastructure, can also be reduced if these two elements are effectively coordinated[2]. • Lower temperature building heating systems coupled with more efficient thermal insulation have been shown to flatten heating profile curves, enabling more efficient base load supply and lower peak generation capacity	• Energy efficiency measures should be prioritised on achieving carbon levels 35% below Building Regulations 2013 Part L, using a range of carefully selected and tested measures appropriate for high density, high rise development. • Specification of energy efficient equipment used in buildings, such as IT and other office equipment, as well as equipment management and maintenance, is a key focus in reducing unregulated demand. Established standards, such as BREEAM[3], should be referenced. • All new development should be designed to ensure compatibility with new, innovative onsite low carbon energy infrastructure. In particular, effective deployment of lower temperature building heating systems as well as higher temperature cooling systems should form a strong design focus.
Building energy demand – monitoring performance and demand side response	• All development will require post-construction monitoring to demonstrate compliance with OPDC energy policies. • Developers will be required to incorporate smart metering equipment that would enable their schemes to participate in demand side response opportunities and facilitate real-time monitoring of energy performance.	• Studies[4] have shown there is often a significant gap between building energy performance predicted in design and actual energy performance. Post-construction monitoring, e.g. as set out in the BSRIA-led Soft Landings framework[5], will allow energy strategies to be adapted as development progresses, with experience on earlier development informing strategies for succeeding development. • Accurate, real-time information on energy demand is key to implementation of demand side response strategies, enabling demand and supply to be better managed, overall costs reduced and more effective energy investment planning.	• Post-construction monitoring of energy performance, incorporating extensive deployment and management of smart real-time systems which can analyse monitoring outputs and identify conservation interventions, will be fundamental to ensuring continued improvement of building designs as well as increasing flexibility in interaction between building and site infrastructure.

2 London's Zero Carbon Energy Resource: Secondary Heat, Report Phase 2, April 2013, GLA.
3 Building Research Establishment Environmental Assessment Method. See www.breeam.com.
4 Carbon Compliance for tomorrow's new homes. A review of the modelling tools and assumptions. Topic 4 – Closing the gap between designed and built performance. Zero carbon hub & NHBF. 2010 (http://www.zerocarbonhub. org/resourcefiles/topic4_pink_5august.pdf).
5 Soft Landings is the BSRIA-led process designed to assist the construction industry and its clients deliver better buildings. Soft Landings helps to solve the performance gap between design intentions and operational outcomes (https://www.bsria.co.uk/services/design/soft-landings/).

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 2: Maximise onsite zero / low carbon energy generation			
Site energy infrastructure - electrical	• OPDC will work with utility companies, energy service providers, regulators and developers to support development of an onsite 'virtual power plant' (VPP). The VPP will be developed using modern smart grid technology capable of integrating electrical supply from a range of local sources, including CHP plant, energy from waste plant, solar PV arrays and energy storage. The VPP will be connected to the national grid. Using advanced control systems the VPP will be developed to flexibly respond to and balance fluctuations in both generation and demand.	• As highlighted in the London Infrastructure 2050[6] reports and elsewhere, three key recent developments are driving a gradual move towards increasing integration of design approaches to district energy systems and renewable energy generation: i) the rapid proliferation and low cost of smart ICT technologies and systems; ii) rapidly falling costs and 'modularisation' of renewables technologies; iii) increasing electrification of energy supply, both for building heating/cooling and transport vehicle traction. In the UK these developments have been further strengthened by policy initiatives resulting in rapid decarbonisation of the national grid. Taken together, the traditional barriers to smaller scale, multi-source supply networks have greatly reduced, and their benefits of flexibility, scalability and resilience increasingly recognised. • Although current Mayoral policy on distributed energy (DE)(Step 2 of the Mayor's energy hierarchy) focuses more on thermal systems, there is strong opportunity to support development of electrical DE networks, using smart grid technology. Such networks also support current Mayoral policy (Step 3 of the Mayor's energy hierarchy) promoting deployment of onsite renewables, particularly solar PV. The costs and revenue streams associated with renewable energy generation can be more effectively managed when deployment forms part of a multi-source smart grid, or VPP.	• Site electrical infrastructure should be developed to be capable of integrating electrical supply from a range of local sources, including CHP plant, energy from waste plant, solar PV arrays and energy storage. Smart grid technology should be developed to flexibly respond to and balance fluctuations in both generation and demand.
Site energy infrastructure - thermal	• OPDC will work with utility companies, energy service providers, regulators and developers to support development of onsite multi-source, lower temperature heat (MSLTH) networks capable of integrating heat supply from CHP (fossil fuel, biofuel or solid waste incineration fired), conventional boilers, secondary sources such as industrial waste heat, rejected heat from buildings and infrastructure, solar thermal panels, as well as heat from lower grade 'natural' sources (water, ground and sewerage networks). MSLTH networks would also incorporate heat storage to help manage demand peaks. • OPDC will work with utility companies, energy service providers, regulators and developers to support development of onsite multi-source, higher temperature cooling (MSHTC) networks capable of integrating cooling supply from mechanical chillers (electric and absorption (direct gas or waste heat fired)), ground or water sources and thermal storage. Other options for producing cooling supply, such as free cooling and thermo-syphon cycles, should also be considered.	• The rationale for VPPs set out above can also be applied to thermal network systems, with similar benefits in terms of meeting or exceeding current Mayoral targets for onsite DE and renewables. Development of multi-source heating / cooling networks also helps reduce some of the key risks associated with traditional energy infrastructure, i.e. security of supply and commodity price volatility, as well as reducing overall costs. • The flexibility and scalability of multi-source heating / cooling networks provides additional advantages of more manageable funding and lower cash flow risks as deployment can be closely linked to build-out phasing and more easily able to respond to demand fluctuation. • Use of lower temperature heating networks and higher temperature cooling networks enables a better fit with low carbon building design than more traditional networks which impose constraints on building systems. • As with VPPs, multi-source heating / cooling networks can be developed for large single buildings, multiple buildings or covering larger areas with a variety of building types. The multiple sources can be of many different types. Sources can be heating only, cooling only or heating and cooling (e.g. water source heat pumps)	• Site heating and cooling infrastructure should be developed to be capable of integrating multiple sources of heating and cooling energy supply of varying scale and generation intermittency. Further work is required to analyse potential conventional and secondary heating / cooling sources, including both onsite and near offsite sources. It was not possible to cover water source and sewerage source heat pump technology in the energy analysis, both of which offer considerable potential for the OPDC site. Other heat sources include warm air from underground rail ventilation systems, power sub-stations, building exhaust air, industrial waste heat and waste heat from data centres. The energy generation potential from all feasible heat sources should be explored with further analysis. Land take and network integration issues associated with each source will be key in determining contribution to site infrastructure in terms of capacity and phasing. • Close collaboration between developers, utility companies, energy service providers and regulators will be required to ensure technical, financing and management mechanisms are developed to overcome short term barriers and take advantage of the substantial benefits of integrated multi-source power, heating and cooling site infrastructure. In addition to increased carbon and resource efficiency, these benefits include increased resilience, more manageable cash flows and greater flexibility of phasing.

6 Enabling Infrastructure: Green, Energy, Water & Waste Infrastructure to 2050, Mayor of London; The cost of London's long-term infrastructure, Final report, GLA, July 2014.

Evidence

This section sets out evidence supporting the policy and strategy recommendations listed in Table 4.1. Evidence comprises the following:

- Key observations from UK and international best practice case studies.
- Results of site energy analysis used to explore scenarios for achieving, and potentially exceeding, current Mayoral targets and guidance.

Best Practice Case Studies

The following case studies have been referenced as examples of current UK and international best practice in terms of energy performance:

From the UK case study examples it is clear that substantial reductions in building energy consumption over Building Regulations 2010 Part L requirements have been targeted, representing 40% or more in terms of carbon emissions, comparable to the Best Practice scenario developed for the present study (see section immediately below).

The examples indicate that substantial levels of low carbon onsite energy generation, as a proportion of onsite demand, comparable to those explored in the present study, have been targeted in mixed use developments, albeit with lower densities and heights compared to those of Old Oak.

King's Cross Central, London, UK

Energy Efficiency

Building energy efficiency and supply efficiency measures deliver a reduction of 50% of carbon emissions, compared with "current business as usual" energy benchmarks. The long term aim is to achieve a 60% reduction in carbon emissions from 2000 levels, by 2050.

Energy Generation

The CHP plant provides 100% of the development's heating and hot water needs and 80% of its electricity.

© John Sturrock

East Village, London, UK

Energy Efficiency

A Zero Carbon standard was defined for the project, where a target of 40% and 65% reduction in emissions over Building Regulations 2010 for non-residential buildings and all current and new homes was set respectively. Additionally, a 35% emissions offset was defined through local Allowable Solutions agreement with local boroughs to reach 'Zero Carbon'.

Energy Generation

20% renewable energy is used on site.

© Atkins

Stockholm Royal Seaport, Stockholm, Sweden

Energy Efficiency

An intelligent electricity grid – the first of its kind in Sweden – will reduce annual energy consumption to a maximum of 55 kWh per square metre. By 2020 CO_2 emissions will be less than 1.5 tonnes/person, compared to 4.5 tonnes/person currently, while by 2030 the area will become fossil fuel-free. All new buildings must comply with Passivhaus energy requirements.

© norradjurgardsstaden

ATKINS

One Angel Square, Manchester, UK

The building is the Co-operative Group's headquarters, designed by 3D Reid and Buro Happold.

One Angel Square is part of phase one of NOMA, a £800 million scheme to redevelop 8.9 hectares of the northern part of Manchester city centre. The 10 year programme will generate a mixed use district, including office space, residential, and leisure facilities.

Energy Efficiency
Accommodating 3000 employees, it is one of most eco-friendly buildings in Europe. Energy efficiency features include LED lighting and waste heat recycling.

Energy Generation
The building uses rapeseed oil and is fuelled by a Combined Heat and Power (CHP) system fed by pure plant oil. One Angel Square has received the highest BREEAM rating for an office building in the UK.

© Trevor Palin

7 More London Riverside, London, UK

7 More London Riverside is the final and largest building with the More London masterplan and delivers a 10-storey, sustainable headquarters for PricewaterhouseCoopers LLP, designed by Foster and Partners.

Energy Efficiency
The building includes a variety of energy saving features, incorporating a high-performance zig-zag façade which permits daylight to enter the office floors. To further exploit daylight and views, the building's symmetrical wings open towards the river to expose the open circular drum at its core. Other features energy efficiency features include green roofs and fully automated building management and metering systems.

Energy Generation
A Combined Cooling Heating & Power (CCHP) trigeneration plant offers a low carbon source of cooling, heat and power and has resulted in 55% less CO_2 emissions than that necessitated under the 2006 Part L2 Building Regulations. The building also incorporates solar hot water panels.

© Shutterstock

Site Energy Scenario Analysis

Energy demand and supply scenarios were developed for Old Oak and Park Royal based on a mixture of industry accepted energy benchmarks and measured data. The aim of developing these scenarios was to evaluate the overall energy demand and supply balance of the proposed development under different energy performance scenarios. The energy demand and supply scenarios were used to:

a) test the prerequisites for meeting current Mayoral policy / guidance requirements;

b) test the potential for exceeding current policy / guidance requirements, under different scenario assumptions; and

c) provide additional evidence for the policy recommendations and supporting strategy set out in Table 4.1 above.

The energy demand and supply scenarios were also used to supporting the carbon analysis (see Carbon topic below).

The results of the site energy scenarios analysis, as well as supporting information, are set out in detail in Appendix B.1. This section provides an overview of the scenarios developed and the results of the analysis.

Energy Demand Scenarios

To explore the potential regulated energy reductions achievable within both Old Oak and Park Royal, a set of energy demand scenarios was developed based on improvements to current 'standard practice' energy efficiency performance of different building types. Preliminary high-level estimates of operational energy demand were then calculated for each scenario based on masterplan data on land uses supplied by OPDC for Old Oak and publicly available data for Park Royal.

The energy demand scenarios developed, and the assumptions underlying them, are summarised in Table 4.2 below. Further information on the energy demand scenarios is provided in Appendix B.1.

Table 4.2 – Energy Demand Scenarios

Energy Demand Scenario		Summary	Assumptions
Standard Practice	**Old Oak**	Represents current UK average sector-wide performance: • **Residential:** building fabric specification to meet minimum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes. Lighting, small power and hot water as per SAP 2012 calculation methodology. • **Non-residential:** represents current sector benchmarked performance.	• **Residential:** referenced to Code for Sustainable Homes. SAP 2012[8]. • **Office:** Max Fordham 'Standard Practice' benchmarks[9]. • **Retail:** CIBSE Guide F 'Standard' benchmarks[10].
	Park Royal	Per Old Oak, with the addition of: • **Industrial:** represents assumed current performance in Park Royal based on national average benchmarks.	• **Office and retail:** per Old Oak. • **Industrial:** based on Energy Consumption Guide 18 'Typical' benchmarks[11] and Department of Business, Energy and Industrial Strategy (DBEIS) measured data[12]. Industrial uses based on Park Royal Atlas[13].
Best Practice	**Old Oak**	Represents current UK best practice, improving on the Standard Practice scenario via: • **Residential:** building fabric specification to meet maximum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes: enhanced fabric insulation, reduced air leakage, optimised solar shading. Improved lighting. Small power and hot water as per SAP 2012 calculation methodology. • **Office:** higher thermal performance building shell, higher air tightness, energy efficient ventilation, daylighting combined with solar shading. • **Retail:** Average better performing facilities, based on measured data.	• **Residential:** referenced to Code for Sustainable Homes. SAP 2012. • **Office:** Max Fordham 'Best Practice' benchmarks. • **Retail:** CIBSE Guide F 'Good' benchmarks.
	Park Royal	Per Old Oak, with the addition of: • **Industrial:** Improvements on Standard Scenario with retrofitting of industrial buildings.	• **Office and retail:** per Old Oak. • **Industrial:** Standard Scenario figures adjusted based on 'Improved' benchmarks, Energy Consumption Guide 18 'Typical' benchmarks and DBEIS.
Pioneering Practice	**Old Oak**	Represents current international pioneering practice, improving on the Best Practice scenario via: • **Residential:** Stringent building envelope thermal transfer, air tightness, shading specifications, mechanical ventilation with heat recovery to ensure very low energy overall energy demand. • **Office:** automatic adjustable shading, greater focus on daylighting and solar control (low g-value glazing), LED lighting, continuous monitoring and fine-tuning performance, interactive user feedback; GSHP cooling. • **Retail:** Per Best Practice, with higher efficiency lighting.	• **Residential:** Passivhaus standard. • **Office:** Max Fordham 'Pioneering Practice' benchmarks. • **Retail:** CIBSE Guide F 'Good' benchmarks adjusted with estimated reduction based on LED lighting.
	Park Royal	N/A	N/A

Note: all scenarios relate to regulated and unregulated energy.

Source: Per references in table. Atkins analysis.

8 The Government's Standard Assessment Procedure for Energy Rating of Dwellings, Building Research Establishment / Department for Energy and Climate Change. 2012. (http://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf)
9 Green Offices Sustainability Matrix. Max Fordham, 2010. (http://www.maxfordham.com/assets/media/images/publications/Sustainability%20-%20Refurbished%20offices/ OFFICES_matrix_website_download.pdf).
10 CIBSE Guide F: Energy efficiency in buildings. Chartered Institute of Building Services Engineers, Cheshire D., Butcher K., 2012.
11 Energy Consumption Guide 18 - Energy Efficiency in Industrial Buildings and Sites, Department of the Environment/Action Agency, 1998.
12 Energy Consumption in the UK. Department for Business, Energy & Industrial Strategy, 2016. (https://www.gov.uk/government/collections/energy-consumption-in-the-uk).
13 The Park Royal Atlas, Greater London Authority, Williams F. et al, 2014. (https://www.london.gov.uk/sites/default/files/Park%20Royal%20Atlas%20Screen%20Version%201.1_0.pdf

Overall estimated indicative demand rates, in kWh/yr/m² GFA, for each land use type under each scenario are shown in Table 4.3 below. The figures in Table 4.3 indicate an overall reduction in estimated energy demand in Old Oak across all land use types of 18% from the Standard Practice scenario to the Best Practice scenario, and a reduction of 26% from the Best Practice scenario to the Pioneering Practice scenario (39% from the Standard Practice scenario). In Park Royal, the figures in Table 4.3 indicate a potential overall reduction of 31% from the Standard Practice scenario to the Best Practice scenario.

Table 4.3 – Energy Demand Rates by Land Use Type and Demand Scenario

Energy Demand Scenario	Energy Demand Rate (kWh/yr/m² GFA)							
	Old Oak				Park Royal			
	Residential	Office	Retail	All Uses	Office	Retail	Industrial	All Uses
Standard Practice	121	153	1,135	152	153	1,128	294	450
Best Practice	98	127	964	125	127	759	202	309
Pioneering Practice	78	72	763	92	N/A			

Source: Atkins analysis.

Note: All figures are indicative estimates only. Figures relate to user energy consumption only, not primary energy, and estimate regulated and unregulated energy. Figures for Industrial uses for Park Royal include building related consumption only; industrial process energy consumption is excluded.

Low Carbon Energy Supply Scenarios

To explore the potential onsite low carbon energy supply achievable, and test the degree to which onsite demand could be met by low carbon energy supply, a set of low carbon energy supply scenarios[14] was developed, based on proven, well-established technologies. Low carbon technology scenarios explored included three types of renewables, summarised in Table 4.4. Further information on the low carbon energy supply scenarios is provided in Appendix B.1. The set of scenarios explored was intended to be indicative rather than exhaustive. Due to time and resource constraints it was not possible to analyse the full range of potential sources of onsite or near offsite energy supply. Some of these offer considerable potential for deployment at the OPDC site; in particular, extraction of low grade heat from water bodies, including the Grand Union Canal, and sewerage mains, as well recovery of waste heat from industrial processes, transport and electrical grid infrastructure, large retail facilities, offices and data centres. Further study is recommended to explore the potential of these energy source options in Old Oak and Park Royal.

Table 4.4 – Onsite Renewable Energy Technologies

Renewable Energy Technology	Summary
Solar photovoltaic (PV)	A solar PV deployment scenario has been developed for both Old Oak and Park Royal. In both cases it is assumed that 35% of the total roof area is excluded for access and maintenance, and a further 15% of the remaining roof space would be occupied by roof equipment. In the case of Old Oak, a further 25% of the remaining roof space has been assumed to be over-shaded by higher buildings, thus limiting the effectiveness of solar PV deployment. Of the remaining roof space, assumed to be available for solar energy generation, 70% has been assumed for deployment of solar PV panels. The assumed conversion efficiency of solar PV panels is based on an average value for units readily available in the UK market.
Solar thermal	From the available roof space for solar PV estimated above, the remaining roof space not occupied by solar PV (30%) has been assumed for deployment of solar thermal panels. The assumed conversion efficiency of solar thermal panels is based on an average value for units readily available in the UK market.
Ground source heat pumps (GSHP)	The GSHP scenario assumes deployment of borehole fields in six of the main public open spaces in Old Oak, equating to a total area of 26,500 m2. This scenario assumes coefficients of performance of 3 for heating and 3.5 for cooling, with GSHP units providing year round heating / cooling output.

Source: Atkins analysis.

14 Solar PV and solar thermal energy scenarios are based on estimation of approximate upper limits for deployment of roof mounted panels. They do not attempt to account for other potential uses of roof space, such as green roofing or amenity uses. Roof mounted panels are not incompatible with such uses. If well designed, they can add to amenity with shaded/sheltered areas, panels being mounted on frames above head height if need be.

In addition to onsite renewables, a set of scenarios was developed to explore potential energy from waste from onsite arisings. These scenarios were based on the waste stream scenarios developed under the Waste topic below, identifying waste types and quantities (in tonnes) for Old Oak and Park Royal (see Table 4.5 below). Using gross calorific values applied to each waste stream, an incineration energy from waste production scenario was developed, and referenced from World Bank Technical Guidance[15] to have 20% energy recovery efficiency for electrical and 65% for thermal generation. Electrical energy generation from anaerobic digestion was estimated based on analysis of Atkins projects and assuming gas turbine technology with electrical efficiency of 35%.

Table 4.5 – Waste Stream Scenarios

Waste Stream Scenario		Summary
Business as Usual	**Old Oak**	Based on current practice in London, a high percentage of waste combustion is assumed and below average recycling rates, compared to other England regions. A significant landfill disposal rate is also assumed.
	Park Royal	Based on current practice in London, assumes around half of waste is recycled with similar proportion to Old Oak sent to landfill and the remainder combusted.
Zero Waste	**Old Oak**	Based on London Plan requirements, a very low landfill disposal rate is assumed, together with high recycling rates and minimal waste combustion.
	Park Royal	N/A
Low Waste	**Old Oak**	N/A
	Park Royal	Based on London Plan requirements, assumes a higher rate of recycling, and lower rates of landfill and combustion compared to business as usual scenario.

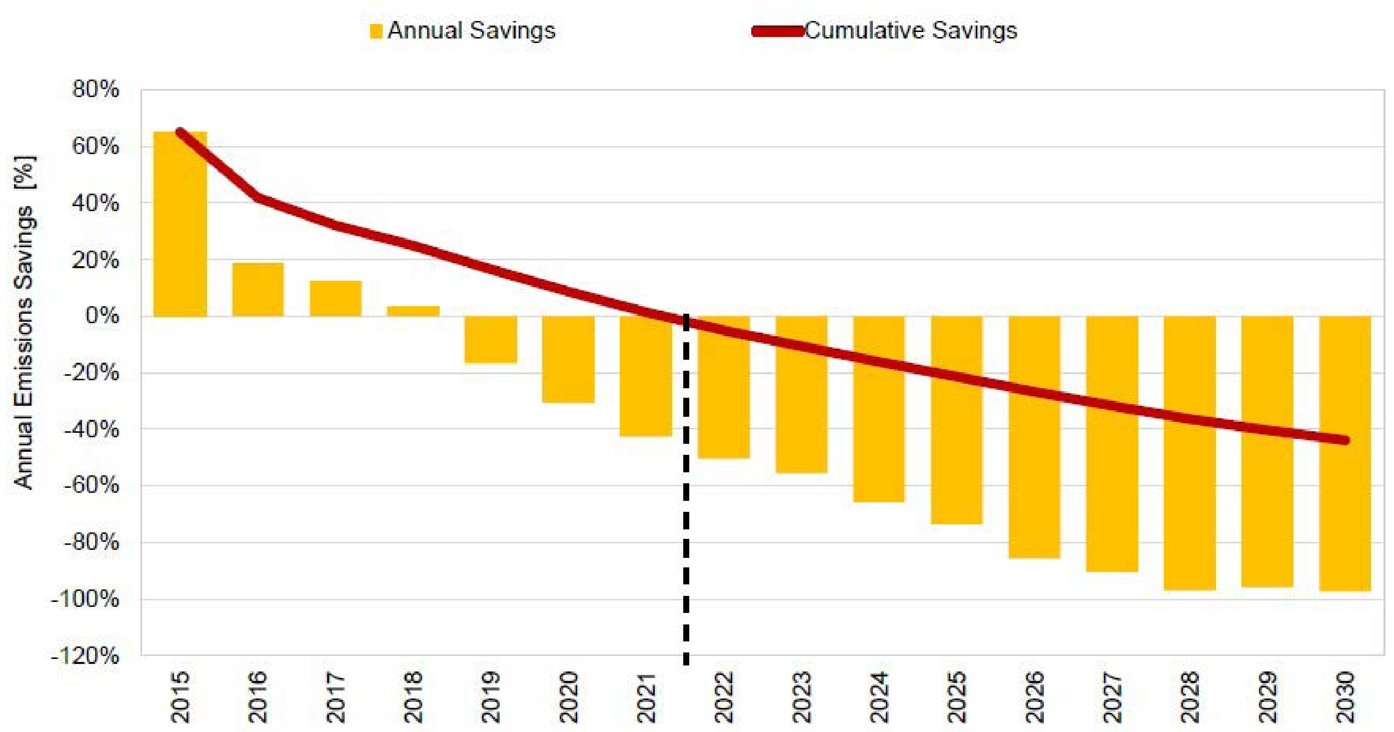
Note: Information in this table is reproduced from the Waste topic in this report below.

Source: Atkins analysis.

A heat led CHP scenario has been assumed to cover 40% of the total annual heat demand of Old Oak and Park Royal developments. The assumed conversion efficiency is 90% with heat to power ratio of two (60% efficiency for thermal and 30% for electrical). In order to estimate the annual savings, the CHP scenario was compared against a notional 100% boilers scenario (90% efficiency assumed).

Recent research[16] has highlighted the decreasing viability of gas fired CHP led district heating systems in terms of carbon savings due to the lower overall thermal efficiency of CHP compared to boiler only heat generation, coupled with rapid grid decarbonisation (see Figure 4.1). The research results suggest that within three years (2019) annual carbon savings from gas fired CHP led district heating will become negative, and cumulative savings (sum of annual savings, positive or negative, from base year) will become negative by 2021 (see Figure 4.1). This analysis indicates that, while gas fired CHP led district heating may be a short term carbon saving option, planning for district thermal networks (including cooling as well as heating) needs to include full consideration of switching to other non-fossil fuel heat sources, e.g. waste heat recovery and energy from waste for CHP, and/or incorporation of renewable generation from heat pumps and solar thermal. Going forward, gas fired CHP plant is thus likely to form one part of a diverse, multi-source distributed energy network.

Figure 4.1: Impact of grid decarbonisation on annual CO_2 savings, for a CHP engine installed in 2015



Source: An Operational Lifetime Assessment of the Carbon Performance of Gas Fired CHP led District Heating, CIBSE Technical Symposium, Arup, April 2016

15 Municipal Solid Waste Incineration: Requirements for a Successful Project, Technical Paper No. 462, World Bank, June 2000.
16 An Operational Lifetime Assessment of the Carbon Performance of Gas Fired CHP led District Heating, CIBSE Technical Symposium, Arup, April 2016.

The increasing electrification of transport, with hybrid and pure electric vehicles projected to rapidly increase as a proportion of the overall vehicle fleet over the next 15 years, plus the increasing unregulated loads associated with proliferation of digital and other consumer electronics, indicate that overall electrical demand is likely to increase substantially over the next decade and beyond. Ensuring electrical generation is low carbon will be increasingly vital to achieving the Mayor's overall carbon reduction target for 2025 and ensuring London contributes appropriately to national carbon reduction targets.

While onsite gas-fired CHP led distributed energy systems could meet a substantial proportion of both thermal and electrical demand (anticipated at around 40% of thermal and 21% of electrical demand given the Standard Practice scenario assumptions outlined above) the limited short term carbon savings would mean such a system would need to be rapidly switched to alternative combustion fuel, i.e. biofuel or waste, to avoid negative carbon savings given projected grid decarbonisation. Designing a CHP led system to be fired from locally available waste streams would appear to offer a more feasible low carbon solution in the medium to long term.

Due to the factors highlighted above, exploration of low carbon energy supply scenarios was focused on consideration of onsite renewables and energy from waste.

Summary of Results

The results of the site energy scenario analysis, detailed in Appendix B.1, indicate that for Old Oak the current Mayoral requirement for 25% of energy demand from localised distributed energy systems could be met and potentially exceeded based on deployment of a mix of renewable generation and energy from waste / anaerobic digestion (AD) facilities (based on the Zero Waste waste scenario) when combined with stringent energy demand reduction measures comparable to the Best Practice or Pioneering Practice energy demand scenario (see Table 4.6 below). The Mayoral target of 25% of energy from localised distributed energy systems would potentially be challenging to meet in Park Royal with deployment of renewables and energy from waste / AD (based on the Low Waste waste scenario), and with energy reduction measures comparable to the Best Practice energy demand scenario.

Table 4.6 – Old Oak Energy Demand Scenarios and Low Carbon Energy Supply

Energy Demand		Low Carbon Supply (MWh/yr)		Percentage of Demand		
Scenario	MWh/yr	1 - Onsite Renewables	2 - EfW / AD (Zero Waste)	1	2	1 + 2
Standard Practice	389,200	45,700	41,600	12	11	22
Best Practice	320,300			14	13	27
Pioneering Practice	235,700			19	18	37

Note: All figures are indicative estimates only. Figures relate to user energy consumption only, not primary energy, and estimate regulated and unregulated energy. Source: Atkins analysis.

Table 4.7 – Park Royal Energy Demand Scenarios and Low Carbon Energy Supply

Energy Demand		Low Carbon Supply (MWh/yr)		Percentage of Demand		
Scenario	MWh/yr	1 - Onsite Renewables	2 - EfW / AD (Low Waste)	1	2	1 + 2
Standard Practice	1,205,000	146,900	11,800	12	1	13
Best Practice	825,600			18	1	19

Note: All figures are indicative estimates only. Figures relate to user energy consumption only, not primary energy, and estimate regulated and unregulated energy. Figures for Industrial uses include building related consumption only; industrial process energy consumption is excluded. Source: Atkins analysis.

Cost Implications

Indicative estimates of capital costs associated with the three energy demand scenarios and each of the low carbon energy technologies included in the energy scenario analyses are set out in Appendix B.1.

Average capital cost uplifts[17] associated with the Best Practice and Pioneering Practice energy demand scenarios were estimated as 12.5% and 19% respectively, compared to the Standard Practice scenario. If the majority of the development comprises buildings with energy performance similar to the Best Practice scenario it may be feasible for developers to recover additional costs from sales premiums associated with new units given their lower energy bills and overall exemplar sustainability credentials.

Indicative average costs for the three onsite renewable energy technologies analysed vary between £1,300 and £1,700 per kilowatt peak. Indicative average costs for energy from waste technologies analysed are £6,700 per kilowatt peak and for AD technologies £5,500 per kilowatt peak. However, when taking into account typical capacity factors[18] the capital cost per capacity factored kilowatt peak for the highest cost energy from waste technology is potentially similar to that of the lowest cost renewable energy technology (solar photovoltaic). Each of these technologies is commercially established and has the potential to contribute to overall low carbon energy generation in Old Oak and Park Royal given appropriate financing and management mechanisms which enable investment risk to be extended over longer time frames and risks and benefits shared between developers and energy services providers. Further work is required to develop site-specific integrated approaches covering financial and management mechanisms as well as system and technical considerations. The flexibility and adaptability of such approaches will be key to longer term viability to accommodate continued rapid evolution of technologies, policy and regulatory drivers.

17 Indicative demand scenario cost uplifts are based on total construction costs.
18 The capacity factor of energy generation equipment is the ratio of its actual output over a period of time to its potential output if it were possible for it to operate at full peak capacity continuously over the same period of time.

Table 4.8 shows indicative costs for each low carbon technology scenario together with indicative unit costs.

Table 4.8 – Low Carbon Energy Technology Indicative Scenario and Unit Costs

Low Carbon Energy Technology	Cost (£)		Total Cost (£)	Indicative Unit Cost (£ / New Home)*
	Old Oak	Park Royal		
Solar Photovoltaic	23,400,000	87,100,000	110,500,000	900
Solar Hot Water	39,100,000	147,900,000	187,000,000	1,500
Ground Source Heat Pumps	30,000,000	-	30,000,000	1,200
Energy from Waste – Business As Usual	16,750,000	3,350,000	20,100,000	700
Anaerobic Digestion – Business as Usual	825,000	275,000	1,100,000	30
Energy from Waste – Zero Waste	6,700,000	1,675,000	8,375,000	300
Anaerobic Digestion – Zero Waste	2,750,000	2,750,000	5,500,000	100

Note: All figures are indicative estimates only. * Figures are for Old Oak only.

Source: Atkins analysis.

Targets

Table 4.9 – Recommended Targets

Objective / Indicators	Target			
	Old Oak		Park Royal	
	Short Term	Medium Term – Long Term	Short Term	Medium Term – Long Term
Objective 1: Minimise energy demand				
Overall energy demand, all building types	35% reductions in carbon emissions beyond Building Regulations 2013 Part L requirements onsite	Residential: Passivhaus standards Non-residential: 25% reduction from Short Term average	Non-industrial: per Old Oak Industrial: 15% overall demand reduction (from 2016 levels)	Non-industrial: per Old Oak Industrial: 25% overall demand reduction (from 2016 levels)
Post-construction performance relative to design performance	Adherence to Soft Landings[19] process	Adherence to Soft Landings process	Adherence to Soft Landings process	Adherence to Soft Landings process
Objective 2: Maximise onsite zero / low carbon energy generation				
Percentage of total onsite demand	15%	20%	10%	15%

Note: Short-Term: up to 2031; Medium Term-Long Term: 2032 onwards

19 Soft Landings is the BSRIA-led process designed to assist the construction industry and its clients deliver better buildings. Soft Landings helps to solve the performance gap between design intentions and operational outcomes (https://www.bsria.co.uk/services/design/soft-landings/).

Table 4.9 sets out the recommended environmental performance targets. The section below provides information on how the targets have been derived.

Rationale for Targets

The following principles underpin development of the targets:

- Compliance with the Mayor's energy hierarchy.
- Current and emerging UK and international best practice.
- Indicative assessment of potential energy demand reduction and low carbon energy supply options, given the site constraints and the nature of proposed development.

Based on energy demand scenario analysis and current and emerging UK and international best practice, guideline energy demand performance targets have been recommended.

The Old Oak Short Term target for overall energy demand is in line with the current GLA target which came into effect in October 2016. The Old Oak Medium – Long Term aspirational target for overall demand is based on reductions from the Best Practice to the Pioneering Practice energy demand scenario (see Table 4.3 above). The Park Royal targets for overall energy demand (excluding industrial processes) are based on a phased reduction commensurate with the Best Practice scenario (see Table 4.3 above). The overall energy demand targets also reflect experience from the best practice case studies.

The target for post-construction performance is based on current UK best practice, as promoted by BSRIA.

The Old Oak Short Term target for onsite low / zero carbon energy generation is based on the renewables plus energy from waste / AD low carbon energy scenario and Best Practice energy demand scenario (see Table 6 above). The Old Oak Medium – Long Term aspirational target for this indicator is based on renewables plus energy from waste / AD low carbon energy scenario and Pioneering Practice energy demand scenario. The Park Royal Short Term target for onsite low / zero carbon energy generation is based on the renewables plus energy from waste / AD low carbon energy scenario and Standard Practice energy demand scenario. The Park Royal Medium – Long Term aspirational target for this indicator is based on renewables plus energy from waste / AD low carbon energy scenario and Best Practice energy demand scenario (see Table 4.6 above). In setting targets for Park Royal it is recognised that, as it is an existing development, deployment may be more problematic, at least in the Short Term, and energy reduction will be incremental. However, opportunities for low carbon energy generation, particularly in relation to heat recovery, as well as roof mounted renewables, may be greater. The onsite low / zero carbon energy generation targets also reflect experience from the best practice case studies.

To assist in achieving the above targets, the following recommendations are made for Old Oak and Park Royal:

- Guideline average annual regulated demand (kWh/yr/m^2 GFA)[20], short term:
  - Residential: 100
  - Office: 130
  - Retail / leisure: 1,000
- EPC rating, all non-industrial building types, short term: B rating.

It is recommended that these guidelines, together with the above recommended targets, are regularly reviewed and revised as appropriate, preferably annually.

20 Guideline figures are based on energy demand scenario analysis. See Table 4.3 above.

WASTE

Waste arisings, treatment and disposal

Introduction

There are pressing environmental imperatives driving the need for change to current waste practices. The rising cost of landfill, in particular due to rising landfill tax, growing concerns around energy security and climate change, the emergence of new commercially available waste management technologies, loss of strategic materials that result from the 'take-make-throw' economy, and changing consumer behaviour have all made a 'business as usual' approach no longer viable. There is an opportunity for London to achieve significant greenhouse gas savings by diverting more municipal waste away from landfill. Most of the waste we throw away could be reused, recycled or composted, or used to generate low carbon energy.

To mitigate climate change impacts the Mayor states that "we need to use resources more effectively and efficiently, reduce our reliance on fossil fuels and other unsustainable materials, and develop the circular economy to reduce waste." (A City for All Londoners, October 2016).

Site Context

As well as being a Local Planning Authority (LPA), OPDC is a Waste Planning Authority (WPA) and is therefore responsible for waste development planning applications and has a statutory duty to prepare a local waste plan, either individually or as part of a joint plan. Although OPDC does not have a waste apportionment target in the current London Plan, the London Plan requires Mayoral Development Corporations to work with boroughs to ensure that borough apportionments are met.

The OPDC site adjoins three boroughs with WPA responsibility. OPDC's aim is to create a state of the art waste management system across the site that is integrated, and which supports the ambition to generate no waste to landfill. There is the opportunity to create a waste infrastructure from scratch, which will need to address issues around recycling and the challenges of constrained space and tall buildings. OPDC will also need to coordinate all the different stakeholders to create a common approach that is properly funded and operated so that local residents are not having to pay more than standard rates across London.

There are existing waste facilities on site that need to be either re-located, retained or re-orientated.

Policy Context

The National Planning Policy Framework (NPPF) does not contain waste specific policies, but refers to the National Waste Management Plan for England. The London Plan sets out a number of policies regarding waste management working towards a target of managing 100% of London's waste by 2026. Other relevant regulations and guidance include the EU Waste Framework Directive, The Waste (England and Wales) (Amendment) Regulations 2012, the Waste Hierarchy and Environmental permitting guidance.

London Plan

The London Plan (Policy 5.16) provides clear targets for solid waste management which set out an ambitious agenda over the next 15 years. Key targets include:

- Construction materials reuse / recycling / re-purposing: 95% by 2020;
- Biodegradable / recycled waste to landfill: zero by 2026;
- Commercial / industrial waste recycling: 70% by 2020; and
- Local Authority Collected Waste (LACW) recycling: 50% by 2020, increasing to 60% by 2031.

The targets are based on application of the well-established waste hierarchy (reduce, reuse, recycle, energy recovery, disposal). Following the waste hierarchy will achieve the highest level of resource efficiency as well as the greatest carbon dioxide equivalent savings. The primary focus is on avoiding waste disposal to landfill.

Resource and carbon efficient management of construction, demolition and excavation waste (CDE), which in 2012 made up around half of all waste arisings in the capital, is of high priority with a correspondingly ambitious target for 2020 set in the London Plan. Policy 5.3 (Sustainable Design and Construction), requires major development proposals to meet the minimum standards outlined in the Mayor's supplementary planning guidance. This includes sustainable design principles that seek to minimise the generation of waste and maximise reuse and recycling.

Policy 5.18 (Construction, Excavation and Demolition Waste), requires construction, demolition and excavation waste to be reused or recycled onsite, wherever practicable, supported through planning conditions (Policy 5.18 A). It also requires consideration to be given to movement of construction materials and waste by water or rail transport wherever practicable (Policy 5.18 B). Developers are required to produce site waste management plans to arrange for the efficient handling of construction, demolition and excavation waste materials (Policy 5.18 C).

Although current commercial / industrial recycling rates are relatively high, LACW waste recycling rates in London (34%) are lower than in other regions (44% UK average). There is thus a strong focus in Mayoral policy on optimising carbon efficient energy recovery from waste due to the high proportions of waste expected to be processed in this way, at least in the short term until recycling rates have improved.

The London Plan (Policy 5.17) requires that facilities generating energy from waste meet, or demonstrate that steps are in place to meet, a minimum CO_2e performance of 400 grams of CO_2e per kilowatt hour (kWh) of electricity produced, with the aim of ensuring that energy generated from waste activities

ATKINS

is no more polluting in carbon terms than the energy source it replaces. However, as highlighted in the Carbon section below, the rapid decarbonisation of grid electricity means that the carbon intensity floor set in the London Plan is higher than the current carbon intensity of grid electricity[1]. Clearly, significantly higher levels of carbon efficiency will be required for future energy from waste facilities. The London Plan states that, wherever possible, opportunities should be taken to provide combined heat and power (CHP) and combined cooling heat and power (CCHP). Energy from waste facilities should be equipped with a heat off-take from the outset such that a future heat demand can be supplied without the need to modify the heat producing plant in any way or entail its unplanned shutdown.

London's Circular Economy

The GLA define[2] a circular economy as "one that produces no waste and pollution, by design or intention. It keeps products, parts and materials at their highest use and value at all times. It offers a sustainable alternative to our current linear economy. This is one in which we make, use and then dispose of products, parts and materials. A circular economy also uses fewer new resources and energy. That means there is less cost to the environment."

The GLA are working with the London Waste and Recycling Board (LWARB) to develop a route map for London's transition to the circular economy. The first part 'Towards a circular economy – context and opportunities'[3] has been published. This document looks at the opportunities for London to reuse, remanufacture and redistribute materials as well as create new jobs.

Large scale developments present opportunities for innovative building design that avoid waste, support high recycling rates, and help accelerate London to a circular economy. OPDC is working with LWARB to explore how circular economy principles can be applied in Old Oak and Park Royal. The circular economy operates at various scales, from the individual component or asset level – or that of individuals – up to the neighbourhood, district and city scale, via various forms of community. The Old Oak and Park Royal area has the development scale and density to take advantage of opportunities at each of these levels.

Objectives and Policy Recommendations

Proposed objectives and waste policy recommendations for Old Oak and Park Royal are set out in Table 4.10 below. Strategic measures are also included as part of a site-wide waste management strategy. These recommendations are based on a review of mayoral policies and guidance set out above and initial site waste analysis below exploring the carbon and resource efficiency of waste treatment / disposal as well as low carbon energy generation potential. Policy recommendations are grouped under the two core objectives developed for OPDC waste policy, which also form the basis of the recommended targets:

1. Zero waste
2. Resource and carbon efficient solid waste treatment / disposal

To implement the set of strategic measures included in Table 4.10 an integrated low carbon, resource efficient site-wide Waste Management Strategy for Old Oak and Park Royal is recommended to be developed. The strategy should follow a sequenced approach based on the Waste Hierarchy, as reflected in the policy areas listed in Table 4.10. Development of the strategy should bring together developers, waste management service providers, local businesses, adjacent WPAs, and regulators, including utility regulators. Development of the strategy would also need to be closely coordinated with that of the site-wide Energy Strategy for Old Oak and Park Royal. A communications sub-strategy designed to encourage behavioural change, both in terms of waste generation as well as reuse and recycling, should form a key component of the Waste Management Strategy.

Evidence

This section sets out evidence supporting the policy and strategy recommendations listed in Table 4.10 Evidence comprises the following:

- Key observations from UK and international best practice case studies.
- Information on UK best practice for construction, excavation and demolition waste management.
- Results of site waste analysis used to explore scenarios for achieving, and potentially exceeding, current Mayoral targets and guidance.

1 Grid electricity emissions averaged 370 gCO_2e/kWh in 2015, falling from 440 gCO_2e/kWh in 2014. Source: Carbon Footprint of Heat Generation, UK Parliamentary Office of Science and Technology, POSTNote Number 523, May 2016..
2 https://www.london.gov.uk/what-we-do/environment/smart-london-and-innovation/circular-economy.
3 http://www.lwarb.gov.uk/what-we-do/accelerate-the-move-to-a-circular-economy-in-london/towards-a-circular-economy/.

Table 4.10 – Old Oak and Park Royal Waste Objectives and Policy Recommendations

Objective / Indicators	Recommended Policy	Rationale	Strategy
Objective 1: Zero waste			
Resource efficiency and the circular economy	• As part of planning applications, developers will be required to submit strategies clearly demonstrating how resource efficiency and circular economy outcomes will be achieved in the development. This should include aspects such as designing buildings for flexible use and reuse; modular construction of building components; and designing for building disassembly and reuse. • Site waste management plans (SWMP) detailing how OPDC construction waste targets will be met will be required for all development. SWMPs will be expected to include a strong focus on maximising reuse of waste construction materials. • OPDC will work with developers and waste management service providers to support development of onsite integrated construction, demolition and excavation (CD&E) waste consolidation, storage and processing facilities designed to serve all construction activities throughout the built-out programme. Developers should aim to meet or exceed OPDC guideline performance targets for CD&E waste management. • OPDC will work with current and future industrial businesses in Park Royal, future businesses in Old Oak, and waste management service providers to support development of new facilities for onsite circular economy facilities focused on key identified waste material flows within Park Royal and Old Oak.	• There is a strong opportunity to promote development of circular economy initiatives within Park Royal, linking to existing and new waste management facilities in Old Oak. • Support should be provided for development in Old Oak to become an exemplar for application of circular economy principles in the built environment. • Supporting development of a circular economy within Old Oak and Park Royal aligns with Mayoral policy and developing initiatives in London by the London Waste and Recycling Board and others. • Existing CD&E targets in the London Plan are ambitious. Development in Old Oak and Park Royal should seek to exceed these.	• Development of circular economy opportunities in both Old Oak and Park Royal should be supported with further work to establish feasibility of potential initiatives, and in particular focusing on linkages with existing and new waste management facilities in Old Oak. Incentives should be provided for developers to explore innovative approaches to building design, construction and operation. • Development in Old Oak and Park Royal should seek to exceed current ambitious targets for CD&E waste reuse and recycling. This will require close coordination between developers and existing and new waste management service providers.
Operational waste collection, storage and transfer	• As part of planning applications, all developers will be required to submit strategies which clearly set out how user-separated solid waste will be efficiently collected and stored within building plots and how regular transfer off-plot will be handled. Strategies will need to give particular attention to issues of a) source segregation of food waste; b) separation of waste collection and storage facilities from users in high density, high rise buildings[4] ; c) control of odour, nuisance and air and noise pollution from waste collection, storage and transfer facilities. Strategies should include building design standards regarding food waste collection from flats and retail units. • Developers will be required to provide sufficient facilities within their development to ensure 100% of user recyclable waste can be collected and stored within plot commensurate with regular transfer to transfer stations. This should cover both within-unit storage, e.g. specifications for 'under counter' separated storage, as well as communal storage, e.g. in basement areas.	• The viability of resource and carbon efficient waste management is highly dependent on effective user separation and collection of waste. This is especially important for high density, high rise development where effective communal facilities are required.	• Measures should be developed to ensure efficient and effective user separation of operational waste. This will require incentives to ensure appropriate within-unit as well as communal waste storage facilities are designed in from the outset.

4 See Westminster City Council Recycling and Waste Storage Requirements Guide for commonly referenced London guidance for waste storage/ space allocation: https://www.westminster.gov.uk/waste-storage-planning-advice.

ATKINS

Objective / Indicators	Recommended Policy	Rationale	Strategy
Objective 2: Resource and carbon efficient solid waste treatment / disposal			
Operational waste treatment / disposal	• OPDC will work with developers, waste management service providers and Park Royal industrial businesses to support development of onsite waste management facilities to recycle operational waste (organic and dry recyclable) generated from development at Old Oak and industrial activities at Park Royal, with the aim of a) minimising residual waste sent to landfill; b) minimising the carbon impacts of waste treatment / disposal; c) close integration with existing facilities.	• Aligned with national waste hierarchy, and location of waste treatment / disposal facilities as close as possible to sources of waste arisings. • London Plan targets for operational waste recycling are ambitious. Development in Old Oak and Park Royal should seek to exceed London Plan targets to achieve exemplary recycling rates. Case studies indicate this is achievable for Old Oak. However, achieving ambitious targets for waste recycling within Park Royal is less certain. The presence of new/expanded integrated local facilities in Old Oak should support achievement of ambitious targets both in Old Oak and Park Royal. • Aligned with London Plan objective of maximising carbon efficiency of waste management.	• Operational waste treatment / disposal facilities for processing all waste streams from Old Oak and Park Royal should be aimed at maximising overall carbon and resource efficiency and minimising waste sent to landfill. Determining the proportion of waste arisings which can be effectively processed via onsite facilities will require further work on projected waste volumes and composition, linkages with existing waste management facilities, and the potential for connecting energy from waste plant to the onsite heating / cooling network infrastructure. • The siting of onsite waste treatment / disposal facilities will require careful consideration of adjacent uses and strict adherence to air (including odour) and water pollution regulations, as well as regulations relating to noise, dust, vibration and nuisance / disturbance. The Air Quality topic below and the Old Oak and Park Royal Air Quality Study should be referenced. • Planning and siting of any onsite or near offsite EfW / AD facilities will require close integration with planning of the onsite heating / cooling infrastructure, as well as close coordination of linkages with existing waste management facilities. Consideration should be given to processing of potential waste streams from both Old Oak and Park Royal, as part of an integrated site-wide approach. • Planning should also give consideration to current and/or potential waste streams from adjacent or nearby areas and should be coordinated across the wider area. • As with waste treatment / disposal facilities generally, the siting of EfW / AD facilities will require careful consideration of adjacent uses and strict adherence to environmental regulations. The Air Quality topic below and the Old Oak and Park Royal Air Quality[5] Study should be referenced.

5 Old Oak and Park Royal Air Quality supporting study for the OPDC Draft Local Plan, OPDC, February 2016.

Objective / Indicators	Recommended Policy	Rationale	Strategy
Energy from waste	• OPDC will work with developers, waste management service providers, Park Royal industrial businesses and the utility regulators to support development of onsite energy from waste (EfW) / Anaerobic Digestion (AD)[6] facilities capable of handling existing and potential waste streams from both Park Royal and Old Oak. Facilities with smaller scale waste inputs and energy outputs[7] will be preferred, to support flexibility and scalability in connecting EfW / AD plant to the onsite heating / cooling network.	• Aligned with London Plan objective of maximising carbon efficiency of waste management. • EfW / AD facilities represent an important part of the transition away from fossil fuelled heat networks, as set out in the London Plan. • Smaller scale EfW / AD facilities may be more likely to comprise AD plant rather than EfW. Such plant has advantages of lower upfront capital costs relative to tonnage capacities and energy generation potential. Phased deployment of smaller AD plant requires less commitment to large waste streams to ensure financial viability and entails reduced land take. EfW / AD plant associated with the development may be onsite or offsite.	• Planning and siting of any onsite or near offsite EfW / AD facilities will require close integration with planning of the onsite heating / cooling infrastructure, as well as close coordination of linkages with existing waste management facilities. Consideration should be given to processing of potential waste streams from both Old Oak and Park Royal, as part of an integrated site-wide approach. • Planning should also give consideration to current and/or potential waste streams from adjacent or nearby areas and should be coordinated across the wider area. • As with waste treatment / disposal facilities generally, the siting of EfW / AD facilities will require careful consideration of adjacent uses and strict adherence to environmental regulations. The Air Quality topic below and the Old Oak and Park Royal Air Quality Study should be referenced.

Best Practice Case Studies

The UK and International case studies below and opposite have been referenced as examples of current best practice in terms of waste performance:

- **East Village, London, UK.** During construction, the project achieved 99% reduction in construction and demolition waste. Zero municipal solid waste to landfill is planned by 2025. By 2020, home recycling and composting is set to be 60%, compared to a London average today of 32%.
- **King's Cross Central, London, UK.** During development, 92% construction waste diverted from landfill. Currently, 81% of estate waste is diverted from landfill, of which 58% is recycled, and 42% is converted into energy.
- **Barangaroo, Sydney, Australia.** 97% of waste was diverted from landfill during construction, by sorting and separating waste and recycling or reusing as appropriate. The area has a collection and recycling process in place that will result in over 80% of operational waste being diverted from landfill. The goal is to achieve a net zero waste outcome for the precinct.

The case studies indicate that high rates (92% or higher) of diversion from landfill of construction, excavation and demolition waste are being achieved both in the UK and in other parts of the world.

High rates (70% or higher) of diversion from landfill of operational waste are also being achieved in some projects in the UK as well as in Europe and elsewhere. However, the proportions of diverted waste which are recycled and converted to energy vary considerably. The UK examples indicate targeted recycling rates of around 60%, while in the Flanders, Belgium example an actual recycling (including reuse and composting) rate of 71% is indicated. By contrast, the Hammarby, Stockholm example indicates much higher reliance on energy from waste and biogas generation, with only 33% recycling.

Hammarby, Stockholm comprised the only example of collection by vacuum system. In all other cases waste collection comprised conventional manual facilities.

The case studies from Malmö in Sweden and Buiksloterham in the Netherlands provide strong indications of the potential benefits from application of circular economy principles given strong and coordinated planning and management drivers.

6 The term 'energy from waste / anaerobic digestion', abbreviated to EfW / AD, is used in this report to refer to the two main types of waste processing plant which are capable of net energy generation. The term 'energy from waste (EfW)' is more commonly used to refer to waste combustion (incineration) plant. Anaerobic digestion (AD) comprises a special case of generation of energy from waste, as AD plant can also be defined as recycling.
7 See Table B.2.10 in Appendix B.2 for an indication of typical scales of waste management facilities.

Hammarby, Stockhom, Sweden

The project has achieved 20% overall waste reduction. 100% of waste is sorted and only 0.7% of waste goes to landfill. 50% of waste is recovered as energy through the waste to energy system, 16% of waste is turned into biogas, 33% is materials recycled, and 1% is hazardous waste. Waste delivered to landfill is 60% less than comparable developments.

An ENVAC waste system is used, where waste is collected via a network of underground pipes to central points for collection. Sewage is composted in a district sewage treatment centre. Hazardous waste has been reduced by 50% relative to comparable developments. 60% of nutrients from waste is recovered and used in farmland. 100% of blocks have recycling facilities. Biodegradable waste is composted nearby.

© Envac

Western Harbour, Malmö, Sweden

90% of waste is recycled or re-used. About 65% of the city's heat demand is met by waste incineration, where household and industrial waste is sent to a CHP incineration plant. In the Western Harbour district, two systems are being tested: food waste grinders in individual kitchen sinks and centralised vacuum chutes. Malmö is also the location for a collaborative project, part funded by Swedish Governmental Agency, Vinnova[8], to achieve industrial symbiosis between companies, municipalities and organisations. In particular, waste and energy efficiencies and improved competitiveness are driving forces of the circular economy at Malmö. Examples of circular waste use include:

- Using organic waste for animal feedstuff and synthetic fertiliser;
- Using steam (a by-product from the Combined Heat and Power Plant) for ethanol production, which in turn produces residual products that can be used for animal feedstuffs and bio-gas[9].

Industrial symbiosis at Malmö reduces and reuses wastes, e.g. heat, steam, materials and water, and also includes sharing services and transport. This has advantages for financial savings, reduced consumption and pollution, as well as increased resilience[10].

© Shutterstock

Flanders, Belgium

The region has the highest landfill diversion rate in Europe with over 70% of residential waste either reused, recycled or composted. As of 2010 waste processing could be broken down into 2% Mechanical Biological Treatment (MBT), 71% recycling, 26% waste to energy, with less than 1% landfilled.

A charging scheme for waste collection, termed 'Pay as You Throw' (PAYT), is used in the region, which is a variable tax system which applies to the collection of different wastes.

As a result of the strategies put into place in Flanders, residual municipal solid waste decreased from 332kg residual waste/capita in 1991 to 149kg in 2009, meeting the regional target of 150kg residual waste/capita. The PAYT system helped promote home composting where, as of 2008, some 34% of organic waste was estimated to be processed.

Bulksloterham, The Netherlands

The neighbourhood was historically an industrial centre in close proximity to the city centre[11]. Stakeholder engagement with research institutes such as Amsterdam Institute for Advanced Metropolitan Solutions and Wageningen UR have allowed innovative solutions to be developed alongside appropriate business models[12].

By 2034 the development aims to be energy self-sufficient with a fully renewable energy supply and to have near 100% circular material flow and zero waste[13]. It also aims to 'close the loop' with all short, medium and long term materials being recoverable and reusable in their highest form possible.

Building principles and source separation programmes are considered to be central in delivering this. The emphasis at Buiksloterham is on bio-based resources, for example biological waste nutrient recovery, and the use of bioprocessing as an alternative to conventional industrial functions.

8 http://www.vinnova.se/en/About-Vinnova/.
9 http://www.cmport.com/news-and-media/newsletters/201503/industrial-symbiosis.
10 http://www.sustainability.lu.se/article/shaping-the-future-of-malmo-through-industrial-symbiosis.
11 https://www.wur.nl/en/newsarticle/Amsterdam-Buiksloterham-living-lab-for-circular-city.htm
12 http://buiksloterham.nl/bericht/2229/amsterdam-launches-living-lab-for-circular-urban-development?netwerk=true
13 http://buiksloterham.nl/engine/download/blob/gebiedsplatform/69870/2015/28/ CircularBuiksloterham_ENG_Executive_Summary_05_03_2015.pdf?app=gebiedsplatform&class=9096&id=64&field=69870

Construction, Demolition and Excavation (CDE) Waste Management

The UK Waste and Resources Action Programme (WRAP) has compiled data on recovery of construction, demolition and excavation materials in the UK. These are shown in Table 4.11 below.

The WRAP figures indicate current best practice averages 90% recovery of CDE materials. This suggests that the current Mayoral target of 95% by 2020 is ambitious.

Site Waste Scenarios Analysis

Waste treatment / disposal scenarios were developed for Old Oak and Park Royal based on publicly available London and national data regarding waste arisings rates and composition for mixed use development and industrial parks, and treatment / disposal types defined by the UK Government in relation to estimation of carbon emissions. The scenarios are based on a timeframe of full build out.

The aim of developing these scenarios was to evaluate the overall resource efficiency of the two developments under different operational waste treatment / disposal environmental performance assumptions. The waste treatment / disposal scenarios were used to:

a) test the prerequisites for meeting current Mayoral policy / guidance requirements;

b) test the potential for exceeding current policy / guidance requirements, under different scenario assumptions; and

c) provide additional evidence for the policy recommendations and supporting strategy set out in Table 4.10 above.

The waste treatment / disposal scenarios were also used to support the carbon analysis (see Carbon topic below).

The results of the site waste scenarios analysis, as well as supporting information, are set out in detail in Appendix B.2. This section provides an overview of the scenarios developed and the results of the analysis.

Table 4.11 – UK Construction, Demolition and Excavation Materials Recovery Rates

Material	Recovery Rate (Percentage)		
	Standard Practice	Good Practice	Best Practice
Timbers	57	90	95
Metals	95	100	100
Plasterboard	30	90	95
Packaging	60	85	95
Ceramics	75	85	100
Concrete	75	95	100
Inert	75	95	100
Plastics	60	80	95
Miscellaneous	12	50	75
Electrical Equipment	No Info	70	95
Furniture	15	25	50
Insulation	12	80	75
Cement	No Info	75	95
Hazardous	50	No Info	No Info
Average	51	76	90

Source: Achieving Good Practice Waste Minimisation and Management, Waste and Resources Action Programme, 2008.

Waste Treatment / Disposal Scenarios

To explore the potential for deployment of resource and carbon efficient waste treatment technologies to process predicted waste streams associated with proposed development at Old Oak and Park Royal, a set of waste treatment / disposal scenarios was developed based on improvements to current 'Business as Usual' practice.

Preliminary high-level estimates of predicted waste arisings, identifying waste types and quantities (in tonnes), were calculated based on the draft masterplan data on land uses supplied by OPDC for Old Oak and publicly available data for Park Royal. Data on use characteristics, waste generation rates and composition from a variety of publicly available sources were also used to develop the waste arisings estimates. An overview of the methodologies used for the waste arisings estimates is set out in Appendix B.2. Waste treatment / disposal scenarios were then used to estimate the total quantities of waste associated with each treatment / disposal type, based on treatment / disposal types defined by the UK Government in relation to estimation of carbon emissions[14].

The waste treatment / disposal scenarios developed, and the assumptions underlying them, are described in Table 4.12 below.

14 2012 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting, Department of Energy and Climate Change (DECC) and the Department for Environment, Food and Rural Affairs (Defra), May 2012.

Table 4.12 – Waste Treatment / Disposal Scenarios

Waste Treatment Disposal Scenario		Summary
Business as Usual	Old Oak	Based on current practice in London, a high percentage of waste combustion is assumed and below average recycling rates, compared to other England regions. A significant landfill disposal rate is also assumed.
	Park Royal	Based on current practice in London, assumes around a third of waste is recycled with similar proportion to Old Oak sent to landfill and the remainder combusted.
Zero Waste	Old Oak	Based on London Plan requirements, a very low landfill disposal rate is assumed, together with high recycling rates and minimal waste combustion.
	Park Royal	N/A
Low Waste	Old Oak	N/A
	Park Royal	Based on London Plan requirements, assumes a higher rate of recycling, and lower rates of landfill and combustion compared to business as usual scenario.

Source: Atkins analysis.

Summary of Results

The waste scenarios analysis indicates that in order to achieve very high diversion from landfill for waste in Old Oak a very substantial increase in recycling and anaerobic digestion rates will be required, with a commensurate reduction in combustion based energy from waste (see Table 4.13 below). Recycling rates similar to those in Flanders, Belgium and South Oxfordshire in the UK would be expected. The current Mayoral targets for commercial / industrial waste and LACW waste recycling also look ambitious in this context. Without substantial increases in recycling, anaerobic digestion and composting the current Mayoral target of zero biodegradable / recycled waste to landfill by 2026 would only be achievable with a large increase in combustion of such materials, which would be contrary to Mayoral policy of increasing the resource and carbon efficiency of waste management.

A considerable increase in recycling rates, together with significant reductions in combustion and landfill rates, would be required to achieve the Low Waste scenario in Park Royal (see Table 4.14 above). The dominance of commercial / industrial waste means that current recycling rates are assumed to already be higher than for LACW waste. Based on the waste scenario analysis results, the current Mayoral target of 70% for commercial / industrial waste recycling by 2020 would appear to be challenging but potentially achievable in Park Royal.

From the site waste scenarios analysis it is clear that achieving the current Mayoral targets will be challenging for the new development at Old Oak and Park Royal. Ensuring a substantial increase in resource and carbon efficiency from the current baseline, as required by current London Plan policy, would entail:

a) rapid and substantial decline in the proportion of waste sent to landfill, compared to the current baseline;

b) high uptake in recycling and reuse of wastes from all tenants / residents and users of community facilities / open spaces;

c) residual waste (after recycling) treated via combustion to be substantially and rapidly reduced, compared to the current baseline, and linked to high efficiency CCHP or CHP EfW / AD plant. Effective use, and associated carbon efficiency benefits, of the thermal component of the output from CCHP / CHP led EfW / AD plant will require careful planning for local heat distribution. Ideally, this should be fully integrated with planning for similar requirements from Park Royal; and

d) progressive decline in residual waste, as is implied in meeting or exceeding the current Mayoral LACW waste recycling targets. This will necessitate careful sizing and phasing of EfW / AD facilities and associated heat distribution networks.

Table 4.13 – Old Oak Waste Treatment / Disposal Scenarios Comparison

Waste Treatment / Disposal Scenario	Waste Treatment / Disposal (%)				
	Recycling	Combustion	Anaerobic Digestion	Composting	Landfill
1. Business as Usual	30%	46%	4%	1%	20%
2. Zero Waste	60%	19%	15%	1%	5%
Change (2-1)	31%	-27%	11%	0%	-15%

Source: Atkins analysis.

Table 4.14 – Park Royal Waste Treatment / Disposal Scenarios Comparison

Waste Treatment / Disposal Scenario	Waste Treatment / Disposal (%)				
	Recycling	Combustion	Anaerobic Digestion	Composting	Landfill
1. Business as Usual	38%	43%	2%	0%	17%
2. Zero Waste	62%	19%	9%	0%	10%
Change (2-1)	24%	-24%	7%	0%	-7%

Source: Atkins analysis.

In order to achieve the Mayoral target of zero biodegradable/ recycled waste to landfill by 2026, without increasing combustion of such waste, there will need to be a very strong focus from the outset in master planning and urban design on ensuring that:

a) facilities necessary to achieve required segregation and capture rates, in particular with regard to food waste, are fully designed in; and

b) sufficient space, access and infrastructure is provided for onsite storage and either transfer or, preferably, local treatment of waste (parts of Park Royal with commercial neighbours may be more appropriate for this than within Old Oak, dependent on technology / facility type and scale).

Achieving or exceeding the Mayoral target of 70% waste recycling of commercial / industrial waste from Park Royal by 2020 will require further investigation of activities in the key waste producing sectors of warehousing, general industrial and light industry, and likely regulation of said sectors, together with a strong focus on localised provision of recycling facilities capable of the most carbon efficient processing of the key waste streams of mixed household waste, metals, organics, paper and cardboard. As the proportion of residual waste sent to landfill is rapidly reduced, planning for carbon efficient CCHP / CHP led EfW / AD facilities to process the remainder should be closely coordinated with that for Old Oak.

Promotion of opportunities for development of industrial activities which can make direct use of locally recycled waste outputs should also be prioritised, enhancing the local circular economy. This will require detailed study of current and potential recycled products, and land and infrastructure requirements for existing or new circular economy industries.

The draft environmental performance targets for waste below have been set with the aim of encouraging the developments outlined above. They have also been coordinated with targets for energy and carbon.

Cost Implications and Land Take

Indicative estimates of capital costs for key waste treatment technologies are set out in Appendix B.2. Of the technologies which do not enable energy recovery from waste[15], windrow composting represents the lowest cost option, followed by in-vessel composting. Recycling of dry recyclable materials also represents a relatively low cost technology.

Capital costs for anaerobic digestion are approximately half those of energy from waste. Mechanical biological treatment capital costs are slightly lower than those for anaerobic digestion. However, this technology typically has lower overall resource and carbon efficiency due to the reduced separation of organic and dry recyclable waste. Advanced thermal treatment, which typically includes pyrolysis, gasification and plasma gasification, represents the highest cost technology.

Cost estimates indicate that the types of waste collection technologies required for high density, high-rise buildings, such as refuse chutes and underground storage systems, would be expected to entail significant additional costs per dwelling when compared to established collection technologies for low density, low rise development.

Estimates of average land take for the main types of waste treatment facility indicate that across most facility types land take efficiency generally increases with greater scale of facility. However, in practice some waste treatment facility types, e.g. mechanical biological treatment, tend to be less space efficient at scale.

15 Technologies which enable energy recovery from waste include energy from waste, anaerobic digestion and some advanced thermal treatment technologies.

Targets

Table 4.15 sets out the recommended environmental performance targets. The section below provides information on how the targets have been derived.

Rationale for Targets

The following principles underpin development of the targets:

- Compliance with Mayoral policy and guidance.
- Current and emerging UK and international best practice.
- Indicative assessment of potential waste diversion from landfill given the site constraints and the nature of proposed development.

The targets for construction, demolition and excavation waste sent to landfill are in line with the current Mayoral target for 2020, which is slightly higher than current average UK best practice according to WRAP.

Short Term targets for operational waste to landfill are based on current lower end best practice examples, which represent a modest improvement to the Business as Usual scenario estimates. The Medium-Long Term operational waste to landfill target for Old Oak is based on the higher end best practice examples, which are similar to the Zero Waste scenario estimate. The Medium - Long Term operational waste to landfill target for Park Royal is based on the Low Waste scenario estimate.

The Old Oak targets for percentage of organic waste processed by anaerobic digestion (AD) or composting are based on meeting the Mayoral target for zero biodegradable waste to landfill by 2026 together with Mayoral policy encouraging resource and carbon efficient waste management. The targets recognise that a significant proportion of the organic waste stream may not be suitable for AD or composting and also that AD facilities are not well established in London. The Hammarby, Stockholm case study indicates that a high proportion of organic waste could be processed by AD. Difficulties with source separation of organic waste in the high density, high rise development proposed for Old Oak have also been considered. The Park Royal targets for percentage of organic waste processed by AD or composting follow the same rationale as those for Old Oak, but recognising that the proportion of the organic waste stream not suitable for these forms of processing is likely to be higher than that for Old Oak.

The Old Oak Short Term target for percentage of dry recyclable waste recycled are based on meeting the Mayoral LACW waste recycling target of 60% by 2031 and commercial / industrial waste recycling target of 70% by 2020, as it is considered that these will be challenging in the high density, high rise development proposed. The targets from the UK best practice examples also informed these targets. The best practice example of Flanders, Belgium informed the Medium Term - Long Term target for this indicator for Old Oak. The Park Royal Short Term target for this indicator is based on meeting the current Mayoral commercial / industrial waste recycling target of 70% by 2020, which is considered will be challenging. Due to the dominance of commercial / industrial waste in Park Royal, and the suitability of conventional collection methods on the site, an aspirational Medium Term - Long Term target exceeding this Mayoral target was set.

It is recommended that the above recommended targets are regularly reviewed and revised as appropriate, preferably annually.

Table 4.15 – Recommended Targets

Objective / Indicators	Target			
	Old Oak		Park Royal	
	Short Term	Medium Term - Long Term	Short Term	Medium Term - Long Term
Objective 1: Zero Waste[16]				
Percentage of construction, demolition and excavation waste sent to landfill	5%	5%	5%	5%
Percentage of operational waste sent to landfill	20%	5%	20%	10%
Objective 2: Resource and carbon efficient solid waste treatment / disposal				
Percentage of organic waste processed by composting or anaerobic digestion	50%	70%	40%	60%
Percentage of dry recyclable waste recycled	60%	70%	70%	75%

Source: Atkins analysis.

16 The definition of 'zero waste' for the purposes of this objective is 'zero, or absolute minimum waste to landfill'

MATERIALS

Low carbon, sustainably sourced, healthy

Introduction

The environmental impact of developments can be significantly reduced through use of sustainable materials[1]. Sustainable materials are commonly defined in terms of the following:

- Low embodied carbon.
- High recycled / reused content.
- Reuse of existing materials / resources.
- Timber and other renewable materials from sustainably harvested sources.
- Materials and products sourced from responsible suppliers seeking to ensure environmental stewardship, resource efficiency and sustainable development.
- Materials and products sustainably produced locally, reducing transport impacts and supporting local economy.
- Low use of unhealthy materials.

Choice and use of materials are key influences on sustainability throughout the development lifecycle, from design, construction, and occupation phases through to 'end-of-life' issues of materials recycling and reuse during decommissioning and deconstruction. In particular, carbon and resource efficiency, ecological performance, indoor air quality, durability and flexibility of building use, local character and place making, can all significantly benefit from use of sustainable materials.

The National Planning Policy Framework (NPPF) suggests the use of sustainable materials which respond to local character and identity as a way of creating sustainable places. This is supported by London Plan policies on sustainable design which highlight the importance of sustainable materials in improving the environmental performance of new developments. Guidance in the Mayor's Sustainable Design and Construction Supplementary Planning Guidance (SPG) recommends use of low embodied energy, sustainably sourced, healthy, durable and pre-fabricated materials where possible, together with an emphasis on reuse of existing materials and resources, and designing for deconstruction, which will assist in achieving an efficient and competitive circular economy, as envisioned by the Mayor's A City for All Londoners.

Site Context

The scale of development proposed at Old Oak and Park Royal provides challenges and opportunities to use carbon efficient, sustainable materials in construction and to reuse, recycle and manage existing materials at the end of their useful life. An efficient circular economy, minimising waste and optimising use of sustainable materials, will promote climate change resilience and a more competitive local economy.

The London Plan sets a series of targets regarding low embodied carbon, responsible sourcing, durable and healthy materials. The Old Oak development presents particular potential for implementing best practice in sustainable materials since it is an entirely new development. In the case of Park Royal, although there is a small new build area planned, most of the sustainable materials application potential derives from retrofit, which is likely to present fewer opportunities for best practice.

In both Old Oak and Park Royal there should be significant opportunities for use of sustainable materials in maintenance and repair of buildings and infrastructure.

Policy Context

The NPPF promotes the use of sustainably sourced, locally relevant materials as an opportunity to improve the built environment. However, it specifies that Local Plans should not be unnecessarily prescriptive or detailed in design policies.

No specific policy regarding construction materials exists in the OPDC Draft Local Plan (Feb 2016).

The Mayor's Sustainable Design and Construction SPG and the London Plan set out guidance and targets related to materials for the design and construction stages. Objectives and targets from these documents are summarised below.

Design Stage

- **Use of low embodied energy materials:** At least three of the key elements of the building envelope (external walls, windows, roof, upper floor slabs, internal walls, floor finishes / coverings) are to achieve a rating of A+ to D in the Building Research Establishment (BRE) Green Guide to Specification[2].
- **Use of sustainably sourced materials:** At least 50% of timber and timber products should be sourced from accredited Forest Stewardship Council (FSC) or Programme for the Endorsement of Forestry Certification (PEFC) suppliers.
- **Use of durable materials:** Cater for their level of use and exposure.
- **Use of pre-fabricated elements:** Maximise their potential use.
- **Use of 'healthy' materials:** Minimise the harmful effects of some materials on human health.
- **Designing for deconstruction rather than demolition:** New buildings should be designed with the prospect of future deconstruction being implementable.

Construction Stage

- **Use of existing resources and materials:** Maximise the use of existing resources and materials.

1 In this report 'materials' includes both raw materials, e.g. stone, timber, and manufactured products used in construction, e.g. concrete, glass, pipes.
2 See https://www.bre.co.uk/greenguide.

The current industry view is that specifications in the BRE Green Guide on use of low embodied materials could be improved. In particular, the wide band of acceptable scores from D (poor) to A+ (good) does not encourage the selection of best practice materials.

With regard to the use of sustainably sourced materials, it should be noted that many construction projects in the UK are now achieving levels of 90% or more timber sourced from accredited FSC/PEFC suppliers.

OPDC Objectives and Policy Recommendations

Based on review of mayoral policies and guidance, review of best practice case studies and initial site materials analysis, sustainable materials policy recommendations for Old Oak and Park Royal have been developed and are set out in Table 4.16 below. Policy recommendations are grouped under the one core objective, covering the different aspects of sustainable materials, which also forms the basis of the recommended targets below.

Evidence

This section sets out evidence supporting the policy and strategy recommendations listed in Table 4.16. Evidence comprises the following:

- Key observations from UK and international best practice case studies.
- Results of initial site materials analysis exploring different aspects of sustainable materials use.
- Consultations with UK developers and contractors / suppliers[16] and the UK Green Building Council.

© Atkins

London 2012 Olympic Games. Overall the sustainable approach adopted for land rehabilitation resulted in: 246 hectares of land rehabilitated; 98% of demolition material recycled; 2.2 million m^3 soil excavated and 80% of soil re-used. Source: Atkins and the London 2012 Games

Table 4.16 – Old Oak and Park Royal Materials Objectives and Policy Recommendations

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Optimise use of low carbon, sustainably sourced, healthy materials.			
Sustainable Materials Plan	• As part of planning applications, developers will be required to submit a Sustainable Materials Plan, comprising the following (see details in policy areas below): • Embodied Carbon Reduction Strategy. • Supplier accreditation details: BRE BES 6001[8], ISO 14001[9]; EMAS[10]; FSC / PEFC, as appropriate. • Local Materials Sourcing Strategy. • Details of compliance with responsible sourcing and healthy materials targets.	• Aligned with London Plan and Mayor's Sustainable Design and Construction SPG requirements promoting sustainable materials in new all new development. • Aligned with Local Plan and Mayor's Sustainable Design and Construction SPG requirements to reduce impacts associated with transport including air quality. • Working with industry to promote best practice in certification. • Support for Old Oak and Park Royal to become an exemplar development for use of low embodied carbon, sustainably sourced and healthy materials promoted through explicit benchmarking against anticipated targets and requirements for development of strategies addressing each of these specific topics.	• Setting out a clear framework and guidance for Sustainable Materials Plans to be submitted as part of planning applications will allow OPDC to assess anticipated development performance against measureable objectives. This will aid delivery of exemplary developments utilising low carbon, sustainably sourced and healthy materials.

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Optimise use of low carbon, sustainably sourced, healthy materials.			
Carbon efficient materials	• As part of planning applications, developers will be required to develop strategies demonstrating how their proposals comply with the site-wide Carbon Planning and Management Framework (CPMF), which OPDC will use to define and implement exemplar zero carbon development at Old Oak and Park Royal (see Carbon Emissions topic section above). The OPDC CPMF will include requirements to ensure data on embodied carbon are collected, monitored and reported. • Developers, utility services providers, associated consultants and contractors, and management services providers will be required to measure, collect, record and submit carbon related data in accordance with the CPMF. The CPMF will cover all phases and stages, from early design through to operation and decommissioning, and include data on embodied carbon emissions as well as operational and 'end-of-life' emissions. • As part of their Sustainable Materials Plan, and also forming part of their CPMF related submission, developers will be required to submit an Embodied Carbon Reduction Strategy clearly setting out the approach to reducing embodied carbon, and measures proposed for quantified reductions to achieve overall embodied carbon reduction targets. Standardised embodied carbon benchmarks will be used to enable developers to measure performance against embodied carbon targets.	• Effective and efficient resource use will assist in the move to a low carbon economy, as promoted in A City for All Londoners. Embodied carbon increasingly represents a large proportion of the carbon footprint for developments as efficiencies in operational technologies improve. Therefore, and as materials technologies also improve, carbon efficient materials will present an increasingly important opportunity for exemplar low carbon practice at Old Oak and Park Royal. • Old Oak and Park Royal should optimise the use of carbon efficient materials. Embodied carbon is currently under the process of being regulated in the UK. There is therefore some level of uncertainty regarding embodied carbon related best practice targets definition. To ensure an early and effective focus on materials in carbon efficient solutions, developers should implement an Embodied Carbon Reduction Strategy aiming to optimally minimise whole life carbon impacts (from cradle to cradle). Examples of low carbon materials to be evaluated could include: • Self-healing concrete; • Pulverised fuel ash (PFA) and ground granulated blast surface slag (GGBS) as cement substitutes[3]; • Carbon nanotube reinforced concrete (CNT); • Cross laminated timber (CLT); and • Hempcrete.	• An appropriate methodology covering both Old Oak and Park Royal should be developed to allow consistent and robust estimation of embodied carbon emissions and evaluating targets (see recommendations in the Carbon Emissions topic section above). • The approach developed for the carbon accounting for London 2012[4,5] is recommended as a starting point for establishing the definition of boundaries, benchmarks and methodology for measuring, reporting on and reducing embodied carbon. This will require further work and is recommended as a part of a separate carbon study. The London 2012 carbon footprinting work indicated that large relative savings can be achieved through a combination of efficient design, elimination and value engineering. The importance of specification of embodied carbon targets early in the design process is also highlighted. • Guidance from the UK Green Building Council on developing briefs for embodied carbon reduction[6], as well as guidance from the Waste and Resources Action Programme (WRAP)[7] on reducing embodied carbon during construction are also recommended references.
Recycled materials	• As part of their Sustainable Materials Plan, developers will be required to set out measures for optimising the overall recycled content of materials. In addition to helping to reduce embodied carbon, use of recycled materials also increases overall resource efficiency and reduces waste to landfill.	• NPPF (paragraphs 58-59), London Plan (policies 5.3, 5.20, 7.6), Mayor's Sustainable Design and Construction SPG, BRE Green Guide, UK WRAP. • The use of recycled materials increases carbon efficiency relative to use of virgin materials, in particular steel and concrete. Reusing existing resources and prioritising use of more durable materials also increase overall carbon and resource efficiency of materials use.	• Exemplary performance in terms of sustainable materials use at Old Oak and Park Royal would require substantial reduction in the use of virgin materials. • 30-35% recycled aggregates is recommended for the concrete substructure at Old Oak.

3 The Inventory of Energy and Carbon (ICE) database, originally developed at the University of Bath, provides estimates of embodied carbon for these well established cement substitutes. See http://www.circularecology.com/embodied-energy-and carbon-footprint-database.html#.WJnnPU1XXIU.
4 London 2012 Carbon Footprint Methodology and Reference Footprint – London 2012 Learning Legacy, London Organising Committee of the Olympic Games, 2012. http://learninglegacy.independent.gov.uk/documents/pdfs/sustainability/cp-london 2012-carbon-footprint-methodology-and-reference-footprint.pdf.
5 Reducing embodied carbon through efficient design – London 2012 Learning Legacy, Olympic Delivery Authority, 2011. http://learninglegacy.independent.gov.uk/documents/pdfs/ sustainability/425009-145-reducing-carbon-aw.pdf.
6 Embodied Carbon: Developing a Client Brief, UK Green Building Council, March 2017. http://www.ukgbc.org/resources/publication/embodied-carbon-developing-a-client-brief
7 Cutting carbon in construction projects, Waste and Resources Action Programme (WRAP). http://www.wrap.org.uk/sites/files/wrap/FINAL%20PRO095-009%20Embodied%20Carbon%20Annex.pdf

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Optimise use of low carbon, sustainably sourced, healthy materials.			
Sustainably sourced materials	• As part of their Sustainable Materials Plan, developers will be required to demonstrate specification of all materials from suppliers who participate in responsible sourcing schemes such as the BRE BES 6001 Framework Standard for Responsible Sourcing[8] and that operate Environmental Management Systems certified against ISO14001[9] or EU Eco-Management and Audit Scheme (EMAS)[10] standards, covering all stages of material manufacturing. • All new and retrofit development will be required to ensure all wood used is from FSC / PEFC certified sustainable sources.	• Responsible sourcing of materials is encouraged by the London Plan and required by BREEAM[11]. In Old Oak high rise buildings there may be potential for use of timber as a structural component, which would provide carbon and other benefits. This needs further exploration. In particular, issues of fire protection needs close attention.	• Developers and designers should specify materials from suppliers who participate in responsible sourcing schemes such as the BRE BES 6001 Framework Standard for Responsible Sourcing[8] and that operate Environmental Management Systems certified against ISO14001[9] or EU Eco-Management and Audit Scheme (EMAS)[10] standards, covering all stages of material manufacturing. • All timber specified should be sourced from schemes supported by the Central Point of Expertise on Timber Procurement[12], such as FSC accreditation (which ensures that the harvest of timber and non-timber products maintains the forest's ecology and its long-term liability) or PEFC accreditation. The Timber Supply Panel set up to facilitate the use of only sustainable timber during the delivery of the Olympic and Paralympic Games provides a good exemplar[13].
Locally sourced materials	• As part of their Sustainable Materials Plan, developers will be required to provide a Local Materials Sourcing Strategy clearly setting out the approach for maximising use of locally sourced materials, i.e. from within or close to London. Where it is proposed to use non-local materials which are available locally, a clear explanation of reasons for this should be set out.	• Many construction materials are available to source locally. This helps reduce carbon emissions from transport of goods to site, improving overall construction-related carbon emissions. It also helps support the local economy and can help enhance the local identity and distinctiveness of development.	• Developers should choose materials which are produced locally, where this is appropriate and feasible. This should be at a level in-line with best practice.
Healthy materials	• As part of their Sustainable Materials Plan, developers will be required to demonstrate compliance with the target of zero toxic materials for all new and retrofit development. A list of proscribed and controlled materials will be developed by OPDC, which all new and retrofit development will be required to comply with . • Use of volatile organic compound (VOC) emitting materials in all new and retrofit development will be required to comply with targets set in the Air Quality topic section above.	• The London Plan (policies 5.3, 7.09) encourages minimising the specification of unhealthy materials. This is reiterated in NPPF (paragraphs 58-59), and the Mayor's Sustainable Design and Construction SPG.	• Old Oak and Park Royal should aspire to zero unhealthy materials, avoiding toxic materials and those that produce VOCs.

8 See http://www.greenbooklive.com/search/scheme.jsp?id=153.
9 See http://www.iso.org/iso/iso14000.
10 See http://ec.europa.eu/environment/emas/index_en.htm.
11 Building Research Establishment Environmental Assessment Method. See www.breeam.com.
12 See https://www.gov.uk/government/groups/central-point-of-expertise-on-timber.
13 See http://learninglegacy.london2012.com/documents/pdfs/sustainability/425009-188-timber-aw.pdf.
15 The Living Building Challenge accreditation scheme (see http://living-future.org/lbc) and the WELL Building Standard, International Well Building Institute, New York, 2016, are recommended as a starting points. A list of proscribed materials could include (but would not be limited to) asbestos, polychlorinated biphenyls and those including lead and mercury.

Best Practice Case Studies

East Village and One Brighton have been referenced as examples of current best practice in terms of materials performance.

They clearly indicate that ambitious targets for sustainable materials in terms of recycled content are being set for large scale new development. In many cases materials with higher recycled content cost no more – and can cost less – than typical 'standard' materials.

Although the use of materials with recycled content as a component of overall carbon reductions is commonly recognised, with the exception of East Village none of the case studies included embodied carbon targets. This is perhaps not surprising given the current still emerging methodological basis for estimating embodied carbon early in the planning and design phases, particularly for larger scale development, in contrast to operational carbon.

The recent UK Green Building Council publication "Embodied Carbon: Developing a Client Brief"[6] provides guidance on how to commission an embodied carbon measurement and also includes suggestions and signposts to resources on reducing embodied carbon. The guidance also includes measurement commissioning briefs from British Land and Derwent London. The British Land approach includes a requirement for a 15% reduction against a set of benchmark ranges for four building types based on industry information and existing British Land detailed project analysis. Both the Derwent London and British Land approaches emphasise a process of measurement and testing as design progresses. This aspect is also emphasised in consultation with developers and contractors / suppliers, including early engagement with materials / product suppliers. In terms of carbon footprinting methodologies, while the Derwent London approach references the BS EN 15978:2011 standard[17], the British Land approach cites the RICS Methodology to Calculate Embodied Carbon (1st edition)[18].

Many construction projects in the UK are now achieving levels of 90% or more timber sourced from accredited FSC / PEFC suppliers. This would indicate that the 50% target in the Mayor's Sustainable Design and Construction SPG is insufficiently ambitious. Current policy commitments by developers Barratts[19] and Lendlease[20] to use of 100% FSC / PEFC accredited timber indicate this should be achievable at Old Oak.

There is increasing pressure on main contractors to ensure that they are buying products / materials from sustainable sources. The UK Contractors Group (UKCG) have committed UKCG members to "support and give preference to procuring products which are able to demonstrate compliance with a recognised responsible sourcing scheme, certified by a third party". Contractor Sir Robert McAlpine reported that 84% of all materials reported were responsibly sourced in 2015[21]. Developers Barratt reported 54% of construction materials responsibly sourced to BES 6001 in 2016[19].

East Village (0% unhealthy materials) provides a strong example of best practice in specification of healthy materials. Elephant and Castle (0% VOCs), described elsewhere in this report, has also set strong healthy materials targets.

East Village, London

The former London 2012 Olympics Athletes Village overlooks the Queen Elizabeth Park. The scheme is close to Stratford International Station and HS1. The density of the apartments is similar to Old Oak Park.

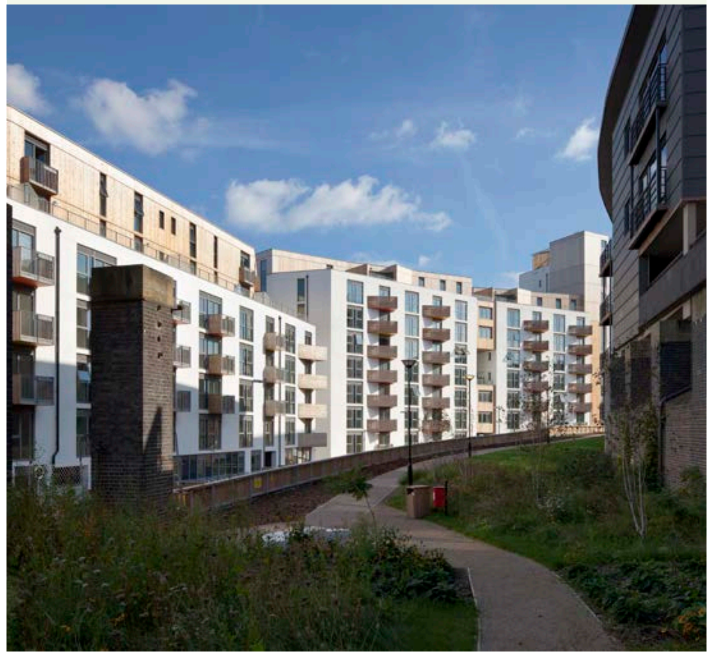
Measures implemented include 15% reduction in embodied carbon (compared to industry baseline); 34% minimum recycled content of major materials (by value); 20% of construction materials reused/recycled; 86% responsibly sourced materials. East Village also includes an ambitious target (100%) for sustainably harvested timber.

East Village (0% unhealthy materials) provides a strong example of best practice in specification of healthy materials.

© Jimmy Wu Photography

One Brighton

This development implemented pouring of greenest concrete frame in the UK: post-tensioned concrete with 50% ground granulated blast furnace slag cement substitute, and 100% secondary aggregates. Specified sustainable construction materials such as natural clay blocks and wood fibre insulation. Healthy, locally and responsibly sourced materials with low environmental impacts. 49% recycled materials (by weight) used in construction.



© Tim Crocker

16 Developers consulted included Argents, British Land and Lendlease. Contractors / suppliers consulted included FM Conway, Royal BAM, Skanska and Tarmac.

Site Materials Analysis Old Oak

Carbon Efficient Materials

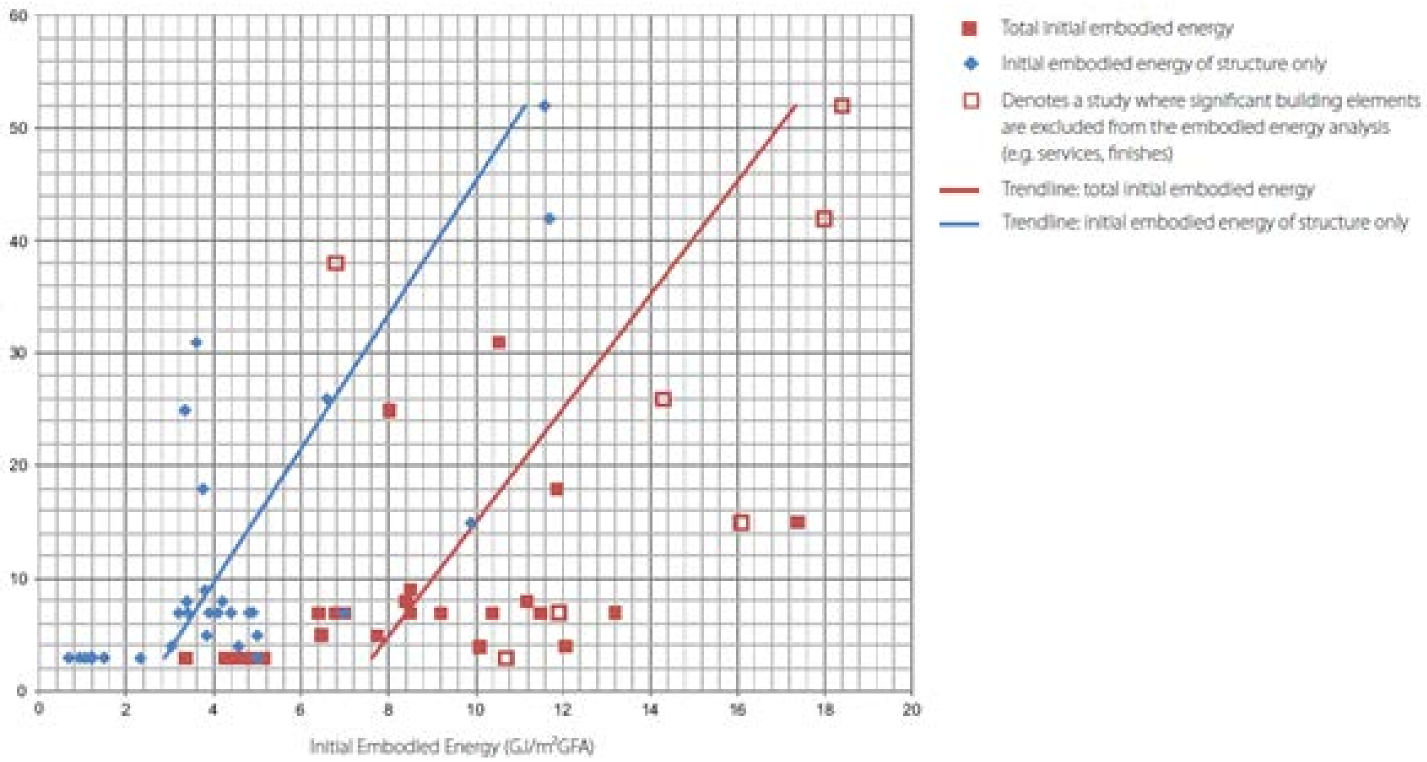
The high density, high rise development proposed at Old Oak will likely entail more dense material use per area unit. In particular, the development's tall buildings are likely to have higher volumes of steel and concrete than lower rise buildings, per m^2 of gross floor area (see Figure 4.2). These materials usually equate to a significant proportion of the total embodied carbon, which could be reduced with selective use of recycled aggregates, cement substitutes and recycled steel. High rise office buildings are also typically characterised by high volumes of glass, which also has a relatively high carbon footprint compared to concrete.

In addition to recycled content and lower carbon materials substitution, reduction in overall mass of materials, in particular more carbon intensive materials, with use of lighter materials and structures can also increase overall carbon efficiency.

Use of Recycled Materials

Due to the high density, high rise development proposed in Old Oak it is expected that high volumes and relative densities of materials will be required, particularly concrete and steel. It is anticipated that enhancing the recycled content of these materials will form a particular focus. The potential for use of high recycled content in other materials should also be fully explored.

Figure 4.2 – Relationship between Building Height and Initial Embodied Energy



Source: Tall Buildings in Numbers, Council on Tall Buildings and Urban Habitat Journal, 2009 Issue III

Exemplary performance in terms of sustainable materials use at Old Oak would require substantial reduction in the use of virgin materials. Table 4.17 below shows exemplary performance regarding recycled aggregates according to BREEAM.

Ensuring that Materials are Sustainably Sourced

Timber is currently most often used in tall buildings in window frames, doors, stairs, floorings and fittings. It is not commonly used for structural purposes in tall buildings. There is, however, an emerging trend for timber-framed high rise buildings in the UK, as well as use of cross-laminated timber in lower rise buildings. The lighter weight, relative to concrete and steel, and renewable nature of the material are two of the benefits most commonly cited for greater use of timber in building construction. However, there is considerable uncertainty regarding the embodied carbon of timber. Although wood itself, if from sustainably managed sources, can be considered carbon neutral, current publicly available figures indicate energy used in the production of timber gives it a carbon footprint higher than concrete[22]. Changing fuel mix in the energy used in timber production could substantially reduce this carbon footprint, making timber closer to overall carbon neutral. Structural use of timber also presents fire protection issues.

Use of timber which is certified to either FSC or PEFC accreditation schemes at Old Oak will be essential in ensuring adherence to UK best practice and exemplary use of sustainable materials, as well as alignment with the London Plan. Current sustainability policy commitments by developers Barratts and Lendlease indicate this should be achievable.

Ensuring all other construction products used at Old Oak are sustainably sourced will also be key to achieving the overall objective of exemplar sustainability performance. A requirement for all materials / products to be supplied from suppliers who participate in responsible sourcing schemes such as the BRE BES 6001 Framework Standard for Responsible Sourcing would provide a robust process for this.

Sourcing Materials from Local Sources

Where appropriate developers should choose materials which are sustainably produced locally. Many natural products such as timber, wool and paper insulation can be sourced in or close to London.

This should be encouraged in Old Oak where possible. One Brighton provides a good example of locally sourced materials being targeted on a development. However, in this development key construction materials were not available locally, or were unable to meet insurance requirements (for example chestnut weatherboarding).

17 BS EN 15978:2011 Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method, British Standards Institute, November 2011. See http://shop.bsigroup.com/ProductDetail/?pid=000000000030256638.
18 Methodology to Calculate Embodied Carbon, 1st edition. http://www.rics.org/uk/knowledge/professional-guidance/guidance-notes/methodology-to-calculate-embodied-carbon-global-guidance-note-1st-edition/.
19 See http://www.barrattdevelopments.co.uk/~/media/Files/B/Barratt-Developments/documents/sustainability-report-2016.pdf.
20 See http://www.lendlease.com/au/company/sustainability/our-progress/material-and-supply-chain/.
21 See http://sustainability.sir-robert-mcalpine.com/_assets/pdfs/McAlpine_Sustainability_Performance_Summary_Download.pdf.

Table 4.17: BREEAM 2014 minimum levels (by weight and volume) of high grade aggregate specified per application (where present) that is recycled or secondary aggregate

Application	BREEAM exemplary performance (min %)
Bound	
Structural frame	30%
Bitumen or hydraulically bound base, binder, and surface courses for paved areas and roads	75%
Building foundations	35%
Concrete road surfaces	45%
Unbound	
Pipe bedding	100%
Granular fill and capping	100%

Source: BREEAM UK New Construction (2014).

Healthy Materials

Old Oak presents the opportunity of specifying zero unhealthy materials, avoiding toxic materials and those that produce VOCs. The Living Building Challenge accreditation scheme[24] has produced a "Red List" of materials which are to be avoided on sites attempting materials accreditation representing best practice, including alkylphenols, asbestos, cadmium, chloroprene, lead, mercury, phthalates and polyvinyl chloride.

Managing Existing Resources

As a completely new development, Old Oak presents the opportunity of taking early stage decisions to implement best practice in sustainable materials use. However, the fact that it is a new development reduces the potential for re-using or re-cycling existing resources. Further research is recommended on this area to evaluate potential re-using scenarios.

Park Royal

In Park Royal there could be possibilities for implementing sustainable materials in building retrofits. This is discussed in the Environmental Quality section below with regard to the potential need for reducing the heating demand of industrial buildings. One means of heat demand reduction would be improving insulation of current industrial buildings. An 'A' rating from the BRE Green Guide should be ensured for all retrofit insulation implementation.

The limited area of new build planned for the south west of the Park Royal site presents potential for implementing sustainable materials. The approach should be similar to the one already outlined for Old Oak in the section above.

Potential for developing new models of commercial building and building use has been identified in Park Royal. This brings the possibility of implementing lightweight materials, such as composite demountable partitions, in order to generate flexible office spaces, aiming to reduce the carbon footprint of retrofit spaces.

If roads, paving and walkways are to be upgraded or replaced, there is potential for use of recycled and renewable materials, such as reclaimed asphalt pavements, coal combustion products, microalgae, pozzolans, etc. Other possibilities could include recycling onsite debris, use of local materials, long lasting pavement and perpetual pavements.

Cost Implications

Case studies in the recent UK Treasury Infrastructure Carbon Review[25] indicate cost savings specifically from embodied carbon reduction initiatives of around 4 – 6% for large infrastructure schemes: water transfer (Anglian Water) and motorway widening (Highways Agency). Consultations with developers and contractors / suppliers indicate that early establishment of an agreed baseline and standardised measurement and analysis methodology are important in reducing costs and creating the conditions and incentives to encourage innovative design solutions which can save costs as well as reduce embodied carbon.

Publically available research indicates that potential costs premiums associated with use of sustainably sourced timber can vary considerably, and depend primarily on supply and demand[26]. A study focused on prices for Malaysian timber[27] indicates a considerable price premium for FSC certified timber for certain species groups, ranging from 5% to 77%. A study of prices for certified logs in the Japanese timber market[28] found a premium of only 1.4% compared to uncertified logs. However, a BRE led study published in 2005[29] indicated that capital cost uplift associated with specification of responsibly sourced timber at design stage can be zero. Consultations with developers and contractors / suppliers indicate that use of 100% certified timber is now becoming established as the norm. However, while PEFC certification does not attract a premium, FSC certification does. A certification target which allows either FSC or PEFC certified timber would not be expected to result in prohibitive cost premiums.

Guidance from the UK Waste and Resources Action Programme (WRAP)[30] indicates that increasing the recycled content of common construction materials, e.g. aggregates, concrete and concrete products, asphalt, drainage products/pipes, need have no impact on project cost or design and there is no need to use unfamiliar materials. By adopting the most significant opportunities to increase recycled content through the use of cost competitive, readily available products, levels exceeding 15–20% are common.

Consultation with developers and contractors / suppliers indicates that there can be cost premiums for use of some recycled materials. Cost for recycled aggregates can sometimes be lower than virgin aggregates, which also attract a levy. However, concrete suppliers' use of additional cement in their

22 The Inventory of Energy and Carbon (ICE) database, originally developed at the University of Bath. See http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html#.WJnnPU1XXIU.
24 See http://living-future.org/lbc.

mix with recycled aggregates can result in an overall premium for concrete with recycled aggregates. Use of recycled materials in asphalt does not usually attract a cost premium and can sometimes result in a cost reduction. The cost impact of use of common cement substitutes in concrete depends on the percentage used. There is generally no cost uplift for use of GGBS up to around 35% content. Use of PFA, the price of which has doubled recently, partly as a result of a reduction in the number of operating coal-fired power stations in the UK, can result in a cost premium. Recycled content in steel reinforcement is now close to 100%. Recycled content of up to 40% for structural steel is also well established and thus has little cost impact.

Targets

Table 4.18 sets out the recommended environmental performance targets. The section below provides information on how the targets have been derived.

Rationale for Targets

The following principles underpin development of the targets:

- Compliance with current Mayoral policies and guidance.
- Current and emerging UK and international best practice.
- Indicative assessment of potential materials strategies to promote use of sustainable, healthy materials, and low carbon, sustainably sourced materials.

Based on the site analysis and current and emerging best practices and methodologies, guideline materials performance targets have been set.

The targets for percentage embodied carbon reduction are based on UK Green Building Council guidance and current UK best practice.

The targets for percentage of recycled / reused content are based on WRAP and BREEAM guidance and current UK best practice. The targets for Park Royal recognise that opportunities for use of higher recycled content materials within retrofit projects may be lower than for new build.

The targets for percentage of wood from certified sustainable sources are based on current UK best practice.

Targets for percentage of materials by value from suppliers participating in responsible sourcing schemes are based on current UK best practice.

The targets for percentage of toxic materials are based on industry guidance and current UK best practice.

It is recommended that the targets and guidelines are regularly reviewed and revised as appropriate, preferably annually.

Table 4.18 – Recommended Targets

Objective / Indicators	Target			
	Old Oak		Park Royal	
	Short Term	Medium Term - Long Term	Short Term	Medium Term - Long Term
Objective 1: Optimise use of low carbon, sustainably sourced, healthy materials				
Percentage reduction in overall embodied carbon (kgCO2e/m^2 GFA) against site-specific benchmarks	15%	20%	15%	15%
Percentage by value of wood from certified sustainable sources	100%	100%	100%	100%
Percentage of materials by value from suppliers participating in responsible sourcing schemes such as BRE BES 6001	80%	80%	80%	80%
Percentage by weight of materials which are toxic	0%	0%	0%	0%

Notes: Short-Term: up to 2031; Medium Term-Long Term: 2032 onwards

23 See www.calrecycle.ca.gov/greenbuilding/Training/StateManual/Materials.
24 See http://living-future.org/lbc.
25 See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260710/infrastructure_carbon_review_251113.pdf
26 Cost of Green Revisited, David Langdon, July 2007. http://smartenergy.illinois.edu/pdf/Archive/Cost%20of%20Green %20Revisited.pdf.
27 Kollert, W. and Lagan, P., Do Certified Tropical Logs Fetch a Market Premium?, XXII IUFRO World Congress 2005, Brisbane, Session 168: Environmental goods, institutions, and markets
28 Yamamoto, Y. et al, Is there a price premium for certified wood? Forestry Politics and Economics, Volume 38, January 2014, Pages 168–172
29 Putting a price on sustainability, BRE Centre for Sustainable Construction, BRE Trust, and Cyril Sweett, May 2005.
30 See http://www.wrap.org.uk/sites/files/wrap/Procurement%20%20Guidance%204pp2.pdf

CARBON EMISSIONS

Overall carbon positive: operational energy, waste, transport

Introduction

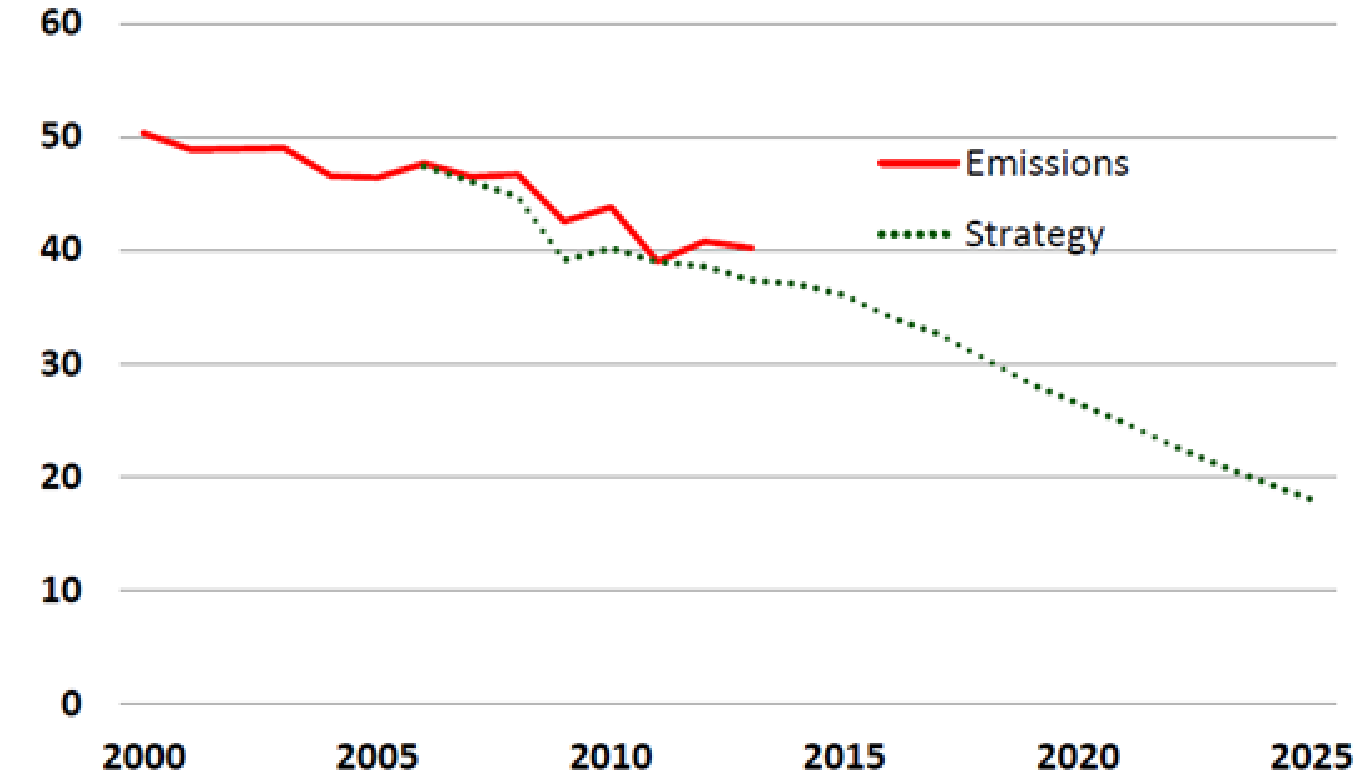
The Mayor has set the ambitious goal for London to become a zero-carbon city by 2050. In his vision, A City for All Londoners (October 2016), he states that London must tackle climate change and become more resilient to its impacts which include warmer, wetter winters and hotter, drier summers and extreme weather events such as heatwaves and heavy rainfall, which are becoming more frequent and intense. To mitigate these changes, he proposes more effective and efficient use of resources, reducing our reliance on fossil fuels and other unsustainable materials, developing the circular economy to reduce waste, reducing our dependency on cars and a shift towards a more affordable, lower carbon energy system and more energy efficient buildings.

Site Context

Recent analysis by the London Assembly Environment Committee[1] indicates that although carbon emissions have fallen since 2005 they are not falling sufficiently to meet the London Plan target of an overall reduction in London's carbon dioxide emissions[2] of 60% (below 1990 levels) by 2025 (see Figure 4.3), and the rate of reduction has been slower than that of the UK as a whole over the same period. Part of the reason for this is the faster than expected population growth in the capital[3]. The London Plan assumed the capital's population would reach 8.8 million by 2031. Updated projections[4] published in 2014 have London reaching 8.8 million by around 2017 and 10 million by 2031.

As with most other urban areas of the UK, London has much lower per capita emissions[5] than less densely populated areas. However, the capital's per capita emissions have been reducing at a slower rate compared to the UK as a whole. London's per capita emissions were 4.9 tonnes in 2012, down from 6.6 tonnes in 1990, a 26% reduction. Overall UK carbon emissions reduced by over a third in the same time period, to approximately nine tonnes[6]. In order to meet the climate targets set by the Mayor and given higher-than-expected population growth, London's per capita emissions need to fall to around 1.9 tonnes in 2025.

Figure 4.3 - Carbon Emissions in London (million tonnes CO_2e per year)



Note: CO_2e: carbon dioxide equivalent[2].
Source: Cutting Carbon in London, 2015 Update, London Assembly Environment Committee, November 2015

Policy Context

Policies regarding carbon emissions are in place across the spectrum of planning policy levels. A core objective of the NPPF is for the UK to become a low carbon economy, encouraging the reuse of existing resources, including conversion of existing buildings, and the use of renewable resources. This is a vision supported in the London Plan. The London Plan has a target to reduce London's carbon dioxide emissions by 60% (below 1990 levels) by 2025. The London Boroughs and Local Planning Authorities are required to develop detailed policies to help aid the achievement of the Mayor's target for London. A number of further regulation and policy documents including Building Regulations Part L 2013 and the Mayor's Housing Supplementary Planning Guidance (SPG) also set targets for reducing carbon emissions for housing and major developments.

London Plan

The 60% carbon emissions reduction target is predicated on a combination of Mayoral action (around 21% of the 60%), and central government action (around 28% of the 60%), on top of underlying business as usual reductions (see Table 4.19). A major component of central government action is centred around decarbonisation of grid electricity.

Government figures[7] from 2012 indicate a 38% reduction in grid electricity carbon intensity between 2016 and 2026, to around 200gCO_2e/kWh[8]. Recently published estimates by the National Grid[9] indicate an even steeper decline of 43% over the same period, to around 160gCO_2e/kWh, for even the most conservative of four scenarios posited (see Figure 4.4). In both

1 Cutting Carbon in London, 2015 Update, London Assembly Environment Committee, November 2015.2
2 Emissions of greenhouse gases (GHG) are commonly expressed in terms of tonnes of carbon dioxide equivalent (CO2e). This takes into account the global warming potential of each greenhouse gas to provide a common, unified measure of GHG emissions. CO2e is commonly referred to simply as 'carbon'.
3 Additional factors include issues related to lifestyles, as well as divergence between designed and actual building performance.
4 Further Alterations to the London Plan, GLA, December 2014.
5 GHG emissions figures for London are from the London Energy and Greenhouse Gases Inventory (LEGGI), which covers Scope 1 and 2 emissions only (as defined by the GHG Protocol).
6 UK national GHG emissions are those reported to the United Nations Framework Convention on Climate Change (UNFCC) which include all scope 1, 2 and 3 emissions with the exception of emissions embodied in imported goods and services.
7 Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, UK HM Treasury, October 2012.
8 Kilowatt hours, a common measure of energy consumption.
9 Future Energy Scenarios, National Grid, July 2016.

ATKINS

cases estimated reductions are driven mainly by the cessation of coal-fired generation by 2025 and increases in renewable generation over the next decade, and are predicated on the need to meet the UK's commitment to an 80% reduction in greenhouse gas (GHG) emissions by 2050. Substantial reductions in the carbon intensity of grid electricity imply lower carbon impacts from electrical heat pump and solar thermal technologies to meet thermal demand compared to the lowest carbon fossil fuelled combustion technology of natural gas. This is explored further under the Energy topic section above. They also imply substantial increases in mode share of electrically powered motorised transport.

Recently issued Mayoral guidance on housing and energy planning has confirmed that, despite the Government removing the national requirement for new homes to be zero carbon by 2016, the Greater London Authority (GLA) will apply the following carbon emissions targets to applications from 1 October 2016: zero carbon (as defined in section 5.2 of the Mayor's Housing SPG) for residential development, and 35% below Building Regulations Part L 2013 for non-residential development. The Mayor's Housing SPG defines 'zero carbon' homes as homes forming part of major development applications (typically 150 units or more) where the residential element of the application achieves at least a 35% reduction in regulated carbon dioxide emissions (beyond Building Regulations Part L 2013) onsite. The remaining regulated carbon dioxide emissions, to 100%, are to be off-set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere. London Plan Policy 5.2 also requires that all non-residential development will comprise zero carbon buildings by 2019. The London Plan includes a presumption that "all major development proposals will seek to reduce carbon dioxide emissions by at least 20 per cent through the use of onsite renewable energy generation wherever feasible". The percentage target applies to all major new development. The use of a full range of renewables technologies, including both thermal and electrical, is encouraged.

Table 4.19 - Project CO_2 Emissions Reductions in London

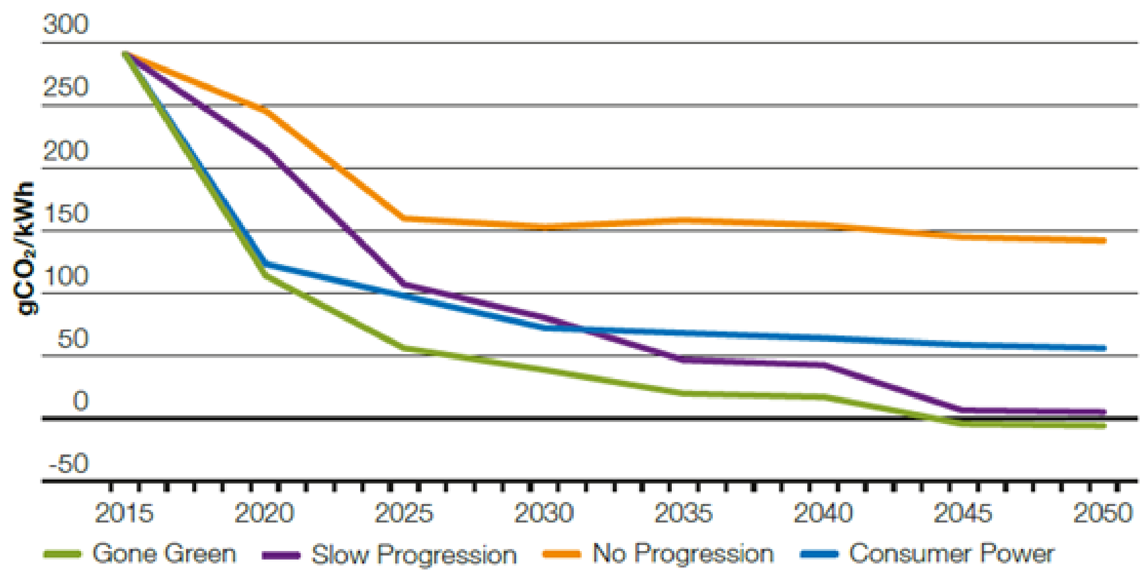
Source		Total savings by 2025 ($MtCO_2$ per year)	Proportion of total savings (per cent)	Contribution to 60 per cent reduction target by 2025
Business as Usual		4.88	18.0	10.8
Committed government action		8.49	31.4	18.8
Mayoral	Committed action	5.84	21.6	13.0
	Further action	3.51	13.0	7.8
Further government action		4.33	16.0	9.6
Total		**27.05**	**100**	**60**

Note: Mt: megatonne (million tonnes).
Source: The Mayor's Climate Change Mitigation and Energy Strategy, Mayor of London, October 2011.

In summary, current Mayoral policy and guidance indicates, as a minimum, the following requirements for all major new developments:

- Per capita carbon (CO_2e) emissions of less than two tonnes by 2025.
- Zero carbon residential development from October 2016, and zero carbon non-residential development by 2019.
- Major switch to electrical energy consumption by 2026, including for building thermal demand and transport.
- 20% reduction in energy related carbon emissions from deployment of onsite renewables.

Figure 4.4 – Electrical Grid Decarbonisation Scenarios



Source: Future Energy Scenarios, National Grid, July 2016.

To ensure the reductions trajectory is sufficient to meet the 2025 target, greater ambition will be required of all developments going forward.

OPDC Objectives and Policy Recommendations

Based on review of mayoral policies and guidance (set out above) and review of best practice case studies and initial site energy analysis exploring onsite demand reduction and low carbon energy generation potential (see sections above), carbon emissions policy recommendations for Old Oak and Park Royal have been developed and are set in Table 4.20 below. Policy recommendations are grouped under the one core objective, overall carbon positive, which also forms the basis of the recommended targets below. Measures are also recommended as part of an integrated carbon emissions reduction strategy for Old Oak and Park Royal.

Table 4.20 – Old Oak and Park Royal Carbon Objectives and Policy Recommendations

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Overall Carbon Positive			
Driving Carbon Emissions Reduction	• Old Oak and Park Royal will be developed as an exemplar of high density, high rise sustainable development. The aspiration is for all new development at the OPDC site to be zero carbon. In line with current GLA policy and London-wide carbon accounting[10], 'zero carbon' is defined in terms of operational emissions which are readily measureable. • In addition to operational emissions, carbon emissions embodied in materials and products used or consumed at the site are likely to form a significant component of the overall carbon footprint. OPDC will work with developers and infrastructure services providers to ensure that data on embodied carbon are collected, monitored and reported from the earliest stages of planning and design through to construction, operation and decommissioning. • OPDC will work with the GLA, other London public authorities, regulators, infrastructure services providers and developers to develop an appropriate Carbon Planning and Management Framework (CPMF) for defining and implementing exemplar zero carbon development at Old Oak and Park Royal. As part of planning applications, developers will be required to develop strategies demonstrating how their proposals comply with the CPMF. This will include submission of a Carbon Reduction Strategy clearly setting out the approach to reducing carbon, and measures proposed to achieve quantified reductions.	• Recent GLA policy requires all major new development to be zero carbon by 2019. This requirement is defined in terms of energy related emissions from buildings. • The analysis in this report indicates that it would be feasible to extend the definition of zero carbon development for the OPDC site to include transport and waste related operational carbon emissions, as set out in the C40 Cities Climate Positive Communities Framework (see Box 1 below). Further work is required to delineate specific potential risks and uncertainties, as well as procedures and mechanisms which would be required. • Methodologies for estimating and measuring overall carbon emissions for London, including embodied carbon, have been the subject of recent study supported by the GLA[11]. There is currently no established methodology or set of emissions factors for estimating embodied carbon from broad planning and design data covering land use and/or building types. However, it is important to ensure that, in addition to data on operational carbon emissions, embodied carbon data are collected, monitored and reported from the earliest stages of planning and design and through to construction, operation and decommissioning, and that a robust CPMF is in place to ensure this.	• To provide a clear mechanism for developing exemplar carbon performance for the site, particularly for Old Oak, it is recommended that the C40 Cities Climate Positive Framework (see Box 1 below) is considered for all or part of the site. This provides for optimal reduction of operational energy, transport and waste emissions, incentivising onsite and near offsite low carbon energy generation and carbon sequestration, with residual emissions offset by support for carbon reduction initiatives in surrounding areas. The C40 Cities Climate Positive Framework is a well-established and globally recognised mechanism for pioneering city led low carbon development initiatives, with an existing project at Elephant and Castle in London. With the new Mayor recently elected as Vice Chair on the C40 Cities Climate Leadership Group Steering Committee, designation of C40 Climate Positive project at Old Oak and Park Royal will provide a unique opportunity for the project to act as a beacon for ambitious low carbon development in London, the UK and internationally. • To ensure maximum buy-in and effectiveness, developing the CPMF should involve a process which includes extensive stakeholder engagement as well technical inputs. In particular, definition of the carbon emissions boundary and data requirements for carbon accounting, will require close attention. The process developed for the carbon footprinting methodology for London 2012 is recommended as a best practice reference for such an approach. Key issues highlighted in development of the London 2012 carbon footprinting methodology included: the importance of early assessment of the footprint, the need for a structured and inclusive approach to carbon management and the importance of external scrutiny and engagement. Developers such as British Land and Derwent London have also developed processes for managing the systematic monitoring and documentation of embodied carbon reductions throughout the planning and design process (see the Materials topic section above), providing templates which can help inform development of the CMPF. • The CPMF should be developed to ensure consistency with the London Energy and Greenhouse Gas Inventory (LEGGI)[10] and the Greenhouse Gas (GHG) Protocol[12]. Development of the CPMF is recommended as part of a separate carbon study.

10 London Energy and Greenhouse Gas Inventory (LEGGI), GLA, 2014. https://data.london.gov.uk/dataset/interim-london-energy-and-greenhouse-gas-inventory--leggi--2014
11 Application of PAS 2070: London case study, British Standards Institute, 2014. https://data.london.gov.uk/dataset/application-pas-2070-london-case-study.
12 The GHG Protocol is a widely recognised set of standards developed by the Greenhouse Gas Protocol Initiative, a partnership convened by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The Protocol provides a step-by-step guide for companies and government agencies to use in quantifying and reporting their GHG emissions. See www.ghgprotocol.org.

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Overall Carbon Positive			
Measuring and Monitoring Carbon Emissions	• As part of the CPMF, OPDC will work with the GLA, other London public authorities, regulators, infrastructure services providers and developers to develop procedures and mechanisms to ensure accurate measurement, collection, management and analysis of carbon related data to create a detailed 'live' carbon footprint for the site. • Developers, utility services providers, associated consultants and contractors, and management services providers will be required to measure, collect, record and submit carbon related data in accordance with the CPMF. The CPMF will cover all phases and stages, from early design through to operation and decommissioning, and include data on embodied carbon emissions as well as operational and 'end-of-life' emissions. • As part of planning applications, developers will be required to submit a CPMF plan setting out how they will ensure compliance with CPMF procedures and mechanisms.	• To ensure policy compliance, as well as support continual improvement, learning and knowledge sharing, it will be essential to develop well designed, practical procedures and mechanisms to ensure efficient and effective measurement collection, management and analysis of carbon related data across all development phases and stages. • Development of a site wide CPMF will be very important in building up a site-specific picture of carbon emissions, including embodied emissions, which can help inform further development and refinement of site-wide and/or sub-area specific policies, measures and targets.	• It is recommended that an appropriate set of procedures and mechanisms is developed for ensuring accurate measurement, collection, management and analysis of carbon related data to create a detailed 'live' carbon footprint for the site. The framework should be designed for use throughout all phases of development at the OPDC site, from the earliest design stages, through procurement, construction supervision, post-construction monitoring, and decommissioning. It should include data on embodied carbon emissions as well as operational and 'end-of-life' emissions, i.e. covering the entire development lifecycle.
Carbon Offsetting	• As part of the CPMF, OPDC will work with relevant stakeholders to develop guidance on site-specific procedures and mechanisms for offsetting residual carbon emissions. • As part of planning applications, developers will be required to develop strategies demonstrating how their proposals will be compliant with OPDC carbon offsetting procedures and mechanisms.	• London boroughs currently apply different carbon offsetting methodologies and different carbon prices for use in offsetting. Clear, site-specific guidance is required for Old Oak and Park Royal to provide consistency and certainty in application of carbon offsetting across all development for the site.	• Exploring potential mechanisms for offsetting residual carbon emissions is recommended for further work. This would cover both onsite and offsite carbon sequestration, as well as potential payment mechanisms.

Box 1 – C40 Cities Climate Positive Framework

The C40 Cities Climate Positive Framework underpins C40 Cities' Climate Positive Development Program, which supports the creation and implementation of large-scale urban communities that reduce greenhouse gasses and serve as models for cities to grow in environmentally sustainable and economically viable ways. The Framework is consistent with the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC), which is in-line with International Panel on Climate Change (IPCC) guidelines and allows for consistent and comparable measuring of city/area wide GHG emissions.

The Framework principally requires measurement of annual operational emissions on completion of the development, although it also includes recording of emissions from site preparation and construction phases. The operational emissions considered are from three main sectors:

- **Stationary energy** - from onsite thermal and electrical uses including from buildings, infrastructure and water use.
- **Solid waste and wastewater** - produced from onsite sources.
- **Transportation** - including emissions from trips that begin or finish onsite.

These categories are not prescriptive and allow flexibility to guide solutions relevant to each development's unique circumstances. For example, it is suggested that 40% of transportation emissions from trips that begin or finish onsite are counted towards the carbon footprint calculation. However, an alternative proxy could be used where it can be justified by local circumstances. Strategies should be identified to reduce the major sources of construction emissions, despite their exclusion from the emissions impact calculation. In particular construction-related sources of emissions including energy, waste, transportation, embodied carbon and land-use change should be monitored and tracked.

The Framework requires climate positive outcomes (net negative emissions) to be achieved by a) reducing total onsite operational emissions; b) offsetting residual emissions with support for measures such as reducing emissions in adjacent communities, e.g. via exporting clean energy, or creating additional carbon sinks through carbon sequestration measures.

Sources:
Framework for Climate Positive Communities, C40 Cities, Clinton Climate Initiative and U.S. Green Building Council, 2011. http://c40-production-images.s3.amazonaws.com/other_uploads/images/1_Climate_Positive_Framework_v1.1 _Aug_2013. original.pdf?1390706960.
C40 Cities Climate Positive Development Program. http://www.c40.org/networks/climate-positive-development-program.

Evidence

This section sets out evidence supporting the policy and strategy recommendations listed in Table 4.20. Evidence comprises the following:

- Key observations from UK and international best practice case studies.
- Results of site carbon emissions analyses used to explore scenarios for achieving, and potentially exceeding, current Mayoral targets and guidance.

Best Practice Case Studies

The following case studies have been referenced as examples of current best practice in terms of carbon emissions reduction (Refer to Appendix A for full case studies):

- **East Village, London, UK.** A Zero Carbon standard was defined for the project, where a target of 40% and 65% in emissions over Building Regulations 2010 for non-residential buildings and all current and new homes was set respectively. Additionally, a 35% emissions offset was defined through local Allowable Solutions agreement with local boroughs to reach 'Zero Carbon'.
- **Woodberry Down, Hackney, London UK.** The project is projected to achieve 51.8% CO_2 emission reduction against Part L, through a CHP system, two energy centres and fabric efficiency measures.
- **King's Cross Central, London, UK.** Building energy efficiency and supply efficiency measures (via a site-wide approach to district heating, incorporating tri-generation from distributed CHP, and using renewable energy technology) targeted to deliver a reduction of at least 39% for carbon emissions, compared with 2005 energy benchmarks. The long term aim is to achieve a 60% reduction in carbon emissions from 2000 levels, by 2050.
- **Elephant Park, London, UK.** A climate positive target was set for the project, in line with the C40 Cities Climate Positive framework (see Box 1). Carbon targets were set that exceed local policy requirements by 30%. An innovative energy solution includes using bio-methane grid injections to offset carbon and connecting 1,000 offsite homes to the CHP system.
- **Stockholm Royal Seaport, Stockholm, Sweden.** By 2020 CO_2 emissions will be less than 1.5 tonnes/person, compared to 4.5 tonnes/person currently, while by 2030 the area will become fossil fuel-free. All new buildings must comply with Passivhaus energy requirements.

From the case study examples it is clear that very ambitious operational carbon reductions have been targeted, including zero carbon

ATKINS

(East Village) and carbon positive (Elephant Park). In cases where reduction targets have been expressed relative to business-as-usual, these are comparable to the Pioneering Practice scenario developed for the present study (see section immediately below). All the case study developments have targeted quantifiable carbon reductions via both energy efficiency and low carbon energy generation. Although several of the case studies (East Village, King's Cross Central and Elephant Park) include energy generation from waste measures as part of quantified carbon reduction targets, only Elephant Park includes transport measures as part of quantified carbon reduction targets.

As highlighted in the Materials topic section above, it is notable that only one case study development (East Village) included a quantified target for embodied carbon.

Site Carbon Emissions Analysis

A set of carbon emissions scenarios was developed for Old Oak and Park Royal. The analysis used to develop the carbon emissions scenarios was based on a) estimates of operational energy and waste from the energy and waste scenarios developed under the site energy and waste analyses for the current study; b) estimates of transport related carbon emissions from the development proposed for Old Oak. The purpose of developing carbon emissions scenarios was to evaluate the overall operational carbon emissions of the two developments under different energy, waste and transport performance scenarios. The carbon emissions scenarios were used to:

a) test the prerequisites for meeting current policy / guidance requirements; and

b) test the potential for exceeding current policy / guidance requirements, under different scenario assumptions.

The results of the site carbon emissions scenarios analysis, as well as supporting information, are set out in detail in Appendix B.3. This section provides an overview of the scenarios developed and the results of the analysis.

Carbon Assessment Methodology

The carbon assessment approach adopted for the present study is broadly based on the BASIC level of the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)[13], which is designed to allow city / area based carbon footprint estimation with limited data availability. Further information on the carbon assessment methodology used, including additional details of standards referenced, is set out in Appendix B.3.

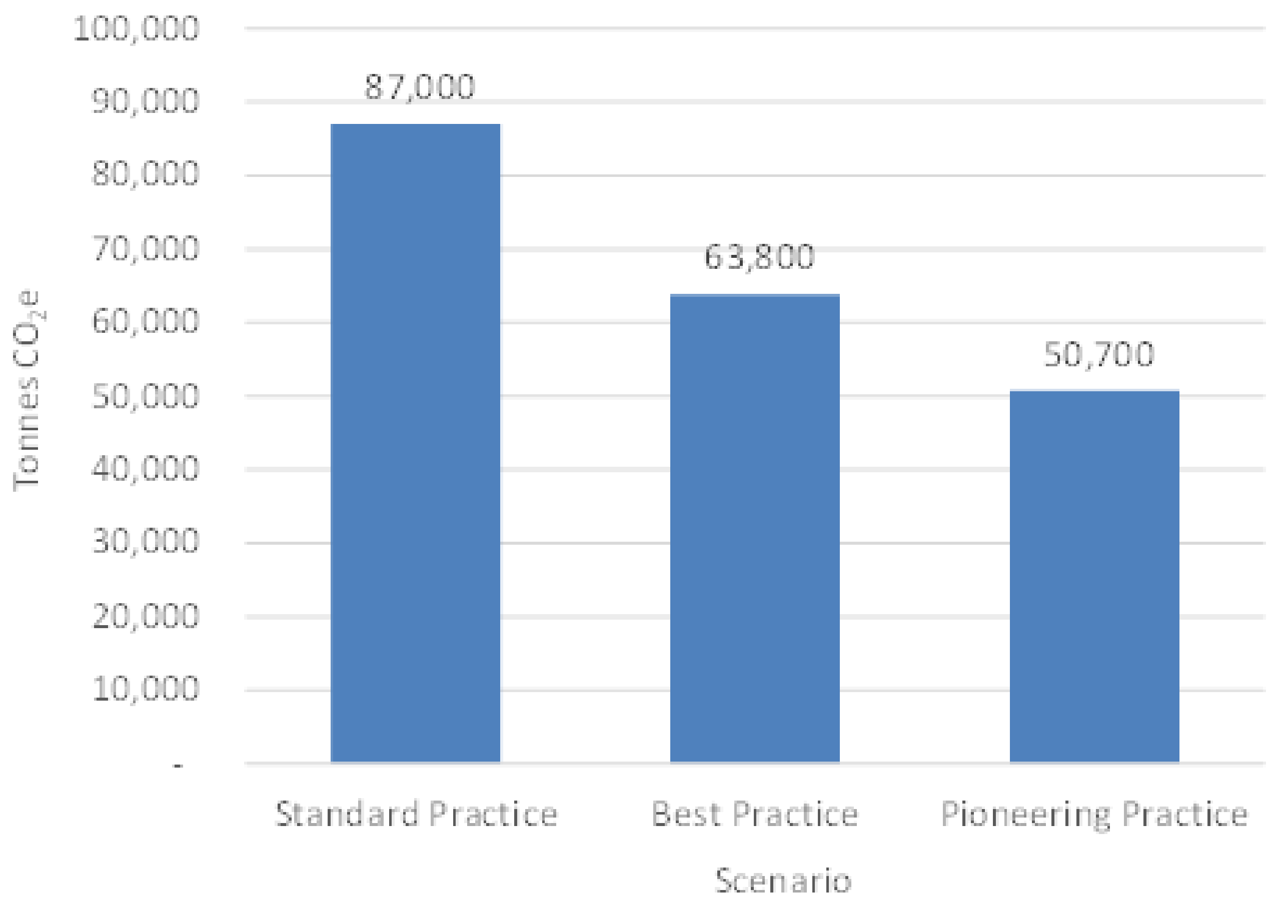
Carbon Emissions Scenarios

To explore the potential operational carbon emissions reduction achievable within both Old Oak and Park Royal a set of three environmental performance scenarios was developed: a Standard Practice scenario and two enhanced performance scenarios - Best Practice, which improves on the Standard Practice scenario, and Pioneering Practice, which improves on the Best Practice scenario. The Standard Practice scenario provides a representation of current average 'Business as Usual (BAU)' practice. The Pioneering Scenario provides a representation of current advanced, leading practice. The carbon emissions scenarios were developed based on combining energy and waste scenarios described in the Energy and Waste sections of this report, together with additional transport scenarios (see Appendix B.3) developed specifically for the carbon emissions analysis. Preliminary high-level estimates of operational carbon emissions were then calculated for each scenario.

Figure 4.5 below compares the total carbon estimates for the three emissions scenarios based on consumption activities only, i.e. without taking into account potential low carbon energy generation. The Pioneering Practice scenario represents a 42% reduction in consumption related carbon emissions from the Standard Practice scenario. Figures 4.6 and 4.7 present a breakdown of consumption related carbon emissions by main sector. These show that consumption related emissions are dominated by emissions from consumption of energy in buildings, with emissions from waste generation forming the smallest proportion of total emissions. Figures 4.6 and 4.7 show that, to achieve the Pioneering Practice emissions scenario involves reductions in the proportions of building energy related and waste related emissions and an increase in the proportion of transport related emissions, although absolute emissions across all three sectors decrease between the Standard Practice and Pioneering Practice scenarios. In other words, emissions from building energy and waste are anticipated to be reduced at a greater rate than those from transport.

13 Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, World Resource Institute, C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability, 2014. http://www.ghgprotocol.org/city-accounting.

Figure 4.5 – Old Oak Carbon Emissions Scenarios Compared



Note: All figures are indicative estimates only. All carbon estimates based on 2031 grid decarbonisation factors.
Source: Atkins analysis

The following sections provide an overview of the measures proposed within each scenario to achieve the projected substantial reduction in consumption related emissions, as well as potential low carbon energy generation which could be deployed to offset the remaining carbon emissions.

The results of the site carbon emissions scenario analysis are then used to evaluate the potential for achieving or exceeding the two current carbon emissions Mayoral targets.

Figure 4.6 – Old Oak Standard Practice Scenario - Emissions Breakdown

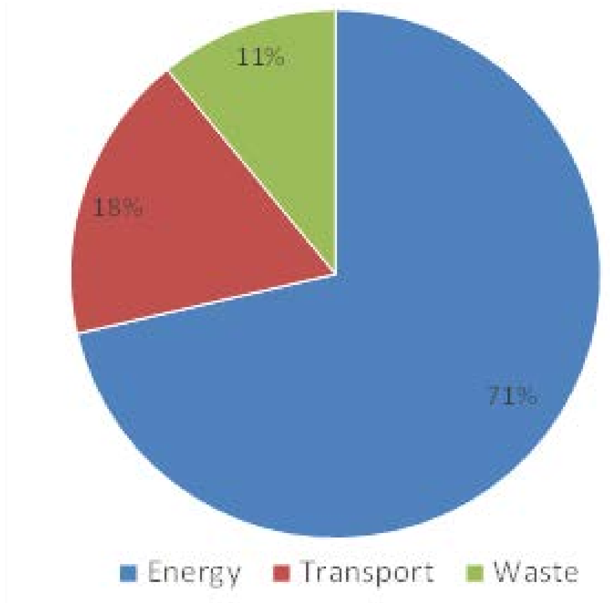
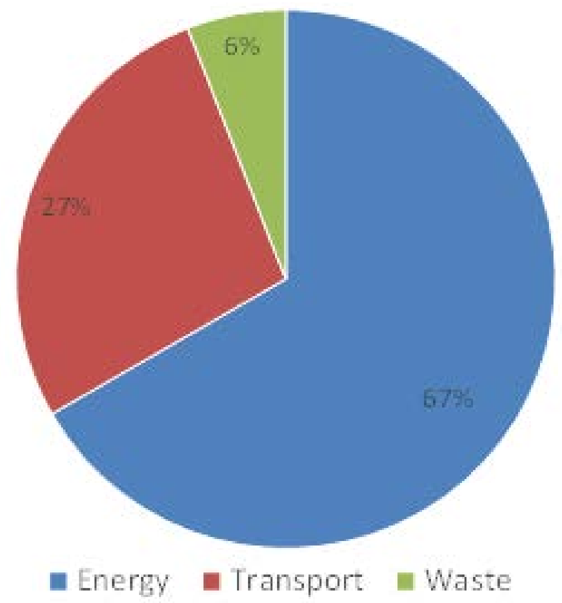
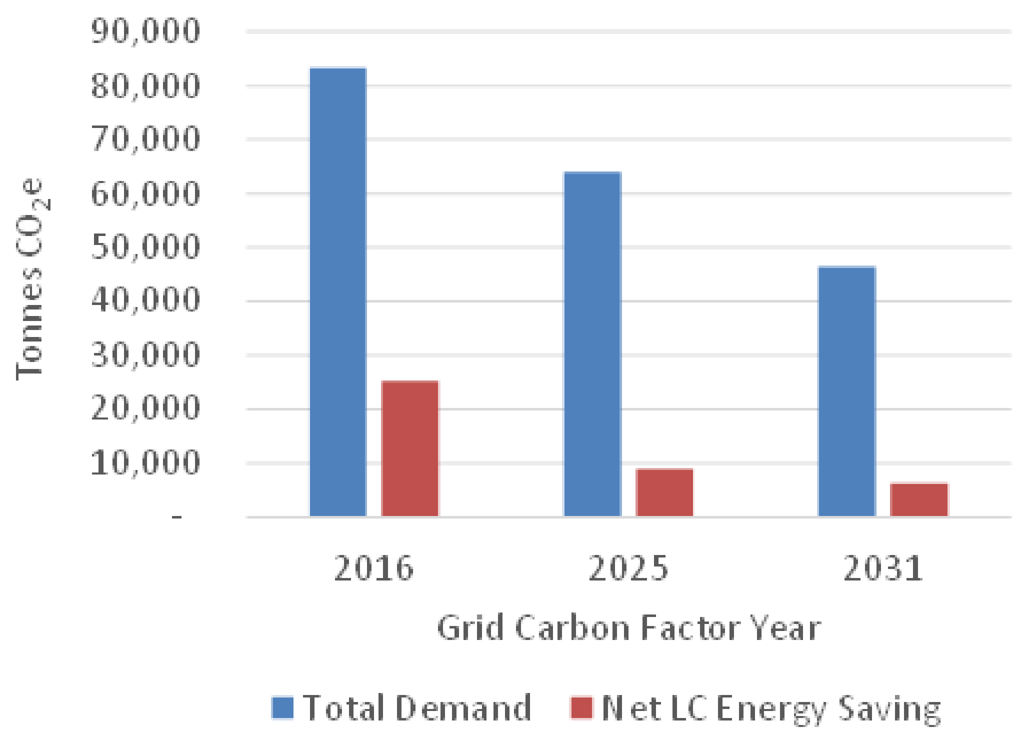


Figure 4.7 – Old Oak Pioneering Practice Scenario - Emissions Breakdown



Note: All figures are indicative estimates only. All carbon estimates based on 2031 grid decarbonisation factors.
Source (all figures): Atkins analysis

Figure 4.8 – Old Oak Building Related Carbon Emissions and Low Carbon Energy Generation Compared by Emissions Scenario



Note: All figures are indicative estimates only. All carbon estimates based on 2031 grid decarbonisation factors.
Source: Atkins analysis

ATKINS

Table 4.21 below summarises the various components comprising each of the carbon emissions scenarios. Summary information on the energy, waste and transport components of each carbon emissions scenario is provided in Tables B.3.2 – B.3.6 in Appendix B.3. Further details on scenario estimates for energy and waste are provided in the relevant topic sections in this report.

Table 4.21 – Summary of Carbon Emissions Scenarios

Carbon Emissions Scenario / Component				Standard Practice	Best Practice	Pioneering Practice
Energy	Old Oak	Demand		Standard Practice	Best Practice	Pioneering Practice
		Low Carbon Energy	Renewables	Combined Renewables Technologies Scenario	Combined Renewables Technologies Scenario	Combined Renewables Technologies Scenario
			Energy from Waste and Anaerobic Digestion	BAU	2016 GD: BAU	2016 GD: BAU
					2025 / 2031 GD: Zero Waste	2025 / 2031 GD: Zero Waste
	Park Royal	Demand		Standard Practice	Best Practice	N/A
		Low Carbon Energy	Renewables	Combined Renewables Technologies Scenario	Combined Renewables Technologies Scenario	N/A
			Energy from Waste and Anaerobic Digestion	Baseline	2016 GD: Baseline	N/A
					2025 / 2031 GD: Low Waste	
Waste	Old Oak			BAU	Zero Waste	Zero Waste
	Park Royal			Baseline	Low Waste	N/A
Transport	Old Oak			BAU	Low Car	Low Car
	Park Royal			N/A	N/A	N/A

Notes: GD: Grid decarbonisation. BAU: Business as Usual.
Source: Atkins analysis.

All scenarios relate to a 2031 development build-out based on master planning figures supplied by OPDC. Due to the importance of electrical grid decarbonisation for several of the parameters underpinning projected carbon emissions, carbon estimates have been calculated using grid carbon factors for 2016, 2025 and 2031 from UK HM Treasury[14]. This allowed the sensitivity of the scenarios to this key factor to be tested.

Summary of Results

The results of the site carbon emissions analysis are detailed in Appendix B.3. Following are the key messages from the carbon emissions analysis:

Mayoral target of 60% carbon reduction (below 1990 levels) by 2025

- **Old Oak.** Implementing the Best Practice or Pioneering Practice carbon emissions scenarios would be expected to result in substantial reductions in overall carbon emissions compared to the Standard Practice scenario (around 25% and 40% reduction, respectively, using 2025 grid decarbonisation factors). Estimates of per capita emissions (1.1 tonnes and 0.9 tonnes respectively, compared to the 1.9 tonnes required by the Mayoral target) based on these overall reductions indicate that this target is achievable. To significantly exceed the target it would be necessary to move beyond business as usual, either in terms of energy efficiency or onsite generation, towards the Best Practice or even the Pioneering Practice carbon emissions scenario, or components thereof. This assumes the grid decarbonises in accordance with current government predictions
- **Park Royal.** Implementing the Best Practice carbon emissions scenario would be expected to result in a substantial reduction in overall carbon emissions compared to the BAU scenario (around 30%, using 2025 grid decarbonisation factors). It was not possible to determine whether this target could be achieved as the measure used (carbon emissions per capita) was not applicable due to the largely industrial nature of area. Further work is recommended to determine an appropriate measure to evaluate this target for Park Royal.

Mayoral target of 20% reduction in energy related carbon emissions from onsite renewables[15]

Old Oak. At 2016 levels of grid decarbonisation it is likely this target is achievable with the mix of low carbon energy generation explored in this study, even under the Standard Practice carbon emissions scenario. With the grid decarbonisation level projected for 2031, the target would be challenging, but potentially achievable. Increasing the proportion of thermal demand which is met by low carbon onsite generation, in particular using electrically powered heat pump technology, could be expected to significantly improve performance against this objective in Old Oak.

Park Royal. Under the Best Practice carbon emission scenario it is likely this target would be challenging, but potentially achievable, with the mix of low carbon energy generation explored in this study, regardless of predicted grid decarbonisation. However, it should be noted that it was not possible to include transport related emissions in the Park Royal carbon scenarios, due to data availability.

14 Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, UK HM Treasury, October 2012.
15 The analysis underpinning the results summarised here is based on the following assumptions: a) energy supply from energy from waste and anaerobic digestion facilities is classified as 'renewable'; b) energy from waste and anaerobic digestion facilities explored in the waste treatment / disposal scenarios can be accommodated onsite.
16 Carbon offsetting estimates in this section are based on a carbon price of £60 per tonne, as indicated in the Mayor's Sustainable Design and Construction SPG.

Total emissions offsetting

Old Oak. Total annual emissions estimates range from around 108 thousand tonnes (highest) for the Standard Practice carbon emissions scenario, with no low carbon energy supply and 2025 predicted grid decarbonisation, to around 44 thousand tonnes (lowest) for the Pioneering Practice carbon emission scenario, with implementation of low carbon energy supply as explored in this study and 2031 predicted grid decarbonisation. Offsetting residual emissions thus represents a substantial potential annual financial burden of around £2.6m to £6.5m annually[16].

Park Royal. Total annual emissions estimates for Park Royal are significantly greater than Old Oak (around 78 thousand tonnes to more than 215 thousand tonnes), and do not currently include transport related emissions. Carbon offsetting would not be retrospectively applied to existing uses, which comprise the majority of emissions sources in Park Royal. However, for purposes of comparison with Old Oak, estimated annual emissions represent a theoretical potential cost for carbon offsetting of around £4.7m to £12.9m annually.

Cost Implications

Indicative capital costs are provided for energy demand scenarios and low carbon energy generation technologies under the Energy topic of this report. Indicative capital costs for waste treatment technologies are provided under the Waste topic of this report.

The indicative costs suggest that a range of potential energy and waste related carbon reduction measures are financially feasible based on commercially established technologies. Key to overall viability are appropriate financing and management mechanisms to enable investment risk to be extended over longer time frames and risks and benefits shared between developers and service providers. Further work is required to explore site-specific integrated approaches covering financial and management mechanisms as well as system and technical considerations which can then be incorporated into carbon emissions scenario components.

Table 4.22 provides indicative normalised costs of carbon saved (£ / tonne CO_2e) for the Best Practice energy demand scenario and low carbon energy generation technologies analysed under the Energy and Waste topics and reported in the relevant topic section above.

Table 4.22 – Indicative Costs of Carbon Savings

Demand Scenario / Energy Generation Technology	Design Life (Years)	Cost (Income) CO_2e Saved (£ / tonne)	Assumptions
Best Practice Building Energy Demand Scenario	60	110 - 180	Overall 5% uplift on current average London construction costs assumed. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Solar photovoltaic (PV)	20	(120) - (190)	FiT assumed to be zero. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Solar thermal	20	(660) - (710)	Currently available grants assumed over design life. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Ground source heat pumps (GSHP)	20	220 - 280	Currently available grants assumed over design life. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Energy from waste ('Zero Waste' scenario)	25	(150) - (210)	Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Anaerobic digestion ('Zero Waste' scenario)	25	(390) - (460)	Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.

Note: All figures are indicative estimates only. Estimated energy savings do not include provision for climate change. Estimated costs exclude operating costs and do not include provision for discounting, taxes, grants or other financial measures other than as indicated.
Sources: Atkins analysis, UK HM Treasury[14], UK Office of Gas and Electricity Markets[17].

16 Carbon offsetting estimates in this section are based on a carbon price of £60 per tonne, as indicated in the Mayor's Sustainable Design and Construction SPG.
17 Feed-in Tariff (FIT): Tariff Table 1 April 2017, Ofgem, February 2017. https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-fit-tariff-table-1-april-2017. Tarrifs and Payments: Domestic RHI, Ofgem, March 2017. https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi/contacts-guidance-and-resources/tariffs-and-payments-domestic-rhi/current-future-tariffs

Targets

Table 4.23 – Recommended Targets

Objective / Indicators	Target			
	Old Oak		Park Royal	
	Short Term	Medium Term – Long Term	Short Term	Medium Term – Long Term
Objective 1: Overall carbon positive				
Overall operational carbon footprint: carbon offsetting - (carbon footprints of operational residual energy + solid waste + transport)	Zero carbon	Carbon positive	10% overall carbon reduction (from 2016 levels)	25% overall carbon reduction (from 2016 levels)

Note: Short-Term: up to 2031; Medium Term-Long Term: 2032 onwards

Table 4.23 sets out the recommended environmental performance targets. The section below provides information on how the targets have been derived.

Rationale for Targets

The following principles underpin development of the targets:

- Compliance with current Mayoral policies and the Mayor's long term goals.
- Current and emerging UK and international best practice.
- Indicative assessment of carbon emissions reduction potential from energy demand and onsite generation, waste treatment and disposal, and motorised transport scenarios.

The Old Oak Short Term target for overall operational carbon footprint is based on current GLA policy for residential and non-residential building. The level of ambition reflected in best practice case studies was also taken into account. To enable achievement of the target, a standardised carbon accounting methodology and appropriate offsetting mechanisms would need to be developed to cover emissions from waste and transport, as well as energy consumption and generation. The Medium-Long Term target for overall operational carbon footprint is based on potential application of the C40 Cities Carbon Positive framework, which is recommended for consideration for all or some of the site, and the example set by the Elephant Park project in Elephant & Castle. The results of the site carbon emissions analysis indicate potential for significant reductions from the BAU scenario, which is lower in terms of per site hectare and per home carbon emissions compared to that reported for the baseline for the Elephant Park. Thus residual annual emissions which would need to be offset to achieve a carbon positive outcome would be likely to be lower, in unitised terms, than those for the Elephant Park.

The Park Royal Short Term and Medium-Long Term targets for overall operation carbon footprint are based on the results of the site carbon emissions analysis, taking into account the absence of transport related emissions in the analysis. As Park Royal is an area of existing largely industrial development, potentially entailing a more piecemeal approach to implementation of carbon reduction measures, an overall zero carbon or carbon positive target was considered less achievable. The targets set assume incremental carbon reduction measures only, without offsetting.

It is recommended that the above targets, together with assumptions underpinning them, are regularly reviewed and revised as appropriate, preferably annually.

WATER

Water neutrality: efficient use, alternative sources, runoff and wastewater discharge

Introduction

The growth of London, and the consequent need to densify to address housing needs is placing stresses on our water infrastructure that it was not designed to deal with. This will be further compounded by our changing climate. We therefore need to reduce some of the pressures on our current water system to ensure it can continue to serve us well into the future. In A City for All Londoners (October 2016), the Mayor states that "As the city develops to accommodate more people, jobs and activity, and as the threats from climate change become more tangible, it is vital both for the health and wellbeing of our citizens and for our business competitiveness to protect and enhance the environment". In the face of a growing population and increasing demand for resources, it makes sense to use the water we have more wisely, plan for a future where there may be less water available, and identify the necessary infrastructure requirements to effectively address the implications of denser development.

Site Context

The Integrated Water Management Strategy (IWMS) supporting study for the OPDC Local Plan issued in December 2016 provides a summary of the water challenges for Old Oak and Park Royal:

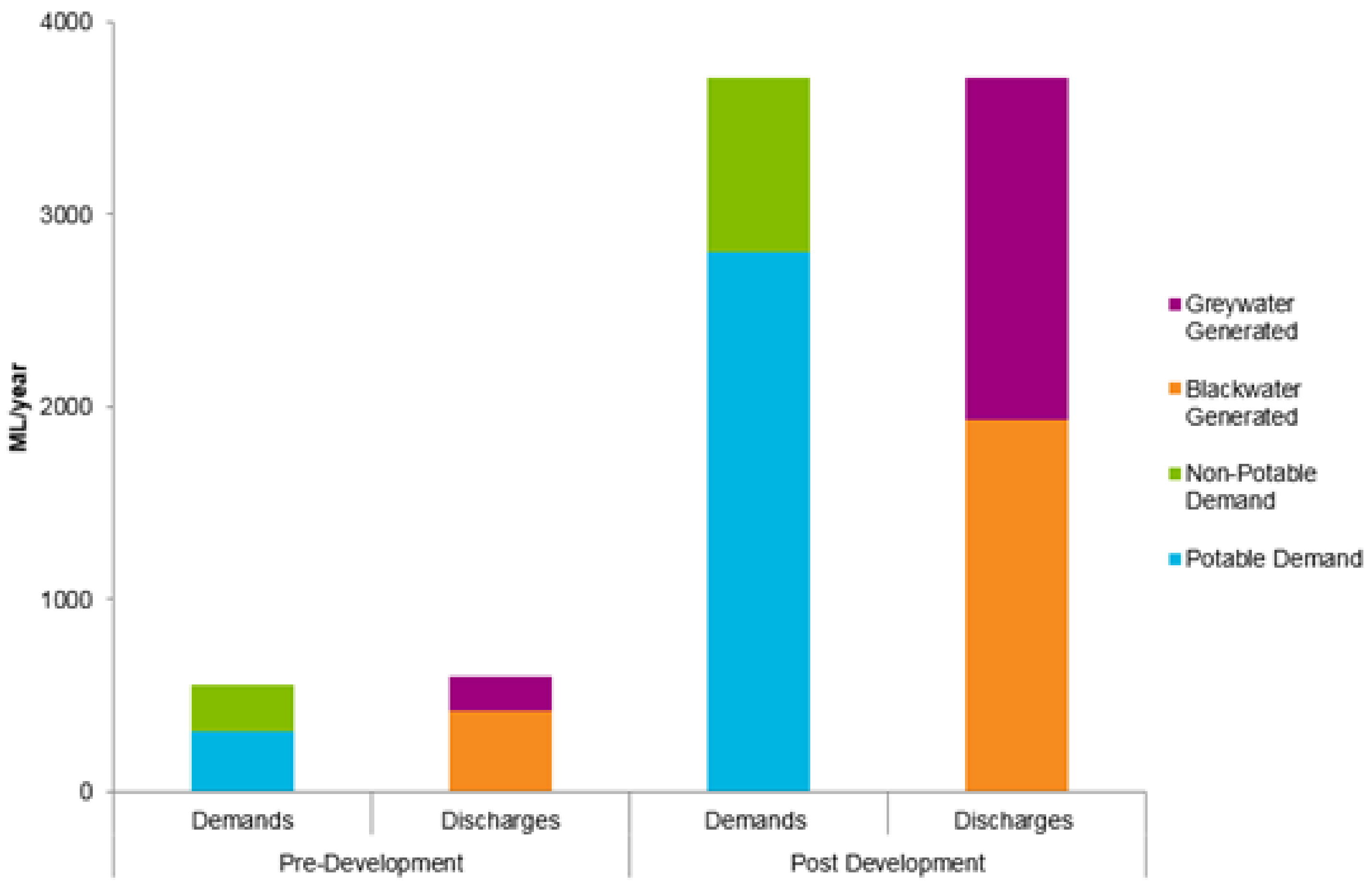
- An acute lack of capacity in the sewer network to accommodate additional foul flows without increasing sewer flood risk downstream;
- A growing deficit in available water supply to meet demand, exacerbated by climate change and a rapidly increasing population in London;
- A lack of suitable water supply and wastewater infrastructure to serve the quantum of growth proposed across the Opportunity Area; and
- Areas of localised surface water flood risk which could be exacerbated by the scale and location of proposed development if not sufficiently mitigated.

The Strategy has been formed around several core objectives:

- To ensure that the rate of wastewater and surface water discharge to the sewer is no greater than it is from the site usage of the Opportunity Area in the present day;
- To minimise the volume of water is discharged to the sewer, and take account of 100 year storm +40% increase for climate change;
- To manage surface water runoff to a position that would match runoff from the site if it were undeveloped (greenfield);
- To reduce as far as possible the demand for centralised water supply by re-using water resources and wastewater resource on site;
- To deliver these objectives in the most sustainable way bearing in mind the need to ensure the overall viability of the site.

Figure 4.9 illustrates the scale of the projected increase in water flows arising from planned development in the OPDC area.

Figure 4.9 – Anticipated Increase in Flow over OPDC Area



Source: Integrated Water Management Strategy, OPDC Draft Local Plan Supporting Study, December 2016

Policy Context

The National Planning Policy Framework considers water management as central to climate change resilience, secure water supply and demand, and for mitigating water pollution and suggests that local plans should set out proactive long-term strategies to deal with these issues. The London Plan sets out water management policies covering a range of topics including flood risk management, sustainable drainage, and water quality and wastewater infrastructure. This is additionally supported by the Mayor's Sustainable Design and Construction Supplementary Planning Guidance (SPG).

Water Neutrality – limiting new demand and using alternative sources of water

Increasing water consumption behaviours, population growth and climate change present a challenge for the management of water in London. To help tackle these challenges the London Plan and the London Water Strategy highlight the need to achieve water neutrality in new development. The definition of 'water neutrality' used by the Government and the Environment Agency is:

"For every new development, total water use across the wider area after the development must be equal to or less than total water use across the wider area before development."

Achieving water neutrality requires both limiting new demand for potable water and using alternative sources of water, in particular onsite rainwater and recycled water, to replace mains potable water. The London Plan sets a target of 105 litres per person per day (l/p/d) or less for mains water consumption from new residential development. A range of measures are expected to be applied to reduce mains water consumption, including reducing leakage and expanding water metering and consumer education.

Although 105 l/p/d is considerably lower than current average residential consumption rates in London (recorded in the London Water Strategy as 167 l/p/d in 2009/10), it is not the lowest consumption level set by the Code for Sustainable Homes (only corresponding to Level 3). The Mayor's Sustainable Design and Construction SPG encourages developers to aim for 80 l/p/d, corresponding to Level 6 of the Code for Sustainable Homes. To put this in context, national planning policy states that all new social housing must be built to the Code for Sustainable Homes Level 3 target from April 2011, and all new private housing must be built to 125 l/p/d. The challenge to retain performance levels, however, remains and at present although it is technically possible to provide fixtures and fittings to deliver a reduction in water use to under 80 l/p/d, the delivery of these additional efficiency savings from around the current 105-120 l/p/d risks the ability to maintain user satisfaction (assuming greywater and rainwater harvesting is not used to reduce demand). Damaging user satisfaction in turn runs the risk that the water saving fixtures and fittings will be replaced by less efficient alternatives, undermining these key measures to reducing potable water demand.

The London Water Strategy notes that non-potable uses may account for over a third of all water used within a house, and other public uses such as landscape irrigation and paving washing can increase the overall proportion of non-potable uses. Rainwater collection and greywater (used water from sinks, baths and showers) recycling are highlighted as alternative water sources to be developed to replace mains water consumption. The London Plan states that all developments should be designed to incorporate rainwater harvesting and the Mayor's Sustainable Design and Construction SPG states that, where practical, rainwater should be collected from all suitable roofs and impermeable surfaces and stored for re-use. Greywater recycling systems should be used where they are energy and cost-effective.

Recycling unseparated wastewater, which includes both grey and black water (sewage from toilets), from sewage treatment works is a significant potential new resource that Thames Water and other companies are currently investigating and could be a real opportunity for this site given the long term development horizon. It requires more treatment and therefore is more resource and energy intensive. There are also issues regarding quality standards and social acceptance of black water recycling. Recycling of black water is not mentioned in the London Plan and the London Water Strategy and is considered only briefly in the Mayor's Sustainable Design and Construction SPG.

Reducing potable water demand and capturing and reusing rainwater reduces the amount of water discharging to the sewer system. Where the sewer system combines foul water and storm water, as is the case at the OPDC site, this acts as a constraint to development in the form of risks of flooding and quality of local water bodies. Separating foul water and storm water flows helps in creating headroom for growth.

Surface Water - Quantity and Quality

Proposals to increase the use of sustainable drainage techniques are in line with England's planning policies, as set out in the National Planning Policy Framework (NPPF). Sustainable drainage is seen as a means by which developments can avoid increasing the risk of flooding elsewhere. New development will be a particularly important aspect of future sustainable drainage delivery.

The London Plan (Policies 5.13 and 5.14) places a strong emphasis on use of Sustainable Drainage Systems (SuDS), both in new development and retrofitting existing development. SuDS would help reduce the pressure on London's sewer infrastructure, assist in rainwater capture, help reduce flood risk, enhance surface water quality and promote opportunities for multi-benefit, multi-function greenspace. The London Plan sets out a drainage hierarchy aiming to ensure SuDS are fully integrated into development design. The most beneficial SuDS schemes will successfully contribute to the delivery of the EU Water Framework Directive by reducing water pollution and enhancing surface water quality.

The Mayor's Sustainable Design and Construction SPG states that:

"London Plan policy 5.13 states that developers should aim for a greenfield runoff rate from their developments. Greenfield runoff rates are defined as the runoff rates from a site, in its natural state, prior to any development. Typically this is between 2 and 8 litres per second per hectare. The CIRIA SuDS Manual generally recommends the Institute of Hydrology Report 124 methodology for calculating greenfield runoff rates. Achieving a greenfield runoff rate is of particular importance where the development is located in a catchment that contributes to combined sewers with known and/or modelled capacity or flooding issues."

"If greenfield runoff rates are not proposed, developers will be expected to clearly demonstrate how all opportunities to minimise final site runoff, as close to greenfield rate as practical, have been taken."

"Most developments referred to the Mayor have been able to achieve at least 50% attenuation of the site's (prior to re-development) surface water runoff at peak times. This is the minimum expectation from development proposals".

"There may be situations where it is not appropriate to discharge at greenfield runoff rates. These include, for example, sites where the calculated greenfield runoff rate is extremely low and the final outfall of a piped system required to achieve this would be prone to blockage. An appropriate minimum discharge rate would be 5 litres per second per outfall."

The Mayor's preferred standard, as set out in the Sustainable Design and Construction SPG, is to achieve 100% attenuation of an undeveloped site's surface water runoff at peak times, and this is a requirement for greenfield sites.

The London Sustainable Drainage Action Plan (Greater London Authority, 2015) states that the target is: "to achieve a 1% reduction in surface water flows in the sewer network each year for 25 years, resulting in a 25% reduction in flows by 2040."

There does not appear to be any guidance regarding what design standard the runoff reduction should apply to, nor the manner in which it should be applied. It is, however, assumed that:

- this should result in both a reduction in the existing rates of runoff for frequent events (1 in 1 year) and total volumes discharging from the site during more severe events (1 in 100 plus climate change); and
- the aspiration is to deliver a development on existing developed land that attenuates rates of runoff back to greenfield runoff for a 1 in 1 year event or at least meets the Mayoral 1% reduction target.

While the ambiguities of the above are typically dealt with on a case by case basis by planning departments through the preparation of a drainage strategy and/or flood risk assessment where management organisations will agree, consent, and appeal against proposals, the nature of the OPDC is such that it can streamline the whole of this process with pre-agreed rates. The challenge is in defining what this rate should be, because whatever rate is established it will need to be strongly evidenced showing that it is feasible, realistic, and reasonable for all involved in the delivery of the development, such that the target is financially deliverable and fairly apportioned

It should be noted that for Old Oak and Park Royal key benefits of reducing runoff via SuDS and/or rainwater collection will be reduced runoff storage requirements, a framework for reducing potable water demands, reduced energy and enhanced greening of the area which will have recreational, health and air quality benefits.

Objectives and Policy Recommendations

Proposed objectives and water policy recommendations for Old Oak and Park Royal are set in Table 4.24 below. Measures are also recommended as part of an integrated low carbon and resource efficient water / wastewater strategy for Old Oak and Park Royal. These recommendations are based on a strategic review of mayoral policies and guidance set out above, and initial strategic site water analysis exploring onsite demand reduction, rainwater harvesting, SuDS and wastewater recycling options and a review of best practice guidance. This analysis and review of best practice is set out below in the Evidence section.

Table 4.24 – Old Oak and Park Royal Water Objectives and Policy Recommendations

Objective / Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Maximise efficient use of water			
Reducing water demand; Metering; Leakage	• All new development will be required to meet or exceed OPDC potable water demand targets. As part of planning applications, developers will be required to include strategies demonstrating how targets will be achieved. • All new developments will be required to install smart water meters, covering wastewater discharge as well as potable water use. • OPDC will work with developers, water companies and regulators to ensure potable supply system leakages are minimised. This is expected to include widespread deployment of smart sensors and network management technology.	• Aligned with London Plan and Mayor's Sustainable Design and Construction SPG requirements for water neutrality and drainage neutrality in all new developments. • Aligned with London Plan and Mayor's Sustainable Design and Construction SPG requirements to increase efficient use of potable water, minimise potable supply system leakages, and maximise the efficient use of the sewer system. • Expanding deployment of smart metering is expected to encourage overall potable water demand reduction and increase efficient and cost-effective management of water / wastewater networks.	• A range of new centralised water supply infrastructure will be required in new build areas, presenting an opportunity for the installation of smart network technologies to optimise operation. • Additionally, customers can be provided with the information and tools they need to make informed choices about their behaviours and water usage patterns.

ATKINS

Objective 2: Water neutrality – maximise use of alternative sources for non-potable water			
Rainwater harvesting	• All development will be required to include equipment to ensure rainwater capture targets are achieved. As part of planning applications, developers will be required to include strategies demonstrating how targets will be achieved.	• Aligned with London Plan and Mayor's Sustainable Design and Construction SPG requirements for water neutrality and drainage neutrality in all new developments. • Implementation of rainwater harvesting across the site will reduce the demand for potable water as well as reducing the requirement for storage for storm water attenuation. • Implementation of greywater recycling across all new development provides an effective means of reducing potable water and sewer demand pressures.	• Implement a site-wide water sensitive urban design strategy covering rainwater harvesting, greywater recycling and storm water attenuation. This expected to add around £1,500 per dwelling to build costs (not taking into account non-residential development), compared to the conventional solution. • Developers pay for rainwater harvesting and greywater recycling. Increases in residential and commercial unit costs, and marketing of the reduced operational costs for potential home owners, would be expected to be offset by water bill savings (estimated at around £59m over 10 years for residential alone) and enhanced marketing value associated with sustainability features. Further work is needed to fully quantify these benefits.
Greywater recycling	• All development will be required to include equipment to ensure greywater recycling targets are achieved. As part of planning applications, developers will be required to include strategies demonstrating how targets will be achieved.		
Objective 3: Water neutrality – minimise surface water runoff and wastewater discharge			
Managing surface water runoff	• OPDC will work with water companies, the regulator and developers to support development of a storm water attenuation system capable of managing a 1 in 100 + 40% storm water event. The storm water attenuation system will ensure controlled discharge of water to the sewer system and, as appropriate, cleaned and purified water to local water bodies or for reuse.	• Aligned with London Plan and Mayor's Sustainable Design and Construction SPG requirements for drainage neutrality in all new developments, and attenuation of at least 50% of peak runoff for previously developed sites. • Due to clay based geology, constraints to the combined sewer system, and the lack of greenspace allocation within the proposed masterplan, underground attenuation of storm water will be essential in managing flood risk over the site. • SuDS approaches should be used wherever feasible, to help realise associated multi-function benefits from onsite green infrastructure. Site conditions and proposed masterplan constraints are likely to limit SuDS deployment but green roofs and walls should be used where appropriate. Guidance on incorporating SuDs is included within the Environmental Quality section of this report.	• The water company pays for storm water attenuation, plus the additional conventional water and drainage infrastructure, based on the network benefits this would provide. • The water company manages all water / wastewater systems, with costs recovered via integrated / consolidated charges which may be expected to be higher overall than traditional water supply plus drainage charges. Further work is required in engaging with the water company to explore the feasibility of this. • The Environmental Quality section of this report considers how green infrastructure can contribute towards providing attenuation storage, and reducing the volume of storage required. Such features can also contribute to a range of wider benefits, including enhanced water quality, provision of habitat for biodiversity, improved air quality and amelioration of the urban heat effect.

Evidence

This section sets out evidence supporting the policy and strategy recommendations listed in Table 4.24. Evidence comprises the following:

- Key observations from UK and international best practice case studies.
- Results of the strategic site water analysis used to explore scenarios for achieving, and potentially exceeding, current Mayoral targets and guidance.

Best Practice Case Studies

The following case studies have been referenced as examples of current UK and international best practice in terms of water performance:

All the case studies demonstrate a basic and varying level of water efficiency in terms of installing low-use fixtures and fittings, and most also have a basic level of SuDs as a minimum. Some of the schemes also start to move towards rainwater / greywater recycling and re-use, either in irrigation or in toilet flushing. While all have been implemented in differing time horizons when viability and policy may have made the implementation of these solutions easier, the latter seems to be seen as a bigger investment. Anecdotal evidence suggests that this can place challenges on the occupiers who ultimately need to understand the dual-plumbing required or find tradespeople that also understand when things go wrong. As a result of this limited education being in place, it is often the schemes where repairs are provided as part of service charges that have found it easier to adopt these systems that involve bringing the water back into the residential units.

East Village, London, UK

East Village, London, UK. 60% reduction in potable water consumption is achieved in the area. All homes average 105 litres/person/day, compared to the London average of 167 litres// person/day. SuDS are incorporated in streets. Significant enhancements to canals have been completed, in which 6.5 km of waterways were revitalised (this was undertaken as part of Olympic Park development). Roofs and gardens are irrigated by water from rainwater harvesting. Low flow showers in bathrooms help to decrease water usage. Separate potable and non-potable water networks have been incorporated. An experimental wastewater treatment plant has been trialled. The current 40% reduction in potable water use in the venues will be reduced with further initiatives.

© OPDC

Vauxhall Nine Elms, London, UK

Vauxhall Nine Elms, London, UK. The development is set to have the UK's largest SuDS system. New developments in Nine Elms have pioneered design features in new buildings and landscaping that capture rainwater, and increase evaporation before directing flows to a surface water network. The rainwater will then drain into large underground pipes buried beneath the new Nine Elms Park which will be a new green channel through the area from Vauxhall to Battersea Power Station. After heavy rainfall the water will be gradually pumped from this underground reservoir into the Thames via an upgraded pumping station in Ponton Road.

© Shutterstock

Hammarby, Stockholm, Sweden

Hammarby, Stockholm, Sweden. 100% of water is recycled. 25% overall water reduction is achieved through flow restrictors. Water use decreased by around 50% per person. All homes average 105 litres/person/day compared to a city average of 200litres/person/day. 100% of surface water is cleaned locally and purified before release. Rainwater harvesting is used in blocks and gardens

© Atkins

ATKINS

Dockside Green, Victoria, British Columbia, Canada

Dockside Green, Victoria, British Columbia, Canada. Onsite wastewater treatment plant (WWTP) treats and filters 100% of sewage and greywater generated by residents and commercial tenants. Projected potable water savings are 66.5% below baseline LEED water standards. It is estimated that 70 million gallons of water per year at full build-out will be saved (equivalent to entire region's water use on driest day of the year). An additional 82,000 litres of treated water will be sold to nearby industrial users.

Barangaroo, Sydney, Australia

Bangaroo, Sydney, Australia. The precinct will include smart design with water efficient appliances, as well as using captured rainwater and treated water for toilet flushing, irrigation, wash down and fire suppression. A chilled water and harbour cooling system will be incorporated. Over one year Barangaroo South will be able to contribute the equivalent of about 60 Olympic swimming pools of recycled water to the rest of the CBD.

© Shutterstock

Going forward, the re-use of greywater and dual plumbing should be seen as the norm, and Old Oak will need to address some of the challenges as it should be embedding these higher standards at the outset. The ability to then minimise runoff through the use of biodiverse roofs followed by swales, rain gardens and green infrastructure, as demonstrated in East Village, should be easier and able to deal with the balance of the water requirements.

We know that climate change will make higher intensity rain events more of a norm, and the ability to manage that water will be vital to prevent flooding, but then re-using it will enable us to manage the challenges around lack of freshwater and the high energy costs associated with moving water or desalination as a last resort.

Strategic Site Water Scenario Analysis

A water model was generated as part of the Old Oak and Park Royal IWMS. The aim of developing this model was to evaluate the overall water demand and supply balance of the two developments under different water performance scenarios. The strategic site water analysis was used to:

- test the prerequisites for meeting current Mayoral policy / guidance requirements;
- test the potential for exceeding current policy / guidance requirements, under different scenario assumptions.

The results of the strategic site water analysis, as well as supporting information, are set out in detail in Appendix B.4.

Substantially reducing water demand and using alternative (reclaimed) water sources, beyond current Mayoral standards and current best practice, is essential for Old Oak to work towards the objective of water neutrality and discharge neutrality. These factors are of course closely interlinked. In the case of OPDC where the sewer is receiving combined foul and rainwater, both demand reduction and reducing wastewater discharge through reclamation are also linked to control of surface water runoff and meeting the goal of 100% attenuation of site peak runoff rates prior to re-development, in order to reduce the risk of surface water flooding. Strategic feasibility work undertaken to inform the establishment of environmental targets for this project has indicated that a Water Sensitive Urban Design development could contribute around 56% towards neutrality. This objective will therefore be challenging to realise.

Even with planned improvements to the local sewer network, based on the current draft masterplan the very high concentration of water demand, the impermeable clay based local geology, the lack of planned greenspace, and the several barriers across the site (Grand Union Canal and railways) make achieving water / discharge neutrality and 100% reduction in peak rates of runoff especially challenging within Old Oak.

The IWMS demonstrates that SuDS measures progressively introduced in Park Royal would help to reduce overall pressure on the sewer system and local water bodies. However, this process is likely to be gradual and opportunistic in nature outside the limited areas of new build in Park Royal. We have proposed a significant increase in the amount of public open space provided onsite (from 9ha to 29.3ha, see Chapter 5). This will be supplemented by private open space (c10ha), green roofs and green corridors connecting the open spaces. However, it may be necessary to consider applying storm water attenuation at substantial scale in areas outside the site boundary, or implementing rainwater harvesting techniques that will reduce attenuation volumes.

There is a study currently being undertaken which aims to establish the existing and proposed peak foul and surface water discharge rates from each development parcel to enable the minimum volume of attenuation storage to be estimated. Once these volumes have been established, the practicality of providing additional storage in order to reduce peak surface water discharge rates further towards greenfield rates defined within the London Plan will be considered, in order to allow the development to reduce the peak discharge to the existing combined sewers.

OPDC is also consulting with the Canal and River Trust to determine whether it will be feasible to redirect surface water from parcels that are situated close to the centre of the site to the Grand Union Canal in order to reduce the volume of surface water that is conveyed by the existing combined sewers, and treated at Beckton Sewage Treatment Works.

Cost Implications

A scenario based approach was used to:

- estimate indicative capital costs of underground storm water flood attenuation requirements that need to be considered during the design of the site for planning purposes. It was assumed that underground storage will be the most feasible approach to discharge planning constraints in regards to flood risk given the site's soil and geology is clay based; and
- estimate indicative high level capital unit costs of achieving "water neutrality" scenarios with a range of rainwater harvesting, greywater, and blackwater solutions while satisfying flood risk planning constraints.

The high level capital unit costs estimated for the five scenarios are shown in Table 4.25 below.

Further information on each of the scenarios and the methodology used for cost estimation are set out in Appendix B.4.

The results of the indicative cost analysis indicate that:

- A conventional infrastructure solution will be cheaper to implement, but it will not deliver the vision for the development nor build in sustainability principles that are essential given the future pressures facing London;
- Rainwater harvesting will substantially reduce storm water flood attenuation requirements, and with appropriate treatment measures, could reduce potable water demand pressures;
- Greywater recycling is an effective measure to reduce water and sewer demand pressures;
- Blackwater recycling is the most costly and should only be considered where relevant and necessary;
- The high level capital unit costs of rainwater or greywater led solutions are relatively similar;
- The water sensitive urban design approach will cost considerably more than a conventional infrastructure solution, but it will reduce future customer water bills while increasing site climate resilience and profitability with appropriate marketing.

Table 4.25 - Water / Wastewater Scenario Indicative Unit Costs

Waste / Wastewater Scenario	Indicative Unit Cost (£ / new home)
Conventional Solution	900
Rainwater Harvesting	1,600
Greywater Recycling	1,600
Blackwater Recycling	4,400
Water Sensitive Urban Design	2,400

Note: All figures are indicative estimates only.

Source: Atkins analysis.

Assuming the 56% water savings of this scenario are carried through to customer bills, this could represent a saving of around £2,200 to potential new home owners – assuming they own the properties for a period of 10 years and the average customer bill (£389) will not fluctuate heavily. This is, however, only one area of potential benefit, and further benefits should be identified and costed, so that the costs can be considered in respect to benefits and allow appropriate funders to be identified for enabling such measures given a more sustainable development is desired by all stakeholders.

Table 4.26 sets out the recommended environmental performance targets. The section below provides information on how the targets have been derived.

Targets

Table 4.26 - Recommended Targets

Objective / Indicators	Target			
	Old Oak		Park Royal	
	Short Term	Medium Term - Long Term	Short Term	Medium Term - Long Term
Objective 1: Maximise efficient use of water				
Potable water consumption (l/person/ day), residential	105	90 - 80	105	90 - 80
Objective 2: Maximise use of alternative sources for non-potable water				
Percentage of within-plot rainwater collected and used onsite	50%	60%	50%	60%
Percentage of greywater recycled onsite	30%	80%	30%	80%
Objective 3: Minimise surface run-off and wastewater discharge				
Surface water run-off rate	To be developed.			

Note: Short-Term: up to 2031; Medium Term-Long Term: 2032 onwards

Rationale for Targets

The following principles underpin development of the targets:

- Compliance with the Mayoral strategy, policy and guidance.
- Alignment with the OPDC IWMS.
- Current and emerging UK and international best practice.
- Indicative assessment of potential potable water demand reduction and surface water runoff attenuation given the site constraints and the nature of proposed development.

Based on strategic site water analysis and current and emerging UK and international best practice, guideline water related performance targets have be set.

The Short Term targets for residential potable water consumption is in line with current Mayoral target. Medium-Long Term targets have been set based on rates achieved in case studies and provided in industry guidance. The targets set for the percentage of within-plot rainwater collected and used onsite have been based on the strategic site water analysis. The Short Term targets for percentage of greywater recycled onsite have been set based on the strategic site water analysis. Medium-Long Term targets have been set based on rates achieved in case studies.

A study including estimation of potential attenuation of surface water run-off for the OPDC site is currently on-going. Once this study is completed targets for the surface water run-off rate will be set. Under the present study the following guidelines are recommended:

- Surface run-off should be limited to the greenfield run-off rate during a 1 in 1 year design storm event.
- All surface water should be attenuated up to the 1 in 100 year plus 40% climate change event.

It is recommended that these guidelines, together with the above recommended targets, are regularly reviewed and revised as appropriate, preferably annually.

AIR QUALITY

Local ambient air quality, air quality positive, indoor air quality

Introduction

Air quality is both a serious environmental and a public health issue linked to chronic respiratory diseases and illnesses, which reduce quality of life. Despite London's air quality having improved greatly over recent decades, much of the city still faces levels of pollution that do not meet EU and national standards. In order to ensure a high quality of life for its inhabitants it is important that Old Oak and Park Royal proactively manages and improves air quality across the site.

The National Planning Policy Framework requires Local Plan compliance with and contribution towards EU limit values and national objectives for air quality. The London Plan and the Mayor's Air Quality Strategy set out a minimum 'air quality neutral' requirement for new developments. These policies are summarised in the Mayor's Sustainable Design and Construction Supplementary Planning Guidance (SPG), which also includes guidance on reducing exposure to pollution as well as emission standards for solid biomass boilers and CHP plant.

The London Mayor launched a consultation on air quality in July 2016 and has set out several initial proposals for mitigating pollution including bringing forward the implementation of the central London Ultra Low Emission Zone (ULEZ) by one year and expanding its area beyond central London by 2020. A new Emissions Surcharge for polluting vehicles, cleaner bus fleet and improved live pollution warnings are all part of the proposals to improve London's air quality.

The Mayor's 'A City for All Londoners' vision document includes a strong emphasis on improving the city's air quality, with measures proposed for both transport and building related emissions.

Site Context

London

The two pollutants of specific concern in London are fine particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2) as these pollutants are most likely to be present at concentrations close to or above their criteria set for the protection of human health (shown in Table 4.27). NO_2 is a secondary pollutant produced by the oxidation of nitric oxide (NO). NO and NO_2 are collectively termed as nitrogen oxides (NO_x). Road transport is responsible for half of all NO_x and PM_{10} emissions in Greater London[1]. In general, pollutant concentrations disperse rapidly away from roads, with lower concentrations at background sites.

Data for London air quality monitoring sites have shown that the majority of sites have met the PM_{10} annual mean objective over the last 10 years, with 100% compliance in 2015 (Figure 4.10). However, the number of sites meeting the NO_2 annual mean objective has shown little change with between 50% and 60% of sites compliant (Figure 4.11). Reducing concentrations of these pollutants is a major focus of the Mayor's Air Quality Strategy.

Table 4.27 - UK Air Quality Objectives

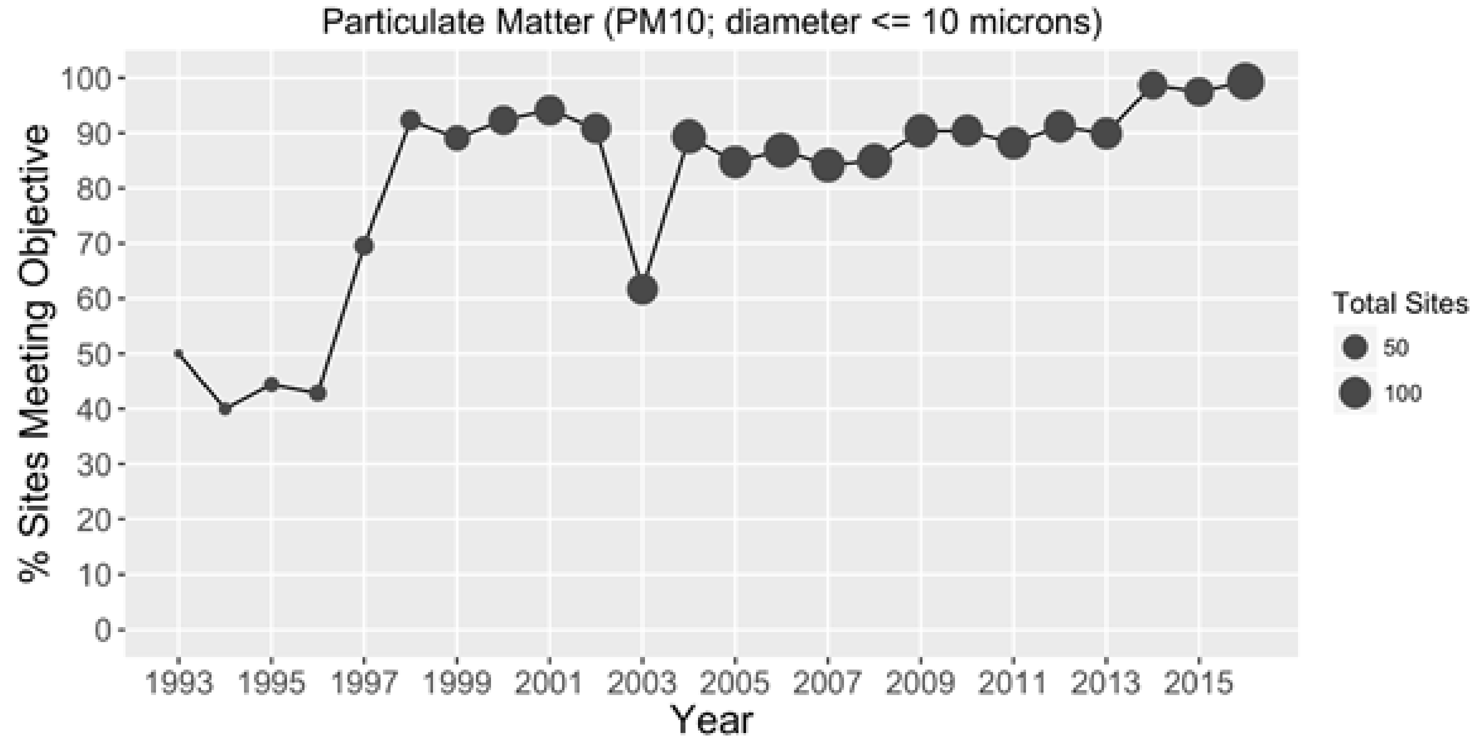
Pollutant	Objective (UK)	Average Period
NO_2	40 µg/m^3	Annual mean
	200 µg/m^3 not to be exceeded more than 18 times a year	1-hour mean
PM_{10}	40 µg/m^3	Annual mean
	50 µg/m^3 not to be exceeded more than 35 times a year	24-hour mean
$PM_{2.5}$	25 µg/m^3	Annual mean
	Target of 15% reduction in concentrations at urban background locations between 2010 and 2020	

Note: µg: microgram

Source: UK Air Quality Strategy, Defra, July 2007.

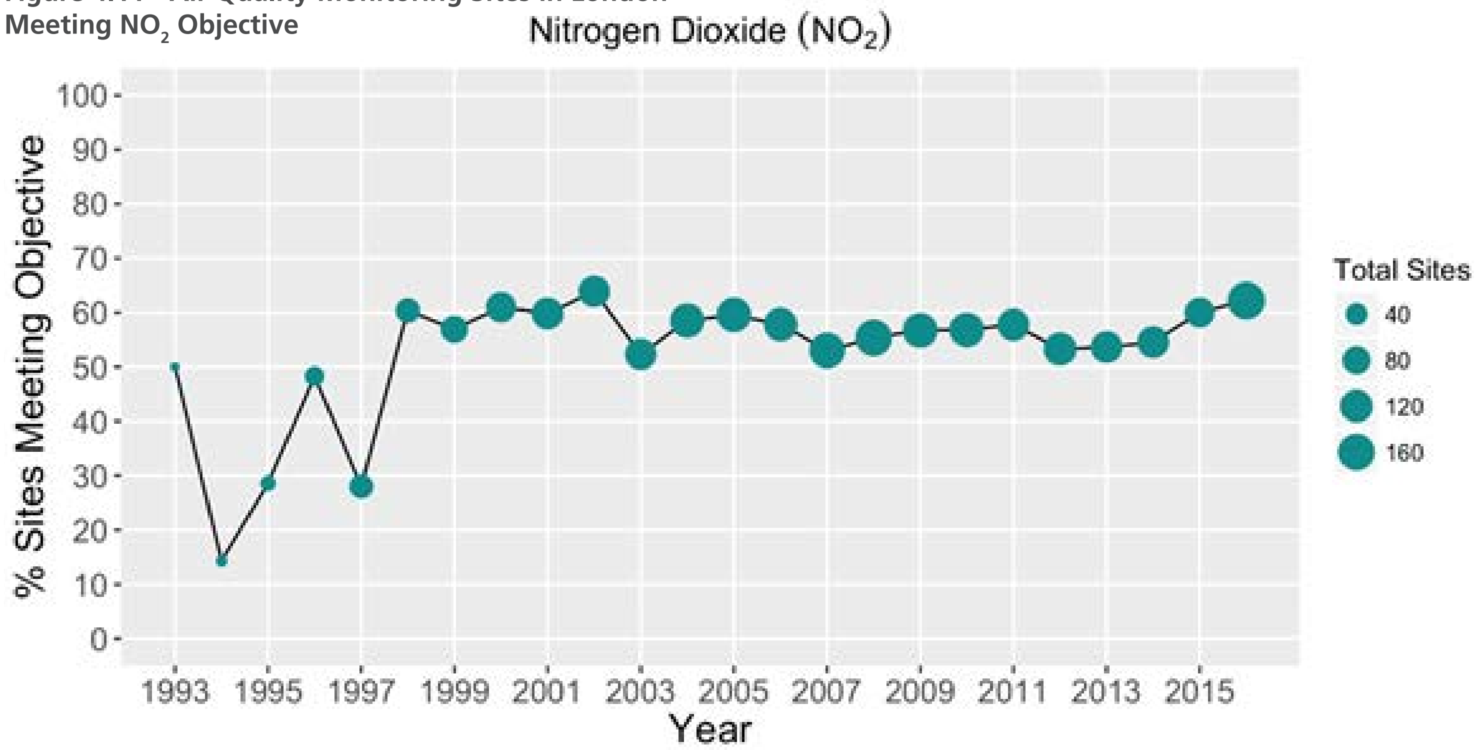
1 London Atmospheric Emissions Inventory 2013, available at: http://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory-2013.

Figure 4.10 – Air Quality Monitoring Sites in London Meeting PM_{10} Objective



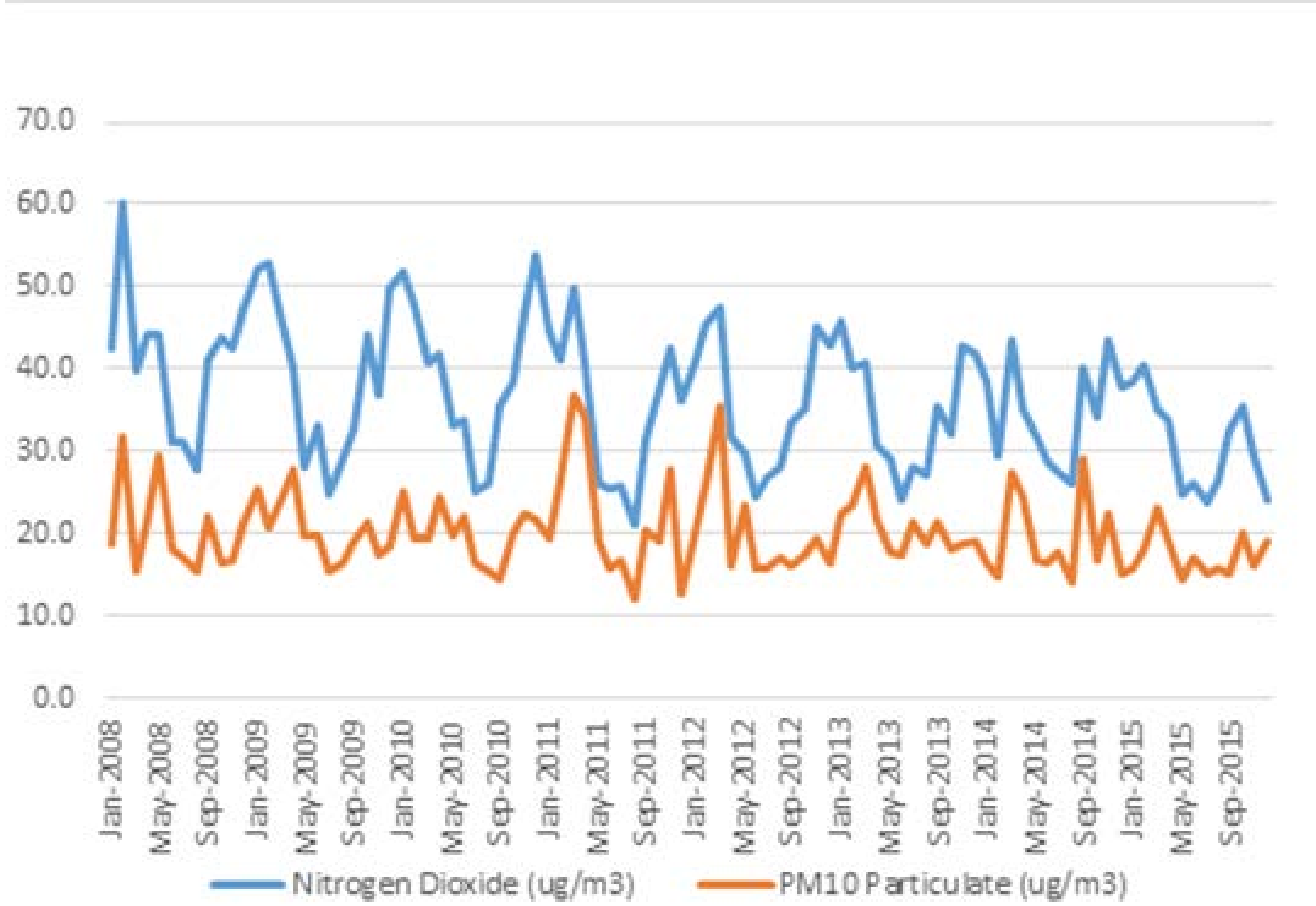
Source: King's College London, GLA London Datastore, March 2016.

Figure 4.11 - Air Quality Monitoring Sites in London Meeting NO_2 Objective



Source: King's College London, GLA London Datastore, March 2016

Figure 4.12 – Average Air Quality Levels in London, PM_{10} and NO_2, 2008 – 2015



Data source: King's College London, GLA London Datastore, September 2016.

Old Oak and Park Royal

During the Local Air Quality Management Review and Assessment process carried out by the London boroughs of Brent, Ealing, and Hammersmith and Fulham, areas within each borough were identified where the relevant health-based national Air Quality Objectives (AQOs) for NO_2 and PM_{10} are exceeded. As a result, each council declared a borough-wide Air Quality Management Area (AQMA) for exceeding annual mean NO_2 and 24-hour mean PM_{10} AQOs.

The Old Oak and Park Royal area straddles these AQMAs. Road traffic is the most important source of air pollution in the OPDC area, and this forms the key area of focus of Action Plan measures.

Details of the site air quality analysis are set out in Appendix B.5.

Policy Context

National and international policy is summarised in the Old Oak and Park Royal Air Quality supporting study for the OPDC Draft Local Plan[2], which provides details of the EU limit values, the national Air Quality Strategy and objectives provided in regulations, Local Air Quality Management (LAQM), the Department for Food and Rural Affairs' plan for tackling nitrogen dioxide, the National Planning Policy Framework and Planning Practice Guidance and the Government's plan for investing in Ultra Low Emission Vehicle infrastructure.

Mayoral policy priorities for outdoor air quality are summarised in the Mayor's Sustainable Design and Construction SPG as (London Plan policy numbers are indicated in parenthesis):

- Developers are to design their schemes so that they are at least 'air quality neutral' (7.14).
- Developments should be designed to minimise the generation of air pollution (5.3, 7.14).
- Developments should be designed to minimise and mitigate against increased exposure to poor air quality (3.2, 5.3, and 7.14).
- Developers should select plant that meets the standards for emissions from combined heat and power and biomass plants set out in Appendix 7 of the SPG (7.14).
- Developers and contractors should follow the guidance set out in the Mayor's Control of Dust and Emissions during Construction and Demolition SPG[3] when constructing their development (5.3, 7.14).

The London Plan and the Mayor's Air Quality Strategy set out that developments are to be at least 'air quality neutral'. To enable the implementation of this policy, emission benchmarks have been produced for building operation and transport across London based on the latest technology (including its effectiveness and viability). Developments that do not exceed these benchmarks will be considered to avoid any increase in NO_x and PM emissions across London as a whole and therefore be 'air quality neutral'. Application of this policy is detailed in Air Quality Neutral Planning Support Update: GLA 80371, Air Quality Consultants and Environ (2014).

The Mayor's Sustainable Design and Construction SPG includes guidance on reducing exposure to air pollution. By considering building design, layout and orientation at the initial design stage, developers can maximise the contribution of these elements in reducing exposure to poor air quality. For example, an air tight building (as required by Mayoral energy policy) with air intakes located away from the main source of air pollution will help minimise increased exposure to poor air quality.

The Mayor's Sustainable Design and Construction SPG also includes emissions standards for solid biomass boilers and CHP plant for developments. The SPG also stipulates that, to protect internal air quality, developers should specify environmentally sensitive (non-toxic) building materials, and the use of materials or products that produce VOC (volatile organic compounds and formaldehyde) which can affect human health should be avoided.

In addition to complying with Mayoral policy and guidance, Policy EU10 of the OPDC Draft Local Plan requires that development implements the recommendations of the Air Quality Study, has regard to the relevant Boroughs' Air Quality Action Plans and the mitigation measures identified therein, and seeks to minimise air quality impacts from surrounding uses.

Policy E3: Air Quality of the Environment Strategy for the Old Oak and Park Royal Opportunity Area Planning Framework adopted in 2015 states that "Proposals should: a. Minimise the generation of air pollution both during and post construction, making new developments 'air quality neutral' or better; and b. Achieve EU established health-based standards and objectives for a number of air pollutants (NO_x, PM_{10} and $PM_{2.5}$)".

OPDC Objectives and Policy Recommendations

Based on review of mayoral policies and guidance, review of best practice case studies and initial site air quality analysis, policy recommendations for air quality for Old Oak and Park Royal have been developed and are set out in Table 4.28 below. Policy recommendations are grouped under the three core objectives developed for OPDC air quality policy, which also form the basis of the recommended targets:

1. Enhance local ambient air quality
2. New buildings and transport to be air quality positive
3. Enhance indoor air quality

2 Henceforth referred to below as the Air Quality Study.
3 https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/ Dust%20and%20Emissions%20SPG%208%20July%202014_0.pdf

Table 4.28 – Old Oak and Park Royal Air Quality Objectives and Policy Recommendations

Objective/Policy Area	Policy Recommendation	Justification	Strategy
Objective 1: Enhance local ambient air quality			
Operational phase emissions - transport	• OPDC will work with developers, transport infrastructure providers and regulators to support use of integrated demand management, public transport and non-motorised transport to reduce emissions, promote improvement of local air quality and reduce exposure to emissions. • As part of planning applications, developers will be required to submit an Air Quality Management Plan (AQMP) which clearly demonstrates how developments will use integrated demand management, public transport and non-motorised transport measures, including streetscape, public realm and green infrastructure planning, to encourage: a) Reduction in overall travel. b) Modal shift to more carbon efficient and lower impact modes.	• Based on the results of the site analyses, which show that there are currently exceedances of the AQOs for NO_2 and PM_{10} and exceedances of NO_2 annual mean AQO are likely to still occur in future, and taking into account Mayoral policy and guidance as well as international and national policy and guidance, Air Quality Study sets out a series of recommended policies for the OPDC area operational phase covering measures to reduce emissions, to reduce exposure to pollution and to inform assessment. Not unexpectedly, for the operation phase the policy recommendations include a strong focus on transport related measures. • The Old Oak Transport Study concluded that, in order to manage congestion and stress on the highway network, it will be necessary to adopt a series of demand management and infrastructure improvement measures to substantially reduce highway trips and facilitate a high public transport mode share. The assumptions underpinning the 'reduced highway / high public transport share scenario' transport model explored in the Study include 5% commercial and 15% residential highway mode share, with the remaining mode share covered by public transport and non-motorised transport.	• OPDC should establish a Low Emission Neighbourhood, an area based scheme covering all types of emissions, a Clean Air Zone, focused on promoting low emission road based public transport and goods vehicles, and a Zero Emissions Network to help local businesses reduce the emissions associated with their activities. • It is recommended that specific regulations and guidance are developed to limit private motorised vehicle mode share, particularly for Old Oak, and promote travel by public transport. OPDC should work with transport infrastructure providers to ensure that sufficient provision is available to meet high public transport mode share. • The Air Quality Study recommendations highlight the importance of establishing an overall policy and planning framework for ensuring that enhancement of local air quality is fully embedded in the planning process, based on the core minimum requirement of overall air quality neutrality, and integrated across land use, urban form / open space, transport and infrastructure.
Low / zero-emission onsite energy generation and waste management	• OPDC will work with energy service providers and developers to support development of onsite energy generation plant and facilities which produces either zero or very low air emissions, exceeding current requirements for London as set out in the Mayor's Sustainable Design and Construction SPG. • OPDC will work with waste management service providers to support development of onsite waste management plant and facilities which minimises air emissions.	• Air emissions from local energy generation, in particular biomass and CHP plant, are the subject of specific guidance in the Mayor's Sustainable Design and Construction SPG. • The Air Quality Study focuses on reducing air emissions from onsite energy generation plant involving combustion processes, including energy from waste plant. • The Air Quality Study analysis of existing air quality on the OPDC site highlights some incidences of exceedance of ambient air quality standards as associated with onsite waste management facilities.	• OPDC should implement a package of regulations, financial and other incentives to promote low/zero emission onsite energy generation, including energy from waste facilities, as recommended in the Air Quality Study. • OPDC should develop specific regulations and guidance aimed at minimising air emissions, as well as exposure to emissions, from onsite energy generation and waste management plant.
Measuring and monitoring ambient air quality	• OPDC will develop and maintain a network of monitoring equipment to enable regular and frequent collection of data on measured ambient air pollutant concentrations. Monitors will be located to ensure effective coverage for both construction related and operational emissions. Data collected will be used to assess performance against ambient air quality targets.	• Infrastructure and capacity to measure and monitor the effectiveness of policies and objectives throughout the development's lifecycle is key for a responsive framework.	• Effective monitoring of emissions, using a network of both automatic and manual monitor equipment and covering both construction related and operational emissions is recommended by the Air Quality Study.

Objective/Policy Area	Policy Recommendation	Justification	Strategy
Objective 2: New buildings and transport to be air quality postive			
New buildings emissions	• As part of their AQMP submission developers will be required develop strategies clearly demonstrating how they will exceed current Mayoral guidance for air quality neutral development, in accordance with OPDC site-wide targets.	• The importance of addressing pressing air quality issues in London is highlighted in the Mayor's A City for All Londoners vision document, which proposes moving all new buildings in London to be air quality positive. This means going beyond the current 'air quality neutral' guidance, with all buildings having to contribute actively to a progressive reduction in the total amount of London's emissions and associated exposure.	• It is recommended that new buildings in Old Oak and Park Royal are required to significantly exceed current air quality neutral guidance, in line with the vision set out in the Mayor's A City for All Londoner's document. It is recommended that initially this requirement is set at 5% below air quality neutral benchmarks (NO_x and PM_{10} average emissions, $g/m^2/annum$) defined in the Mayor's Sustainable Design and Construction SPG.
Freight related emissions	• OPDC will work with developers, infrastructure providers and freight operators to support development which promotes lower impact and more efficient movement of freight. As part of their AQMP submission, developers will be required develop strategies clearly demonstrating how emissions from freight deliveries will be reduced.	• London Plan supports opportunities for integrating sustainable modes of freight infrastructure. International, national and regional guidance suggest policies to reduce emissions, to reduce exposure to pollution and to inform assessment. • The Air Quality Study also provides information highlighting the effectiveness of freight consolidation centres and zero/low emissions 'last mile' deliveries in reducing freight movement related air pollutant concentrations. Such measures could be applied in both Old Oak and Park Royal, and could cover construction and logistics as well as operational freight movements.	• OPDC should develop regulations and guidance on provision of freight consolidation centres and promotion of zero/low emissions 'last mile' deliveries, as recommended in the Air Quality Study.
Low emission vehicles, electric vehicles and CAVs[4]	• OPDC will support the provision of infrastructure and financial or other incentives promoting low emission vehicles and which enables future use of CAVs. • OPDC will support provision of infrastructure for low emission vehicles and supporting financial or other incentives, which encourage modal shift to more carbon efficient and lower impact transport modes. • As part of their AQMP submission, developers will be required to develop strategies clearly demonstrating how development will support use of low emission vehicles, electric vehicles and CAVs.	• The Mayor's A City for All Londoners vision document suggests changing the way people travel as a key step in reducing air pollution. One such identified way is through use of low emission vehicles. • The Air Quality Study and the Old Oak and Park Royal Transport Studies all include proposals for promoting use of low emission vehicles, including electric vehicles. • The site analyses show congestion and Heavy Duty Vehicles (HDVs) are the main contributors of air pollution within the OPDC area. In order to be an exemplar low emission development strong policies are required targeting emissions from these sources.	• Recommendations in the Air Quality Study and the Old Oak Park Royal Transport Studies regarding low emission vehicles and electric vehicles should be implemented. • It is recommended that further work be completed to update the Old Oak and Park Royal Transport Studies and the Air Quality Study with specific exploration of the potential impact of electric vehicles and CAVs, given more recent projections of faster than expected uptake of these vehicles over the next 10-15 years.
Construction related emissions	• OPDC will work with developers and contractors to support development which minimises air emissions from construction. • As part of their AQMP submission, developers will be required to develop strategies clearly demonstrating how construction related emissions will be minimised. Such strategies should be closely linked to those for operational freight movement, including minimising movement, using lower impact transport modes and equipment/plant, and controlling dust/ particulates.	• The Mayor's Air Quality Strategy, Sustainable Design and Construction SPG and Control of Dust and Emissions during Construction and Demolition SPG provide strong emphasis on minimising air emissions from construction • Integrated approaches for managing air emissions from construction are recommended in the Air Quality Strategy. These should be closely linked to freight movement measures highlighted above.	• The Air Quality Study recommends a comprehensive package of measures to minimise air emissions from construction, including minimising movement, lower impact equipment/plant and transport modes and controlling dust and particulates.

4 Connected and autonomous vehicles. Through extensive use of smart technology, CAVs are projected to improve the efficiency of overall vehicle movements and increase overall vehicle fuel efficiency, thus reducing associated air emissions.

Objective/Policy Area	Policy Recommendation	Justification	Strategy
Objective 3: Enhance indoor air quality			
Controlling indoor air quality	• As part of their AQMP submission, developers will be required to develop a low/zero VOC emissions materials, fittings and fixtures strategy for all development demonstrating how site-wide VOC related indoor air quality targets will be met. • As part of planning applications, all development proposals will be required to include a ventilation, air filtration and air cleaning systems design clearly demonstrating how site-wide CO_2 and VOC emissions targets will be met.	• The Mayor's Sustainable Design and Construction SPG provides guidance on protection of internal air quality. • CO_2 concentrations and VOC emissions from fixtures and fittings are the basis for the OPDC indoor air quality targets, based on analysis of current standards, guidance and best practice. • Ventilation strategies will be key to maintaining internal air quality, utilising opportunities for real time, dynamic control and smart building technology.	• A focused approach to controlling indoor air pollutant concentrations related to building construction and operation is recommended with the use of site-wide targets. Pollutants emitted from building materials, fixtures and fittings, and CO_2 concentrations related to building occupation levels, are considered most important to targets. VOCs are considered the key type of pollutant in relation to emissions from building materials, fixtures and fittings.
Measuring and monitoring indoor air quality	• Post-construction, pre-occupancy testing and verification will be required for all new and retrofit development to ensure compliance with site-wide VOC emissions targets. Post-occupancy testing and verification will be required for all new and retrofit development to ensure compliance with site-wide CO_2 emissions targets. • All developments will be required to include smart technology enabling users to monitor in real time building performance against site-wide indoor air quality targets.	• Infrastructure and capacity to measure and monitor the effectiveness of policies and objectives throughout the development's lifecycle is key for a responsive framework. • Smart monitoring technology, integrated with building management systems, enables efficient automated performance based control of indoor air quality, in addition to providing real time performance information for users. • Dynamically controlled ventilation has benefits for cost and energy efficiency as well as improving indoor air quality and its associated health and wellbeing impacts.	• OPDC should ensure appropriate procedures are developed and resources put in place to enable post-construction, pre- and post-occupancy testing and verification of indoor air quality for all new and retrofit development.

Evidence

This section sets out evidence supporting the policy and strategy recommendations listed in Table 4.28. Evidence comprises the following:

- Key observations from UK and international best practice case studies.
- Results of initial site air quality analysis.

Best Practice Case Studies

Relatively few of the case studies reviewed in the present study included targets or strategy elements directly focused on ambient (outdoor) air quality. Most of the case studies include support for lower emission transport as a general objective.

The Vauxhall Nine Elms scheme includes mention of a variety of transport measures specifically aimed at reducing negative impacts on ambient air quality from the development.

The Stavros Niarchos Foundation Cultural Centre (SNFCC) is unusual in highlighting the ambient air quality benefits of extensive greening of a large urban area, in addition to carbon sequestration and urban heat island reduction benefits. Both these aspects are highly relevant to development at Old Oak in particular, with the projected significant increase in trips to/from the site and the constraints on green space, particularly trees and denser vegetation, anticipated in the masterplan proposals.

There is also generally little focus on indoor air quality in the case studies reviewed. Hudson Yard provides a good example of the importance of effective building ventilation systems with flexible air flow in promoting indoor air quality.

Vauxhall Nine Elms, London, UK

Air pollution index and air quality management: the anticipated increase in vehicle movements and related emissions will negatively impact on air quality within the Opportunity Area, particularly adjacent to arterial routes and Vauxhall gyratory, unless a range of mitigation measures are implemented. Measures may include:

- A reduction in parking ratios for residential schemes;
- Car-free and permit free residential and mixed-use schemes in conjunction with improvements to public transport accessibility and capacity;
- Bus priority measures;
- Pedestrian and cycle priority measures, including segregated routes and signalised crossing facilities;
- Comprehensive public transport accessibility and capacity improvements; and
- Green travel plans for both residential schemes and sites of employment.

© Shutterstock

The Stavros Niarchos Foundation Cultural Centre (SNFCC), Athens.

Spread over 170 acres and covering 85% of the total area of the SNFCC, the Stavros Niarchos Park is one of the largest green areas in Athens. The Park comprises 1,400 trees and 280,000 shrubs, and features a Mediterranean Garden, Vegetable Gardens, a lush circular Labyrinth, playgrounds and a gentle uphill slope.

The Stavros Niarchos Park doubles the green indicator per capita in the neighbouring areas, while it also significantly improves air quality. The Park's plants absorb approximately 11,000kg of CO_2 emissions annually.

The Park's creation also reduces the temperature within the space by approximately 2°C, in comparison to the temperature in the surrounding urban areas.

© Yiorgis Yerolymbos_SNF

Hudson Yard, New York, USA

The building's outdoor air system has the capacity to deliver 30% more outside air than ASHRAE[5] 62.1-2007. Outside air will be filtered with activated carbon[6], MERV[7] 8 pre-filters and MERV 14 design filters.

During construction, the base building's ventilation system components will be protected from dust to minimize indoor air pollution when the system is turned on. Fan systems are be capable of varying from 100% of design airflow to 25% of design air flow.

The building will be maintained with a green cleaning and maintenance protocol. The exhaust fans in the parking garage are modulated according to carbon monoxide levels rather than run at constant volume.

© Shutterstock

5 American Society of Heating, Refrigerating and Air-Conditioning Engineers. See www.ashrae.org.
6 Activated carbon is a carbonaceous, highly porous adsorptive medium that has a complex structure composed primarily of carbon atoms. The intrinsic pore network in the lattice structure of activated carbons allows the removal of impurities from gaseous and liquid media.
7 Minimum Efficiency Rating Value (MERV) is a measurement scale developed by ASHRAE (ANSI/ASHRAE Standard 52) to rate the effectiveness of air filters. The MERV scale ranges from 1 (lowest) to 20 (highest). See https://www.nafahq.org/understanding-merv/.

Summary of Site Air Quality Analysis

This section provides a summary of the site air quality analysis for Old Oak and Park Royal, which combines discussion of the results of the Air Quality Study with additional analysis of indoor air quality considerations for the development. Details of the site air quality analysis are set out in Appendix B.5.

The Air Quality Study provides an evaluation of current air quality conditions in the OPDC area and future estimated air quality conditions with the development. Using a combination of publicly available data and study-specific dispersion modelling the results of the evaluation of current air quality conditions indicate that there are currently a high number of exceedances of the annual mean AQO for NO_2, largely associated with the road network. Recent monitoring data also indicates that the 24-hour mean AQO for PM_{10} has also been exceeded, and that exceedances appear to be associated with operation of industrial and waste management activities in the area.

The Air Quality Study reports on dispersion modelling which used the Old Oak Transport Study 2031 'with development' scenario and 2030 projected background concentrations to estimate the ambient concentrations of NO_2 and PM_{10} across the site for 2031 build out. The results indicated that, due to turnover in the vehicle fleet, which will see older vehicles replaced by newer vehicles which meet tighter European emission standards, emissions and background and roadside pollutant concentrations are expected to be lower in the future.

Consolidating freight movements using dedicated centres is well recognised as a means of reducing overall freight trip numbers and trip kilometres with benefits in terms of reduced congestion, carbon and other air pollutant emissions, as well as other environmental benefits. The Air Quality Study cites a number of examples of freight consolidation centres (FCC) in the UK (see the Freight Consolidation and Zero Emissions Last Mile section in Appendix B.5).

The use of FCCs in relation to construction activities is also highlighted by the Air Quality Study, citing examples in London which have had a major effect in reducing vehicle trips and associated local emissions as well as increased delivery reliability.

The Air Quality Study also emphasises the concept of zero emissions 'last mile' deliveries. This involves use of electric vehicles or cycles. The study cites a pilot in the City of London which showed zero local air pollutant emissions were generated and the amount of space taken up by delivery vehicles dropped by 50%. Based on modelling reported in the London Local Air Quality Management Borough Air Quality Action Matrix[8], the Air Quality Study highlights that, by removing all light goods vehicles emissions, as an approximation of the impact of encouraging zero emissions last mile deliveries, it was shown that NO_2 and PM_{10} concentrations would decrease by 11% and 12% respectively.

In addition to outdoor air quality, the quality of air within buildings is also a key issue for development in the OPDC area. For the present study, the focus is on indoor air pollutant concentrations related to building construction and operation. In particular, pollutants emitted from building materials, fixtures and fittings, and CO_2 concentrations related to building occupation levels, were considered most important to OPDC air quality targets. VOCs were considered the key type of pollutant in relation to emissions from building materials, fixtures and fittings. From a review of relevant UK and international standards and guidance recommended target emissions levels (see Table 4.29 below) and policy recommendations (see Table 4.28 above) were developed for Old Oak and Park Royal.

Cost Implications

The Development Infrastructure Funding (DIFS) supporting study for the OPDC Draft Local Plan provides cost estimates for the set of interventions recommended in the Old Oak Transport Study as part of the proposed transport strategy. The proposed transport strategy is based on the Reduced Highway / High Public transport Share scenario explored in the study in which a 5% commercial and 15% residential car mode share was assumed. The DIFS cost estimates cover highways improvements, rail capacity improvements, bus capacity improvements, bridges and underpasses, cycling and walking improvements. Costs associated with delivering HS2 and Crossrail, with the exception of a Crossrail to WCML spur, have not been included. Costs associated with demand management and 'smarter choices' initiatives have not been included, as these are anticipated to come through normal development processes. The total estimated cost for implementing the proposed transport strategy amounts to £1.066bn.

The Old Oak Transport Study proposed transport strategy includes provision for FCCs. This is not covered in the DIFS cost estimates. A study for South East Scotland Transport Partnership[9] gives indicative figures of approximately £1.37m capital cost and £248,000 annual operating cost for a retail FCC of 500m² floor area. However, it should be emphasised that costs can vary considerably depending on how FCCs are implemented, in particular whether an existing facility is used or a new facility developed. A study for Birmingham City Council10 estimated capital costs for the former could be as low as £20 - 50,000.

8 https://www.london.gov.uk/sites/default/files/air_quality_action_matrix.pdf.
9 Freight Consolidation Centre Study, South East Scotland Transport Partnership, April 2010. http://www.dryport.org/files/doc/SEStran_Freight%20Consolidation%20Centre%20Study%20-%20Final%20Report.pdf.
10 Birmingham Mobility Action Plan, Birmingham Connected Technical Package 3 Servicing and Logistics, Birmingham City Council, November 2014. https://www.birmingham.gov.uk/downloads/file/1931/birmingham_connected_technical_package_3_servicing_and_logistics.

Targets

Table 4.29 sets out the recommended environmental performance targets. The section below provides information on how the targets have been derived.

Rationale for Targets

The following principles underpin development of the targets:

- Compliance with current Mayoral policies and guidance.
- Current and emerging UK and international best practice.
- Indicative site air quality analysis.

Based on current mayoral policy and guidance, the site analysis and current and emerging best practices and methodologies, guideline air quality performance targets have been set.

Targets for incidences of exceedance of national AQO have been set based on the vision in the Mayor's 'A City for All Londoners' and to help ensure long term protection of human health. The targets set for percentage of trips in to or out of Old Oak by combustion engine private vehicles are based on the assumptions underpinning the 'reduced highway / high public transport share scenario' transport model explored in the Old Oak Transport Study and which informed the recommended interventions set out in the Study. The targets set for percentage reduction in freight trips in to or out of Park Royal as a result of freight consolidation are based on case study examples quoted in the Air Quality Study and summarised in the site analysis section above. The Short-Term target is based on average of lower trip reductions listed in the examples. The Medium-Long Term target is based on average of higher trip reductions listed in the examples.

The targets for NO_x and PM_{10} average emissions percentage level below air quality neutral benchmarks in Mayor's Sustainable Design and Construction SPG are based on the vision in the Mayor's 'A City for All Londoners', which proposes that all new development in London should be air quality positive. This is interpreted as a significant improvement, i.e. at least 5%, beyond the air quality neutral benchmarks in the Mayor's Sustainable Design and Construction SPG.

The indoor air quality targets set for carbon dioxide, total VOCs and formaldehyde concentrations are based on the lowest limit value specified in national and international guidance (see the Indoor Air Quality section in Appendix B.5).

Table 4.29 - Recommended Targets

Objective/Indicators	Target			
	Old Oak		Park Royal	
	Short Term	Medium Term - Long Term	Short Term	Medium Term - Long Term
Objective 1: Enhance local ambient air quality				
Incidences of exceedance of national air quality objectives per annum	Zero	Zero	Zero	Zero
Percentage of trips in to or out of Old Oak by combustion engine private vehicles	15%	10%	N/A	N/A
Percentage reduction in freight trips in to or out of Park Royal resulting from consolidated delivery, relative to current baseline	N/A	N/A	60%	75%
Objective 2: New buildings and transport to be air quality postive				
NO_x and PM_{10} average emissions (g/m²/annum) percentage level below air quality neutral benchmarks in Mayor's Sustainable Design and Construction Supplementary Planning Guidance	5%	5%	5%	5%
Objective 3: Enhance indoor air quality				
Carbon dioxide concentration	Less than 800 ppm at any point in time (post occupancy)	Less than 800 ppm at any point in time (post occupancy)	Less than 800 ppm at any point in time (post occupancy)	Less than 800 ppm at any point in time (post occupancy)
Total Volatile Organic Compounds	Less than 300μg/m³ over 8 hours, (post construction, pre-occupancy)	Less than 300μg/m³ over 8 hours, (post construction, pre-occupancy)	Less than 300μg/m³ over 8 hours, (post construction, pre-occupancy)	Less than 300μg/m³ over 8 hours, (post construction, pre-occupancy)
Formaldehyde	Less than 100μg/m³ averaged over 30 minutes (post construction, pre-occupancy)	Less than 100μg/m³ averaged over 30 minutes (post construction, pre-occupancy)	Less than 100μg/m³ averaged over 30 minutes (post construction, pre-occupancy)	Less than 100μg/m³ averaged over 30 minutes (post construction, pre-occupancy)

Short-Term: up to 2031; Medium Term-Long Term: 2032 onwards

5. Environmental Quality and Resilience

Woodberry Down

Woodberry Down lies in the northwest of the London Borough of Hackney alongside the Seven Sisters Road. The Council has worked in partnership with Berkeley Homes and Genesis Housing Association on the regeneration of the estate to deliver over 5,000 new homes, 41% of which will be affordable, as well as 6 hectares of landscaped public open space by 2035. To the south of the site are the two large East and West Reservoirs, a fantastic natural resource which has inspired the design of the landscape spaces, with green fingers reaching back into the heart of the development. In April 2016, Sir David Attenborough officially opened the Woodberry Wetlands new nature reserve which has been created on the site of the East Reservoir. He declared the nature reserve a ‘transformative model for London’, hailing it as ‘a force against urban alienation and a tranquil place in which to find peace of mind’.

© Berkeley

5. Environmental Quality and Resilience

Introduction

This chapter addresses the second of the overarching environmental themes, environmental quality. This involves consideration of Green Infrastructure and Biodiversity, Microclimate, Overheating, Flood Risk, Noise and Sustainable Transport.

Objectives

Green Infrastructure & Biodiversity

- Maximise multi-function, multi-benefit green infrastructure
- Restore natural habitats and enhance biodiversity
- Promote high quality, liveable built environment for diversity of residents, employees and visitors

Microclimate

- Light, comfortable, healthy, vibrant open space / public realm
- Light, comfortable, healthy building internal environments
- High quality, liveable built environment for diversity of residents, employees and visitors

Climate Resilience

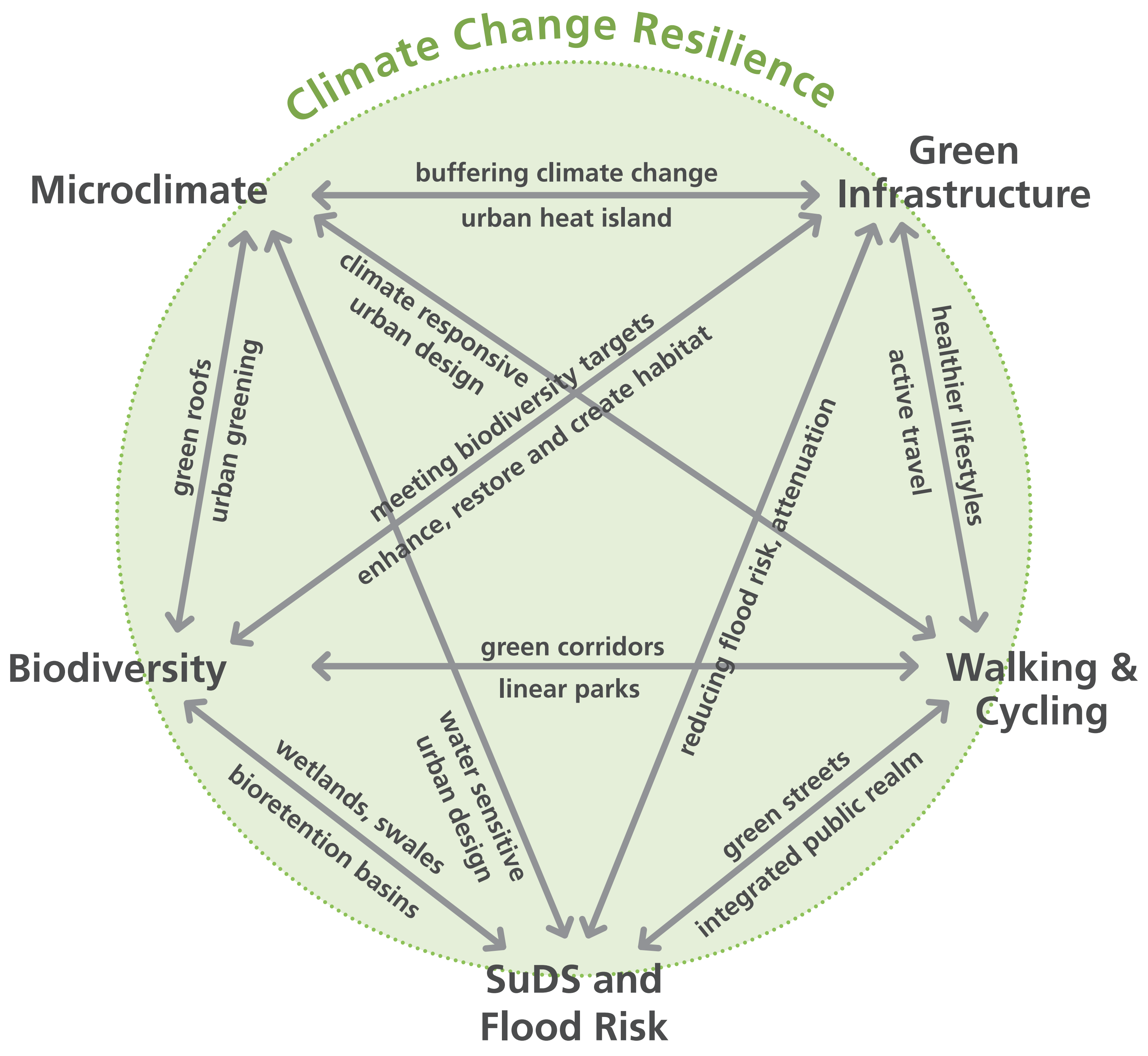
- Mitigate the urban heat island (UHI) effect
- Prevent overheating of outdoor areas and indoor spaces
- Minimise flood risk

Noise

- Plan for comfortable and healthy homes and open space / public realm
- Reduce the negative noise effects of dense urban environments
- Reduce exposure to infrastructure / industrial generated noise

Sustainable Transport

- Maximise low / zero carbon movement
- Strong walking and cycling networks
- Restricted parking
- Fossil fuel free vehicles



GREEN INFRASTRUCTURE & BIODIVERSITY
Multi Functional, Multi Benefit

Objectives

- Maximise multi-function, multi-benefit green infrastructure
- Restore natural habitats and enhance biodiversity
- Promote high quality, liveable built environment for residents, employees and visitors

Introduction

Green infrastructure is promoted on all levels of planning policy. The National Planning Policy Framework (NPPF) cites improved health, recreation opportunities, ecology and sustainability as core reasons to provide green infrastructure within developments.

The London Plan aims to protect, improve and increase the amount of green infrastructure as London continues to grow and become more compact and intensive in its built form. Related Supplementary Planning Guidance produced by the Greater London Authority (GLA) includes The Mayor's All London Green Grid, The Biodiversity Strategy and The Green Infrastructure Task Force Report.

Definition of Green Infrastructure

The concept of a green infrastructure has been set out in the current London Plan and the policy framework provided by the All London Green Grid which defines green infrastructure as:

A network of green spaces – and features such as street trees and green roofs - that is planned, designed and managed to provide a range of benefits, including: recreation and amenity, healthy living, reducing flooding, improving air quality, cooling the urban environment, encouraging walking and cycling, and enhancing biodiversity and ecological resilience.

The London Infrastructure Plan 2050 states that green infrastructure needs to be regarded as infrastructure in its own right, assisting with flood protection, water storage and recycling, and providing shade, new pedestrian and cycling routes as well as space for recreation and biodiversity.

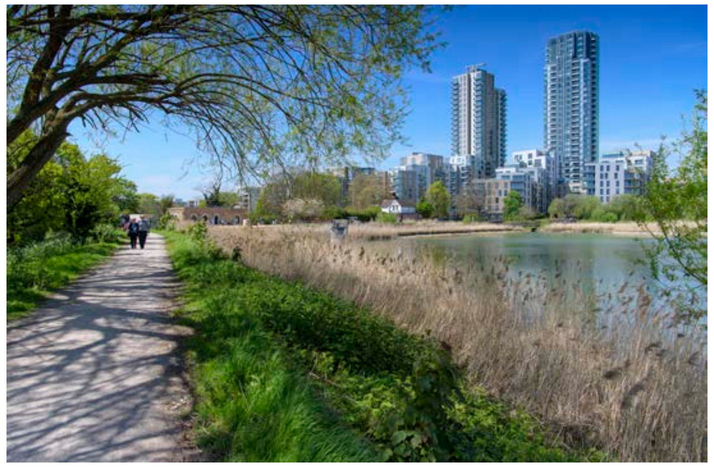
Public Health Benefits of Green Infrastructure

A range of bodies, including Government agencies, have promoted the physical and mental health benefits of access to green space. The Houses of Parliament POST note 538 October 2016 summaries the evidence for physical and mental health benefits from contact with nature and the report by Forest Research: Benefits of Green Infrastructure provides links to a range of case studies and research related to health benefits.

Urban green spaces impact positively on the health of local populations in many ways:

- **Physical benefits:** Provide opportunities for physical activity, which contribute to the prevention of many health problems such as cardiovascular disease, diabetes, stroke, some cancers and osteoporosis. The urban tree canopy also helps to reduce the risks from ultraviolet radiation exposure and the heat island effect.
- **Mental benefits:** Improve mental health and well-being by enhancing concentration, work productivity, and self-esteem. They can alleviate anxiety and depression, and boost immunity. Urban green spaces provide areas of quiet and solitude where people can escape from the stresses of life and provide areas for contemplation, reflection and inspiration.
- **Social benefits:** Provide opportunities for education, social inclusion and cohesion by supplying space for social mixing, creating networks and relationships. Playing in parks and gardens helps children to develop intellectually and learn about social interaction.

Woodberry Down



© Berkeley

Kidbrooke Village

© Atkins

King's Cross

© John Sturrock, King's Cross

ATKINS

Environmental Benefits of Green Infrastructure

In addition to health and wellbeing benefits, green infrastructure can provide a number of environmental benefits by helping to mitigate the impact of climate change by reducing flood risk; sequestering carbon dioxide in trees and plants and reducing atmospheric pollution; lowering air temperatures and aiding climate change adaptation and mitigation:

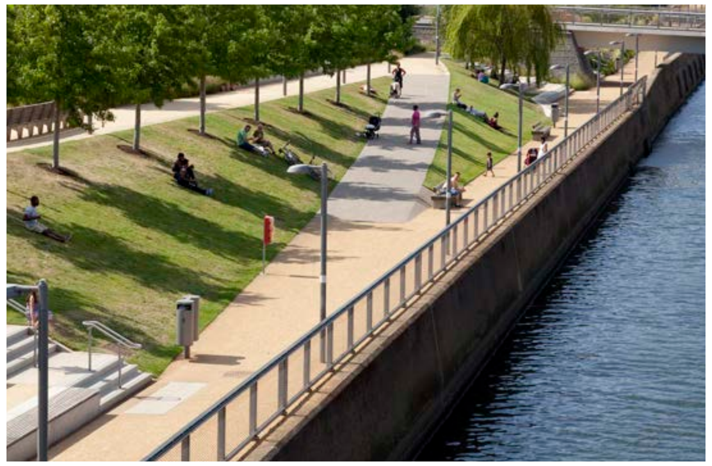
- **Reducing Flood Risk:** A high coverage of impermeable surfaces in urban areas prevents surface water from soaking into the ground, increasing the risk of flooding and pollution from heavy rainfall. The integration of sustainable urban drainage systems with green infrastructure can reduce the volume of urban runoff by controlling the water at source through trees and vegetation, green roofs, infiltration trenches, swales and basins.
- **Improving Air Quality:** Exposure to high levels of air pollution can cause and exacerbate respiratory problems, heart disease and cancer. Trees and vegetation can reduce air pollution directly by trapping and removing fine particulate matter, and indirectly by lowering air temperatures through transpiration which can reduce the formation of ozone, and through the direct production of oxygen through photosynthesis.
- **Heat Amelioration:** Urban areas often experience elevated temperatures compared with the surrounding countryside, because of extensive heat absorbing surfaces, such as concrete and tarmac, concentrated heat production and impeded air flow. Green infrastructure can lower air temperatures through the evaporation of water from vegetation and shading.
- **Climate Change Adaptation:** Green infrastructure has an important role in supporting the adaptation of people who live in dense urban centres to a changing climate. The NPPF, the UK Climate Change Risk Assessment 2012 and the subsequent National Adaptation Programme 2013 all recognise the role of urban green infrastructure in climate change adaptation. This is reflected in the London Climate-Change Adaptation Strategy, which aims to increase green space in central London to provide a cooling effect.

  Green infrastructure provides a range of climate change services that can make both a substantial contribution towards adapting to climate change and a limited yet important contribution towards mitigating climate change, for example, large canopy trees, green networks, parks, green walls and roofs can all play a significant role in mitigating the urban heat island effect.
- **Biodiversity:** Green infrastructure can have a positive impact on biodiversity by: increasing habitat area, increasing populations of protected species and increasing species movement. The habitats provided in urban green spaces can be particularly important for a range of species, for example, green roofs are used by birds and a wide range of invertebrates. Linear features such as canals and railway embankments can act as corridors for wildlife and increase species movement.

Greenwich Peninsula, London

© Atkins

Queen Elizabeth Park



© Atkins

Granary Square, King's Cross

© John Sturrock

Hale Village, London

© Atkins

Economic Value

Placing accurate economic values on green infrastructure is vital to support the case for sustained investment. There is a lack of understanding of the full potential of green infrastructure to address social and economic challenges. There is a need for a better business case for investing in it with accounting methods that can properly value the functions of green infrastructure, for example, increased land values. Traditionally green infrastructure has been managed and funded by the public sector and so often suffers most from budget tightening during periods of austerity.

An innovative ecosystem valuation, utilising a value transfer methodology, of the Camley Street Natural Park in King's Cross, concluded that this greenspace contributes £2.8 million to the local economy. See case study opposite.

Camley Street Natural Park

© Atkins

King's Cross, Camley Street Natural Park

Camley Street Natural Park – Two acres of nature reserve lie between London's busy rail stations – King's Cross and St Pancras. The park was an old coal yard until 1984, and is an important example of the re-use of brownfield land to create urban green infrastructure in the heart of the capital.

Atkins undertook an ecosystem service valuation of the Camley Street Natural Park for the London Wildlife Trust which demonstrated that the park contributes £2.8 million to the local economy and society annually. These benefits include enhancing the local environment and property market; volunteering and education opportunities; and visitor spend in the local economy.

In addition to this, the park plays an important role in delivering many other benefits. Some of these are not always possible to value in monetary terms, for example, regulating $C0_2$ in the atmosphere and reducing pollution.

© Camley Street Natural Park – John Sturrock

Greenwich Peninsula

The 260 ha Greenwich Peninsula, formerly Europe's largest town gasworks, is one of the largest brownfield development sites in London and of major strategic importance.

The landscape structure of the original masterplan reflects the importance of the natural environment and conceives three interconnected parks of individual identity. Central Park acts as a formal green spine at the heart of the development. Southern Park acts as a village green for the Greenwich Millennium Village. The Ecology Park recreates elements of the Peninsula's historic marshland and contains multiple man-made, fresh water habitats within a small area, resulting in a high biodiversity. The park is managed by a conservation trust and is a valuable resource for the community and for nature conservation.

The provision of major green infrastructure at the early stages of the project, in advance of development, provides a model for Old Oak.

© Atkins

ATKINS

Summary of Policy Recommendations

Green infrastructure policy recommendations for Old Oak and Park Royal have been developed and are set out in the Table below. These are based on a review of mayoral policies and an analysis of case studies.

Table 5.1: Green Infrastructure Policy Recommendations

Policy Area	Policy Recommendation	Rationale	Policy Context
Green Infrastructure	The development should support the delivery of the spatial vision by delivering and/or contributing towards a high quality, multi-functional green and blue infrastructure network, i.e. accessible for play and recreation, promotes walking or cycling safely, and supports wildlife, urban cooling and flood management. Proposals should: A. Provide a minimum of **30%** of Old Oak's total area allocated to publicly accessible open space, which should consist of a network of well-managed, high quality, multi-functional green and civic open spaces and Green Streets, which are linked to the wider London Green Grid and Blue Ribbon Network; • This equates to approximately **4.14sqm** per resident and **1sqm** per worker. This standard would also be appropriate for new build in Park Royal; • In addition to provision of at least 30% accessible open space, developers should contribute towards ensuring that these spaces provide a good mix of facilities, are fully accessible, well located and properly managed and maintained; • Wormwood Scrubs is excluded from the 30% but it would be required to fulfil the role of a district park, providing good quality access to outdoor sports facilities and open space. An open space strategy will review the capacity of this open space and its facilities to identify what facilities should be provided within the development site and where facilities and open space on Wormwood Scrubs could be enhanced through developer contributions; B. Contribute towards and/or deliver 3 new local parks that are no less than 2ha in size and a range of small public open spaces and pocket parks; C. Provide a minimum **10sqm** of dedicated play equipment per child; D. Incorporate a Grand Union Canal Linear Park; E. Limit overshading of open spaces. Public and private spaces should benefit from good light and microclimate, at least 2 hours of daylight on 21st March into 50% of space in line with BRE guidance; F. Aim to be **biodiversity positive,** in which biodiversity rich, multi-benefit, multi-functional green spaces and water bodies are highly interconnected and closely integrated with the wider green infrastructure network in a clear functional hierarchy; G. Make a positive contribution towards climate change. Green infrastructure should be maximised to provide summer shade and cooling, to the buildings and external environment, and appropriate provision for localised surface water attenuation, including sustainable drainage techniques;	The proposed development will result in a significant demand for green space to: • Provide sufficient open space recreation; • Encourage walking and cycling; • Support and enhance local wildlife; • Mitigate the urban heat island effect; • Contribute to the attenuation of surface water runoff. The major determinants of ill-health in rich developed countries are now lack of exercise and over-eating. There is growing evidence that green space boosts health by increasing opportunities for physical exercise, increasing social inclusion and reducing air pollution. As well as improving physical health, green space also increases psychological health and creates a more comfortable microclimate for living and working. The initial analysis undertaken (see below) identifies that 30% of public open space (including pedestrian priority streets and squares) would be the minimum required to achieve a comfortable environment to live and work in and would be comparable with other high density, mixed use schemes within London. In addition semi-private communal areas for residents (courtyards or terraces) will be provided which should incorporate children's play areas, this would increase open space coverage by approximately 10%. The scheme would also be expected to provide a network of pedestrian and cycling routes set in connected green corridors, linking open spaces with a linear park along the Grand Union Canal and connecting over the rail corridors by means of green bridges to Wormwood Scrubs and other areas of open space and recreational facilities. The Grand Union Linear Park should be a fully accessible route that includes a mix of public squares, play areas, green space and other recreational areas along the entire length of the canal within the OPDC area. **Biodiversity positive** means a net gain in biodiversity as a result of development. Green infrastructure can have a positive impact on biodiversity by increasing habitat area, increasing populations of protected species and increasing species movement. Green infrastructure needs to be carefully designed so that it is effectively integrated into the overall spatial design of the area in order to ensure it makes a positive contribution to the overall liveability of the area and is multi-functional. To ensure that green infrastructure achieves the range of benefits set out above, its quality should be assessed using both qualitative and quantitative assessment processes.	NPPF paragraphs 9, 58, 73-74; London Plan policy 2.18, 7.1, 7.5, 7.18, 7.19; The Mayor's All London Green Grid; The Mayor's Green Infrastructure Task Force Report; The Draft Local Plan (Regulation 18 Consultation February 2016)

Policy Area	Policy Recommendation	Rationale	Policy Context
	H. In order to ensure the long term quality and performance of green infrastructure is sustained, developments will be expected to contribute to its management and maintenance. Developers will be required to provide a detailed management plan which should set out the longer term revenue funding arrangements for open spaces and commitments around continual public access; I. It is recommended that a 'Green Space Factor' is adopted to attain minimum quantities of greenery, and special green and blue attributes for the green spaces within residential areas in Old Oak.	The Green Space Factor methodology was developed in Sweden and has been adopted by a number of Local Authorities in the UK. This is being tested by GLA to see how it can be applied in London to major developments.	
Provision of Play Space	Old Oak must provide a hierarchy of play facilities in accordance with the London Plan SPG Play and Informal Recreation. Children's play will be integrated into the urban design of Old Oak from the outset. A range of play options will be provided from informal and natural through to adventure play and sports recreation. Development proposals should maximise opportunities for a range of high quality multifunctional play and informal recreation for all ages and provide: • A minimum of **10sqm** of dedicated play space per child (0-18); • Inclusive play equipment within 400m of all residential properties serving all age groups; • Local parks with multi-use games areas that are readily accessible and include high intensity sports facilities within easy walking distance of homes; • A network of multi-functional open space that links walking, cycling and jogging and includes elements such as climbing walls, outdoor gyms and multi-use games areas (MUGA's); • These play spaces should be located in areas that are not too exposed and receive a minimum of 2 hours of sunlight on the 21 March.	A hierarchy of dedicated play areas for different age groups should be provided in accordance with the Mayor's Play and Informal Recreation SPG. This bench mark standard recommends a minimum of **10sqm** of dedicated play space per child. The strategy for play should also include: • Green Streets and courtyards designed as Home Zones with informal play opportunities; • A safe and connected network of open spaces with opportunities for informal play set within a green grid; • Natural play and trails to be provided within Wormwood Scrubs and the Grand Union Linear Park; • Schools to have access to outdoor classrooms, wildlife areas, nature trails and trim trails.	NPPF Paragraph 9, 69; London Plan policy 3.6; Mayor's Play and Informal Recreation SPG
Private and Semi-Private Amenity Space	All new housing must be designed in accordance with the London Plan provision and standards of private amenity space. **A minimum of 5sqm of private outdoor space should be provided for all 2 person dwellings and an extra 1sqm for each additional occupant.** The required minimum width and minimum depth for all balconies and other private external space is 1500mm. Communal gardens for residents, such as courtyards and terraces need to be: • Of sufficient size to be useable and inviting; • Well designed and integral to the character of the development; At least 50% of each residential courtyard space should be sunlit for at least 2 hours a day on 21 March.	The provision of private open space can be accommodated through sky gardens, roof terraces, balconies and internal courtyards, but these elements will not be sufficient to ensure that all residents and workers have access to open space. As a result tall buildings will be required to proportionately contribute to the provision of a high quality public realm. Every home shall have the benefit of some private or communal amenity space. Private outdoor space can be provided in a variety of ways, for example in: • Balconies; • Communal gardens within perimeter blocks at podium level; • Roof terraces.	NPPF paragraphs 9, 17, 57; London Plan policy 7.1; Mayor's Housing SPG Standard 24, 26, 27

Policy Area	Policy Recommendation	Rationale	Policy Context
Urban Greening	Urban Greening measures should include: A. Maximising provision of soft landscape and incorporating green roofs and green walls on all suitable new buildings; B. Incorporating sustainable drainage features into streets and open spaces; C. Retention of existing trees and planting of new trees on new developments; D Greening of streets and public realm using **50% native species** and 'right place, right tree' approach; E. Planting trees to provide cooling through shade and evapotranspiration.	Urban greening describes the green infrastructure elements that are most applicable in central London and London's town centres. Due to the morphology and density of the built environment in these areas, green roofs, street trees, and techniques such as soft landscape, are the most appropriate elements of green infrastructure. The high density proposed in Old Oak will very likely lead to enhanced urban heat island (UHI) effect in the outdoor spaces. One of the most effective ways to address this is maximising green infrastructure across the site, for example, large canopy trees, green networks, parks, green walls and roofs can all play a significant role in mitigating the UHI. Greenspace can also be used to sustainably manage rainwater, reduce stormwater run-off and flood risk. Such natural interventions are increasingly being recognised as a desirable 'win-win' approach to combating climate change, as they also help to deliver multiple other social, economic and environmental benefits.	NPPF paragraph 99, 114, 118; London Plan policy 5.10; The Mayor's All London Green Grid; The Mayor's Green Infrastructure Task Force Report; The Mayor's Biodiversity Strategy; The Draft Local Plan (Regulation 18 Consultation February 2016)
Local Food Production	New allotments for local food growing spaces will be supported, including the temporary use of vacant or derelict land or buildings. Use of incidental open space on housing estates or other open space areas will also be supported where this does not conflict with other policy objectives or land use priorities. Areas such as roofs, balconies, walls, courtyards and amenity areas can also be used for food growing.	Green infrastructure presents a range of opportunities for food production, from privately managed allotments to community managed gardens. In addition to its economic value, and reducing 'food miles', local food production is recognised as providing several other benefits including community cohesion, health and education.	NPPF paragraph 17; London Plan policy 7.22; The Mayor's All London Green Grid
Temporary public spaces	Proposals for interim green or public open space on temporarily vacant or derelict land will be supported where the uses will add vitality through community, leisure or cultural uses. Proposals must be able to demonstrate that the interim uses will not impact the deliverability of planned site allocations or extant planning permissions and will have no unacceptable adverse impacts on amenity or function of existing permanent business or residential communities.		The Mayor's All London Green Grid
Biodiversity and access to nature	To be biodiversity positive the proposed development will need to: A. Deliver and/or contribute to new and diverse nature habitats; B. Protect land identified as sites of local, borough, regional or national significance and provide an Ecological Management Plan where any development is in close proximity to the nature conservation areas of the Grand Union Canal or Wormwood Scrubs to ensure nature conservation and biodiversity objectives of these sites are met; C. Where sites of ecological importance are impacted or lost through development, compensation must be provided either through provision of new areas of biodiversity that are equal or better than those lost or through financial compensation. D. Enhancements will be secured through the use of planning conditions and where appropriate, planning obligations. Strategic projects will potentially be funded through the Community Infrastructure Levy (CIL); E. Once a development has been completed, management and monitoring of habitats will be required. Management plans must be provided by the developer prior to receiving planning permissions.	Biodiversity refers to the variety of plants and animals and other living things in a particular area or region. It encompasses habitat diversity, species diversity and genetic diversity. Biodiversity has value in its own right and has social and economic value for human society. The habitats provided in urban green spaces can be particularly important for a range of species, for example, green roofs are used by birds and a wide range of invertebrates. Linear features such as canals and railway embankments can act as corridors for wildlife and increase species movement. Further guidance on measures that can be taken are provided within the document. Reference should be made to the evidence for why these sites are designated, this can be found on the council websites for the London Boroughs of Brent and Ealing and the London Ecological Unit Handbook 25 which London Borough of Hammersmith and Fulham cites as evidence for their sites.	NPPF paragraph 7, 9, 99, 109, 114, 117, 118; London Plan policies 7.18, 7.19, 7,21; The Mayor's Green Infrastructure Task Force Report; The Mayor's Biodiversity Strategy; The Draft Local Plan (Regulation 18 Consultation February 2016)

Evidence

This section sets out evidence supporting the policy recommendations listed in Table 5.1. Evidence comprises the following:

- The analysis of public open space provision and accessibility.
- Key observations from UK best practice case studies.
- Standards and design guidelines for private and semi-private residential open space.
- Standards and design guidelines for green streets.
- Assessment of the wider benefits of green infrastructure in tackling climate change and flood mitigation, enhancing biodiversity and providing local food production along with proposed standards, where appropriate, and design guidelines to help create an interconnected green network across the site.

Analysis of Public Open Space Provision and Accessibility: Old Oak

Public Open Space Categories

Public Open Space categories, as defined in The London Plan, (Table 7.2, Chapter 7) provide a benchmark for the provision of public open space across the capital, categorising spaces according to their size, facilities and local importance.

The Public Open Space Categorisation (summarised below) suggests that every Londoner should have access to a Local Park or Small Open Space within 400 metres (5 minutes' walk) of their home and a District Park within 1.2 km (15 minutes' walk).

London Plan Policy 2.18 is clear that public open space standards are best set locally. The OPDC area is a clear example of the need for a locally derived standard. The expected growth in workers, visitors and residents will increase the demand for open space in a place which will have some of the highest densities anywhere in the UK.

The London Plan sets out guidance on assessing local public open space needs. Local Plans should:

- Include appropriate designations and policies for the protection of public open space to address deficiencies.
- Identify areas of public open space deficiency, using the public open space categorisation set out in the London Plan as a benchmark for all the different types of public open space identified therein.
- Ensure that future publicly accessible open space needs are planned for in areas with the potential for substantial change such as opportunity areas, regeneration areas, intensification areas and other local area.
- Ensure that open space needs are planned in accordance with green infrastructure strategies to deliver multiple benefits.

London Plan Public Open Space Categorisation

Open Space category	Size guideline (hectares)	Distances from homes to open spaces
Regional	Over 400 ha	8 km
Metropolitan	60-400 ha	3.2 km
District parks	20-60 ha	1.2 km
Local parks	2 ha plus	400m
Small open spaces	0.4-2 ha	400m
Pocket parks	Under 0.4 ha	400m
Linear open spaces	Variable	Where feasible

Current Level of Provision

The current level of open space provision shown in the Illustrative Masterplan accompanying the Draft Local Plan is assessed below. The hierarchy of public open space and the distance from homes is based on the Mayor's London Plan Public Open Space Categorisation. A comparison has also been made with six London case studies, which range in density from 250-600 dwellings per hectare. These are covered in more detail in Chapter 7 and in Appendix A.
A more detailed Open Space Study is required to confirm these findings, which is beyond the scope of Atkins' current commission.

OPDC is proposing higher densities than the most densely populated inner London Boroughs and should ensure that the benefits of open space provided are maximised and the open space is designed to be of high quality and highly resilient to cope with the high number of people that will use it.

A review of the current level of open space as shown on the Illustrative Masterplan included in the Draft Local Plan highlights the following issues:

- **Wormwood Scrubs:** this important open space already acts as the London Borough of Hammersmith and Fulham's only Metropolitan Park. It also acts as a District Park to the neighbouring communities on its eastern, southern and western boundaries. The **25,737** new homes will place the Scrubs under increasing pressure, particularly in terms of outdoor sports provision.
- **Local Parks:** there are no open spaces of this category in the current masterplan. They provide for court games, children's play, sitting out areas and nature conservation areas.
- **Small Open Spaces:** this category of open space ranges in size from 0.4 to 2.0 hectares. The only space that fall within this category is Old Oak Gardens (1.15 ha).
- **Pocket Parks:** pocket parks under 0.4 ha are included in the current masterplan and will be important for younger children's play close to homes.
- **Linear Open Spaces:** The Grand Union Canal bisects Old Oak and will be an important focus for walking, cycling and informal recreation. The canal corridor includes the 1.2 ha Birchwood Local Nature Reserve. Also within this category are railway embankments which are not fully accessible to the public.

The Illustrative Masterplan also includes the following additional accessible open space not included in London Plan categorisation:

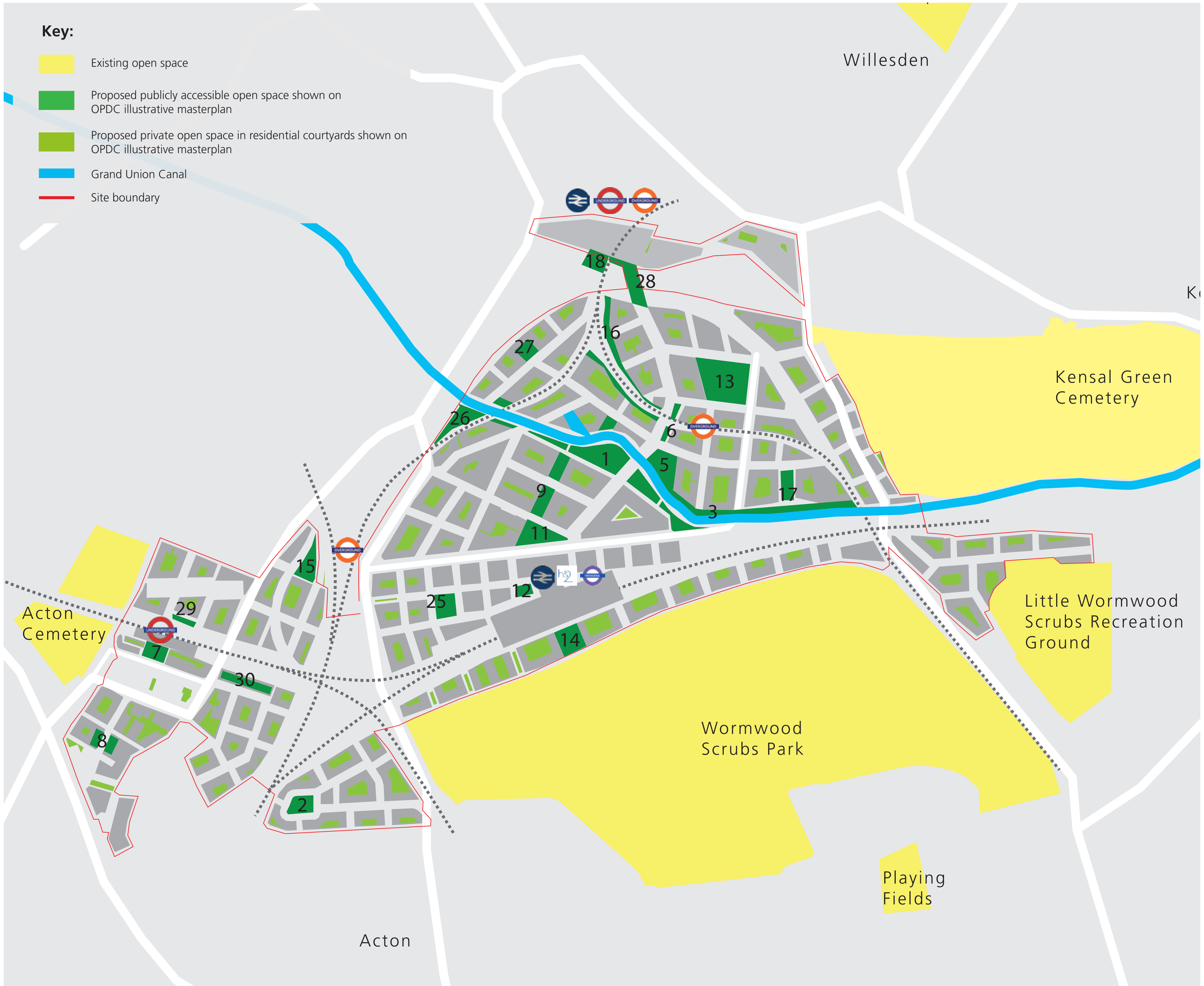
- **Civic Squares:** the masterplan proposes important squares next to the main HS2/ Crossrail station and the other stations. Due to the intensity of use, these will need to be primarily paved spaces with large canopy trees.
- **Pedestrian Priority Street:** the masterplan proposes a linear green corridor connecting the canal to the main station square through Old Oak South.

Publicly Accessible Open Space

Current Level of Provision shown on OPDC illustrative masterplan

Old Oak Site Developable Site Area: **97.5ha**

Plot no.	Key Spaces	Size Guideline Approx. area	Provided Approx. area
	District Park	**ha**	**ha**
n/a	Wormwood Scrubs	20 - 60	68
	Not included in calculation		
Private Open Space in Residential Courtyards			
n/a	**Open Space in Residential Courtyards**		10 Approx.
	Not included in calculation		
A. Public Open Space Categories as defined in London Plan			
	Local Parks		
	None	2 - 20	None
	Small Open Spaces		
13	Old Oak Gardens	0.4 - 2.0	1.15
	Sub Total:		**1.65**
	Pocket Parks		
2	Brunel Park	Under 0.4	0.25
8	North Acton park		0.4
15	Park Royal open spaces		0.3
	Sub Total:		**0.95**
	Linear Open Spaces		
9	Old Oak South linear park	Variable	0.34
3	Canalside spaces		2.56
1	Birchwood Local Nature Reserve		1.2
	Sub Total:		**4.10**
	Total:		**6.70**
B. Additional Open Spaces Categorisation: Civic Spaces			
	Primary Civic Spaces		
5	Grand Union Square	0.2 - 0.5	0.2
6	Hythe Road Central Square		0.1
7	North Acton Square		0.3
11	Old Oak Station Square		0.5
12	Old Oak Common Station square (west)		0.2
14	Old Oak Common Station square (south)		0.4
18	Willesden Junction Station Square		0.6
	Total:		**2.3**
Total Publicly Accessible Open Space: A+B=			**9.0**



Information taken from Figure 64: Proposed and Existing Open Spaces, Local Plan, 4 February 2016

Current level of public open space

The level of publicly accessible open space allocated within the illustrative masterplan in the OPDC draft Local Plan (9ha or 9.2%) is considered to be insufficient to meet the leisure and recreational needs of the future population. The very limited level of coverage is also likely to be insufficient to help address the other benefits of the green open space including: reducing flood risk, improving air quality, heat amelioration and biodiversity.

It is recognised within London that a high level of onsite open space provision is not always achievable especially where there is considerable planning policy impetus to deliver mixed use development comprising commercial, residential and other uses at optimum densities. It is also recognised that office workers and other users do not use open space to the same level as residents (particularly at weekends or evenings).

In Chapter 3 we identify that the majority of the site falls within the London Borough of Hammersmith and Fulham which has an existing borough-wide ratio of 1.35ha per 1000 people which is expected to drop to 1.22ha per 1000 people as the borough's population rises.

In the absence of a borough-wide standard for the quantity of open space in new developments it will be important to ensure that residents and workers of the new development have access to sufficient high quality civic and public open space in line with the London Plan open space hierarchy guidelines. This will also ensure that the new population does not put unacceptable pressure on the capacity of Wormwood Scrub open space and its facilities.

Based on an analysis of the current illustrative masterplan and comparison with other high density, mixed use schemes in London, it is recommended that at least **30%** of publicly accessible open space (including pedestrian priority streets and squares) is provided within the re-development of Old Oak. This is **29.3ha** of the Old Oak area (not including Park Royal) and equates to approximately **4.14sqm** per resident and **1sqm** per worker.

The analysis below demonstrates that increasing onsite provision from **9%** to **30%** would allow a more favourable per resident/ worker comparison of provision with other schemes. It is considered that this would help to provide a comfortable environment to live, work and play in. It takes account of the very high density of the proposed development and the need for significant multi-functional green infrastructure, the need for large civic squares to serve the new HS2/Crossrail station and commercial development, the opportunity to create a linear park along the Grand Union Canal and the need to ensure that the new population does not put unacceptable pressure on the capacity of Wormwood Scrubs open space and its facilities.

A more detailed Green Infrastructure / Public Open Space Strategy is required to:

- Confirm level of on site provision taking account of open space deficiencies in the local area, the capacity of existing adjacent publicly accessible open space and other requirements for green infrastructure.
- Review the capacity of Wormwood Scrubs and its facilities to identify what facilities should be provided within the development site and where facilities and open space on Wormwood Scrubs could be enhanced through developer contributions.
- Confirm amount of space dedicated to active outdoor recreation.
- Identify the extent of existing public accessible open space within Park Royal and measures to address deficiencies.

East Village - 8.7 sqm of accessible open space per resident

© Mike Odwyer & VOGT

Comparison with Other London Case Studies

Six London case studies have been assessed in terms of the amount of publicly accessible open space as a percentage of the overall site area, and the amount per person. The table below illustrates that the percentage of open space ranges from approximately 24% to 35% of the site area. The current Old Oak draft masterplan by comparison is 9%.

If 1sqm of accessible open space per worker is adopted, the remaining amount of accessible open space per resident ranges from approximately 2.4sqm to 10.5sqm. Old Oak draft masterplan by comparison is 0.55sqm but when the area of accessible open space is increased to 30% this figure is increased to 4.14sqm per resident which compares more favourably.

Full details of the case studies are provided in Appendix A.

Indicators	London Case Studies							
	Woodberry Down	King's Cross Central	Elephant Park	Wood Wharf	East Village	St Andrew's	Current Old Oak	Old Oak 30% plus 20.3ha
Site area (ha)	24.5	26.41	9.7	8.75	21.56	3	97.5	97.5
Area of accessible open space (ha)	6.15	7.45	3.38	2.93	5.28	0.98	9	29.3
% of accessible public open space (%)	25.1	28.2	34.9	33.5	24.5	32.8	9.2	30.1
Accessible open space per resident (sqm)	5.10	10.50	6.62	2.38	8.73	3.76	0.55	4.14

Woodberry Down

© Berkeley

King's Cross Central

© John Sturrock

Woodberry Down

Overall

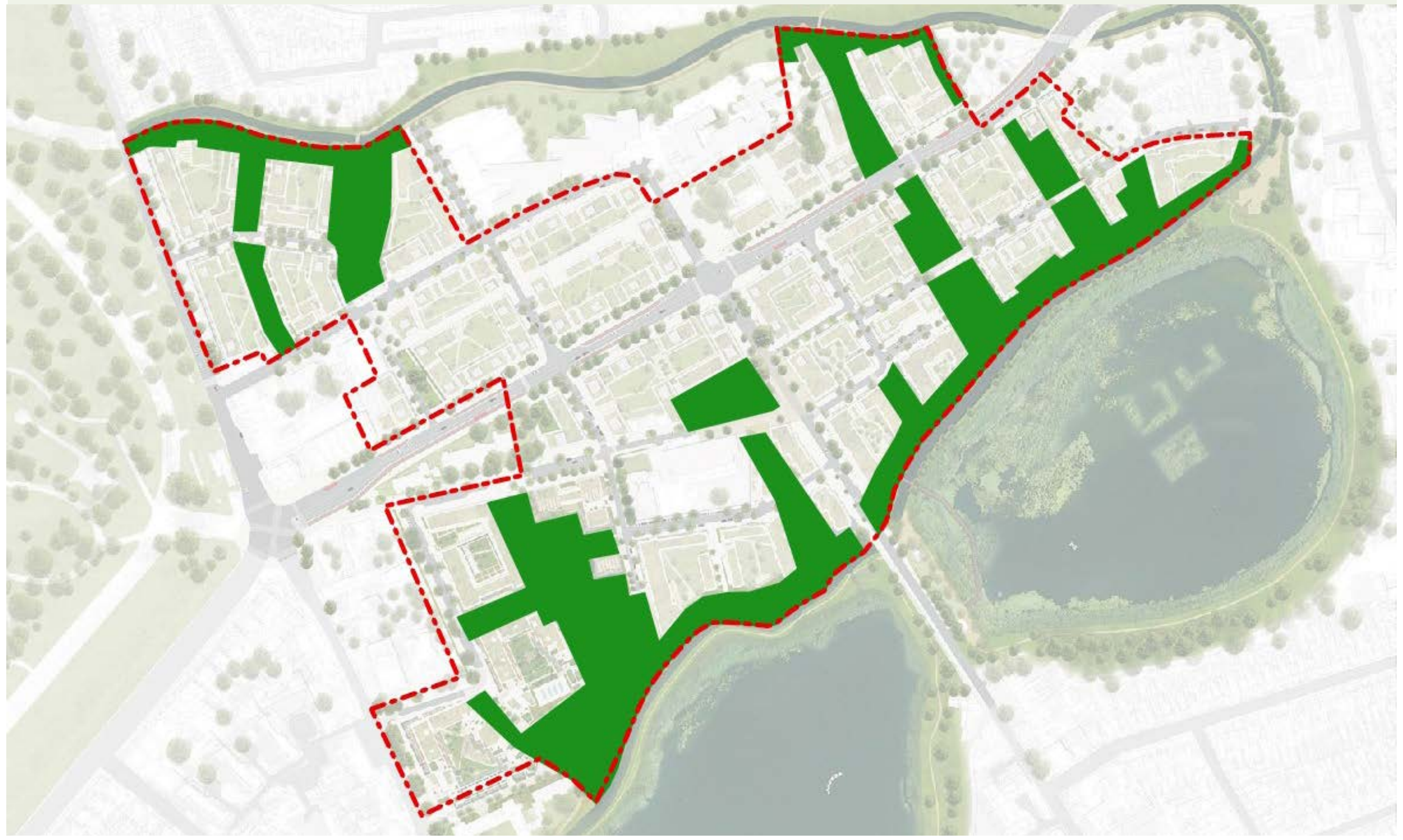
Accessible Open Space	Site Area	% Open Space
6.15ha	24.5ha	25.1

Breakdown

Category	Ha	% of Overall
Green Space	4.93	80.1
Civic Space	0.36	5.8
Civic / Green Space	0.17	2.7
Green Streets	0.32	5.2
Non-Vehicular Public Realm	0.38	6.2
Spaces within/adjacent to streets	0	0.0

Key Features

- Regeneration is led by London Borough of Hackney in partnership with Berkeley Homes with Genesis Housing Association.
- Involves the demolition of 1980 homes and construction of 5,500 new homes 41% of which will be social renting and shared ownership.
- Majority of the site is 8-10 floors with a number of taller blocks ranging from 18-30 floors.
- It will deliver 3 new public parks and has also contributed to the creation of a new 12ha wetland park and visitor centre in partnership with the London Wildlife Trust.
- The site borders Finsbury Park and the West Reservoir, a 15ha water sports centre managed by Hackney.
- It is also bordered by the New River green grid.



Source: OPDC

ATKINS

King's Cross Central

Overall

Accessible Open Space	Site Area	% Open Space
7.45ha	26.41ha	28.2

Breakdown

Category	Ha	% of Overall
Green Space	2.30	30.9
Civic Space	3.02	40.5
Civic / Green Space	1.14	15.3
Green Streets	0.08	1.1
Non-Vehicular Public Realm	0.56	7.5
Spaces within/adjacent to streets	0.35	4.7

Key Features

- The development includes a range of civic and green amenity spaces, a MUGA, diverse children's play and indoor sports and swimming facilities.
- Accessible open space includes Station Square, Granary Square: the hub of King's Cross with floor fountains and terraced steps down to Regent's Canal and The Boulevard which connects the squares.
- Long Park is a tapering green spine with trees, gardens and lawns.
- Regent's Canal bisects and forms an integral part of the development. There is enhanced public access balanced with protection of natural and cultural heritage.
- Camley Street Natural Park is retained and a protected natural green space.
- Financial contributions provided towards improvement of nearby open spaces including Bingfield Park.

Source: OPDC

Elephant Park

Overall

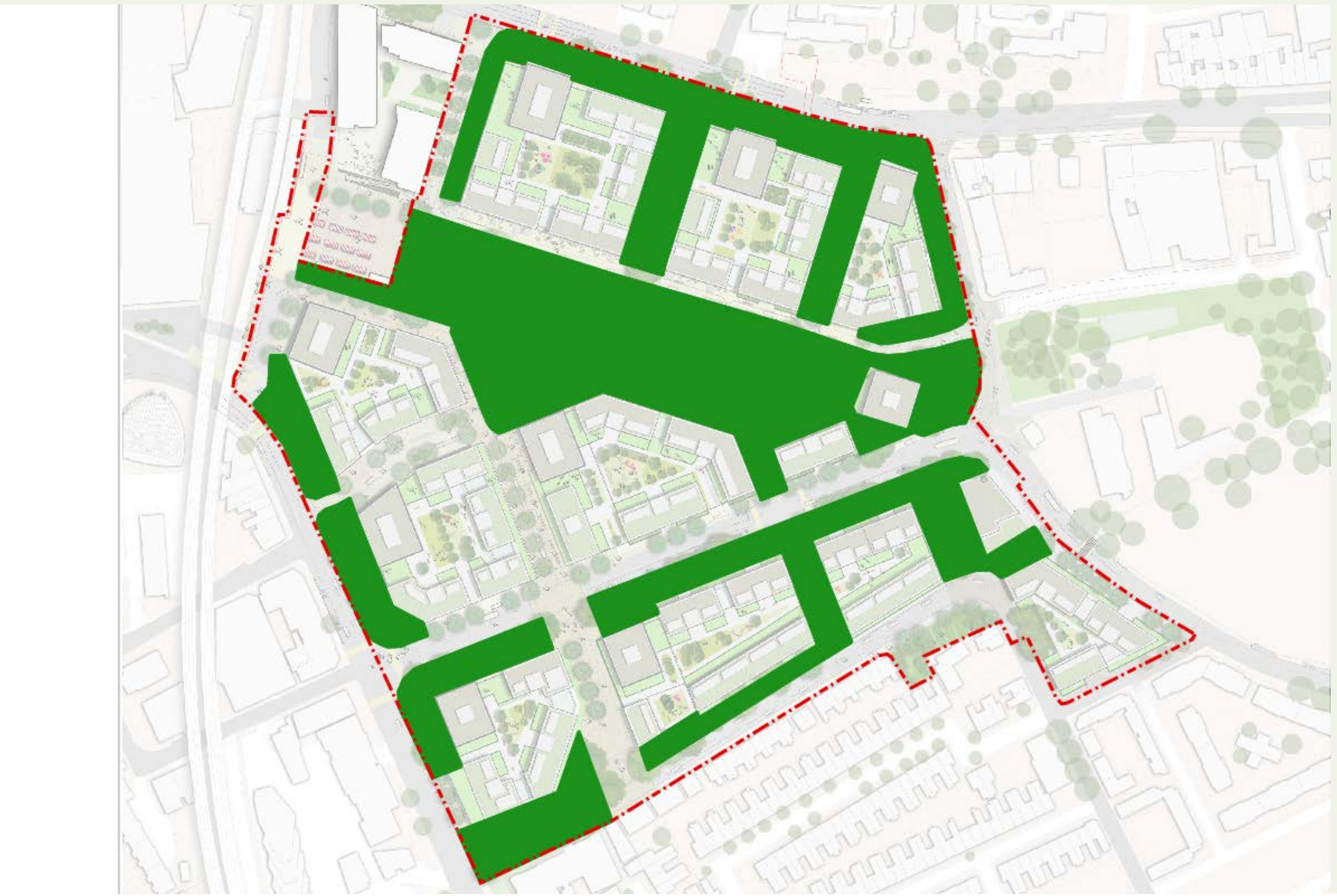
Accessible Open Space	Site Area	% Open Space
3.38ha	9.7ha	34.9

Breakdown

Category	Ha	% of Overall
Green Space	0.87	25.7
Civic Space	0.83	24.7
Civic / Green Space	0.13	3.8
Green Streets	0.15	4.5
Non-Vehicular Public Realm	0.20	5.9
Spaces within/adjacent to streets	1.20	35.5

Key Features

- The new development includes Elephant Park, a 0.9 ha new public park providing the green spine for the development.
- Elephant Square will be created through removal and transformation of the area's northern roundabout and the creation of a major new public space.
- Financial contributions towards existing open spaces at Victory Park and St Mary's churchyard.
- Retention of existing 120 mature trees from the former Heygate Estate.
- Over 1,000 new trees being planted both on and offsite forming part of an extensive greening programme.



Source: OPDC

East Village

Overall

Accessible Open Space	Site Area	% Open Space
5.28ha	21.56ha	24.5

Breakdown

Category	Ha	% of Overall
Green Space	2.91	55.1
Civic Space	1.24	23.5
Civic / Green Space	0.25	4.7
Green Streets	0.7	13.1
Non-Vehicular Public Realm	0	0
Spaces within/adjacent to streets	0.19	3.7

Key Features

- Developed as part of the London Olympics to serve as the village for the athletes and their teams in 2012. Subsequently converted into a new residential neighbourhood in the heart of the Queen Elizabeth Park.
- It includes over 5ha of new accessible open space which connects the development along a grid of green streets to the 100ha Olympic Park which features a number of play areas and the best collection of sports facilities in the UK.
- The green grid includes quiet and safe routes for children to walk or cycle to school, landscaped water features that provide natural drainage to the area and new biodiverse rich planting.

Source: OPDC

St Andrew's, Bromley-by-Bow

Overall

Accessible Open Space	Site Area	% Open Space
0.98ha	3ha	32.8

Breakdown

Category	Ha	% of Overall
Green Space	0.44	45
Civic Space	0.27	27.9
Civic / Green Space	0	0
Green Streets	0.27	27.1
Non-Vehicular Public Realm	0	0
Spaces within/adjacent to streets	0	0

Key Features

- This development by Barratt London and Circle Anglia has transformed an old Victorian Hospital into new homes and community facilities.
- The 3ha site includes nearly a hectare of accessible open space.
- The area includes 5 new public spaces including public gardens, a linear park and pocket parks.
- The development is less than 2 miles from Victoria Park.

Source: OPDC

ATKINS

Wood Wharf

Overall

Accessible Open Space	Site Area	% Open Space
2.93ha	8.75ha	33.5

Breakdown

Category	Ha	% of Overall
Green Space	0.98	33.4
Civic Space	0.82	28.1
Civic / Green Space	1.13	38.5
Green Streets	0	0
Non-Vehicular Public Realm	0	0
Spaces within/adjacent to streets	0	0

Key Features

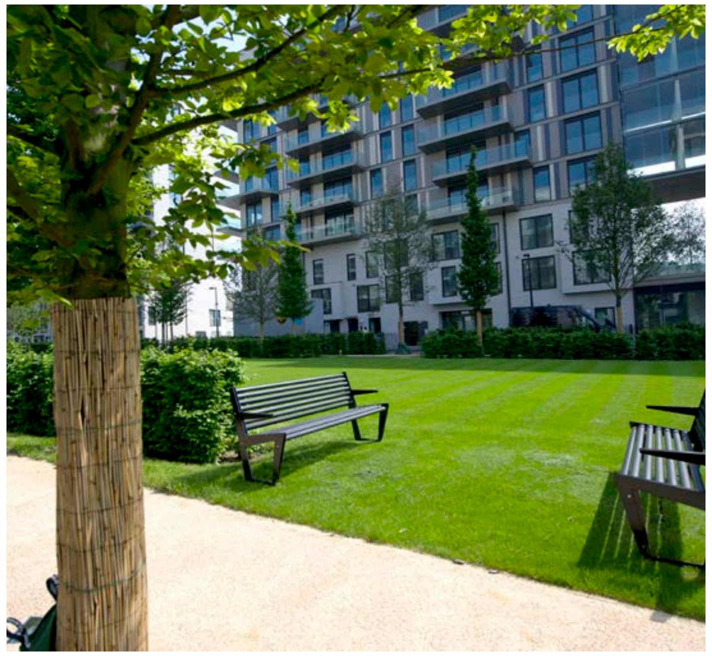
- Major new development adjacent to Canary Wharf. It will be one of the highest density developments in London when complete.
- Whilst the area provides c3ha of open space throughout the development much of this will be shaded by the development.
- However, it sits on the South Dock and Harbour Quay close next to the River Thames which provides a great natural backdrop to the project and will give residents access to a water park and quiet walks.
- The area will lack larger open green space for play and outdoor sport.

Source: OPDC

Elephant Park

© Atkins

East Village



© Mike Odwyer & VOGT, East Village

St Andrew's, Bromley-by-Bow

© Jimmy Wu Photography

Wood Wharf

© canarywharf

Proposed Accessible Open Space Standards

Initial Recommendations

The key to local provision is not just the amount of open space but quality, access and safety. The following initial recommendations are made to address the deficiency in onsite public open space but this will need to be confirmed through the masterplanning exercise and a full public open space strategy:

- The percentage of publicly accessible open space in Old Oak's developable area should be increased from **9%** to a **minimum of 30%.** This would bring the total area of open space to **29.3ha.** This figure falls within the band of London case studies and equates to approximately **4.14sqm** per resident and **1sqm** per worker. This standard would also be appropriate for new build within Park Royal.
- This should be a minimum and the future masterplanning exercise should seek innovative ways of achieving more accessible open space.
- Open spaces should benefit from good light and microclimate especially in the smaller community spaces and pocket parks.
- The additional 20ha should partly be used to provide 3 Local Parks (2ha<). These spaces are sufficiently large to accommodate multi-use games areas (MUGA's) and play areas for older children.
- The above calculations exclude the use of Wormwood Scrubs to provide local open space. It will, however, be required to fulfil the role of a District Park in particular provision of sufficient good quality outdoor sports facilities and playing fields, and access to natural greenspace.
- The 30% should include local Green Streets which are fully accessible and designed predominantly for high pedestrian and cycle flows, with very restricted access to motorised vehicles.
- Financial contributions towards offsite open space provision and improvements where the above cannot be achieved onsite should be sought.
- The opportunity exists to create valuable public open space on the large roof of the HS2 station. This is illustrated further in Chapter 6.

Strategic Industrial Location (SIL)

The 30% public open space requirement should be applied to all development schemes outside of the Strategic Industrial Location (SIL) designation in Park Royal. SIL is vital to the London economy and needs protecting. It is a location for light and heavy industry and is not an appropriate location to provide high quantums of public open space. Opportunities should, however, still be taken to provide public open spaces and other private/communal spaces at appropriate locations in SIL, where environmental impacts can be appropriately mitigated. These spaces will provide valuable amenity space for workers in the industrial estate.

Provision of Play Space

The Mayor's Play and Informal Recreation SPG recommends a benchmark **minimum of 10 sqm** of dedicated play space per child. The number of children projected to be in Old Oak (not including new development in Park Royal):

0 – 9 year old:	**8,773**
10 – 18 year old:	**3,367**
Total:	**12,140**

Based on this calculation of **12,140** children, there would need to be **121,400 sqm (12.14ha)** of dedicated play space. The play space for 0-9 year olds should be able to be accommodated within the central residential courtyards. There is not, however, sufficient space in the current OPDC draft masterplan to provide for 10-18 year olds. This can be addressed by the three additional Local Parks proposed above.

The three new Local Parks should each include a Neighbourhood Playable Space and a Youth Space as defined in the London Plan adopted supplementary guidance (SPG) on Play and Informal Recreation (September 2012), together with space and facilities for informal sport or recreation activity. This could include multi-use games area (MUGA), climbing walls, skatepark or BMX track and exercise trails.

Proposed Publicly Accessible Open Space

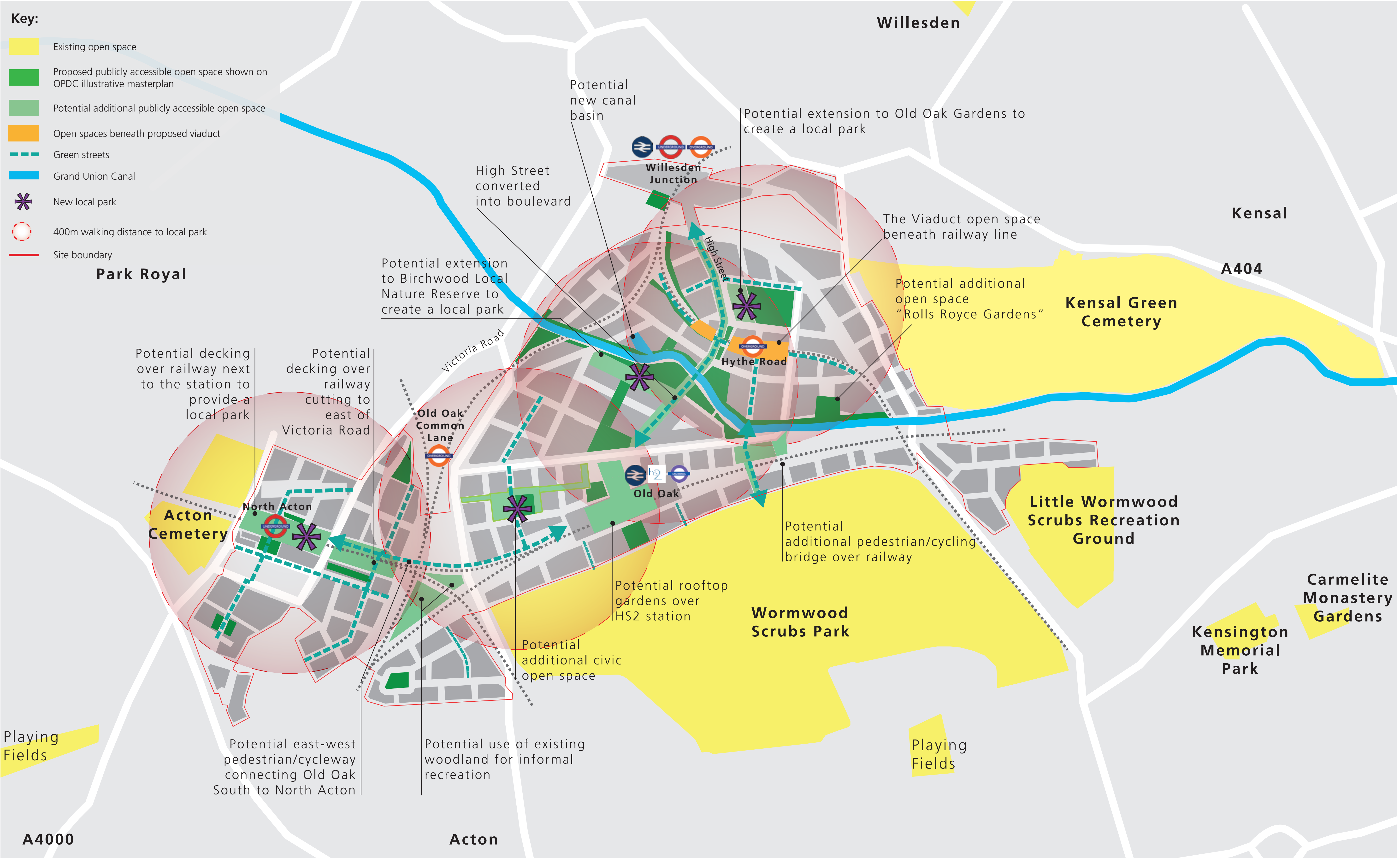
The plan opposite illustrates additional accessible open space which could supplement that identified within the current illustrative masterplan. It includes accessible open space currently planned within the CarGiant/L&R Old Oak Park scheme, plus areas that OPDC has identified with potential to accommodate 3 Local Parks to ensure Local Park accessibility to all residents.

We have also included Green Streets identified within the draft OPDC Old Oak & Park Royal Street Grain/Green Grid Review report (March 2017) and proposed some additional spaces including a Local Park created at North Acton by decking over the railway cutting, a green bridge connection to Wormwood Scrubs and a roof top garden over the HS2 station.

With all this potential accessible open space included it is possible to see how the 30% could start to be achieved. This will need to be tested by the future masterplanning exercise.

Woodberry Down play area

© Berkeley


Key:
Existing open space
Proposed publicly accessible open space shown on OPDC illustrative masterplan
Potential additional publicly accessible open space
Open spaces beneath proposed viaduct
Green streets
Grand Union Canal
New local park
400m walking distance to local park
Site boundary
Willesden
Kensal
A404
Park Royal
Potential new canal basin
Potential extension to Old Oak Gardens to create a local park
High Street converted into boulevard
Willesden Junction
The Viaduct open space beneath railway line
Potential additional open space "Rolls Royce Gardens"
Kensal Green Cemetery
Potential extension to Birchwood Local Nature Reserve to create a local park
Victoria Road
High Street
Hythe Road
Potential decking over railway next to the station to provide a local park
Potential decking over railway cutting to east of Victoria Road
Old Oak Common Lane
Old Oak
North Acton
Acton Cemetery
Little Wormwood Scrubs Recreation Ground
Potential additional pedestrian/cycling bridge over railway
Potential rooftop gardens over HS2 station
Wormwood Scrubs Park
Carmelite Monastery Gardens
Kensington Memorial Park
Potential additional civic open space
Playing Fields
Potential east-west pedestrian/cycleway connecting Old Oak South to North Acton
Potential use of existing woodland for informal recreation
Playing Fields
A4000
Acton

Provision of Green Streets

Creating communities with fewer cars and car-free areas which are pedestrian friendly and where it is pleasant, safe and convenient to get to school or the office by walking and cycling, not only reduces CO_2 emissions, but can also improve health. The provision of car-free streets is fully in accordance with the 'Healthy Streets' approach advocated by Transport for London (refer to the section on Sustainable Transport).

The opportunity exists to create a Green Grid of pedestrian and cycling routes set within continuous green corridors providing safe and convenient access between residential areas and stations, schools and community facilities. The analysis above identifies that Green Streets will have a significant role to play in helping to ensure development can meet 30% accessible open space coverage.

An extensive, connected walking and cycling network across the overall development will connect with the surrounding local communities and the wider London Green Grid. This will include:

- Creation of Green Streets where cycling and walking is made safer and more appealing.
- Provision for informal children's play.
- Outdoor seating sited in areas of street with maximum daylight and sunlight.
- Buildings fronting onto the street to activate the public realm.
- Designing streets to ensure sufficient space for large canopy trees and urban greenery.
- Adopting principles of CIRIA's Water Sensitive Urban Design.
- Making use of permeable and porous materials.
- Creating SuDS features including rain gardens that can store water.
- Adopting rainwater harvesting to re-use higher volumes of water.
- Provision for emergency access and refuse collection.

Refer to Chapter 6 for more detailed guidance on Green Streets.

St Andrew's, Bromley-by-Bow

Green Streets, Freiburg

Green Flag Award

The Green Flag Award scheme is the benchmark national standard for parks and green spaces in the UK. It was first launched in 1996 to recognise and reward the best green spaces in the country. It continues to provide the high level of quality against which parks and green spaces are measured. It is also seen as a way of encouraging others to achieve high environmental standards, setting a benchmark of excellence in recreational green areas.

Sites for a Green Flag Award are judged against eight key criteria:

- A welcoming place
- Healthy, safe and secure
- Clean and well maintained
- Sustainability
- Conservation and heritage
- Community involvement
- Marketing
- Management

It is recommended that Green Flag Award status is sought for the new parks and green spaces within Old Oak.

Hale Village was awarded a Green Flag Award in 2016 for it's extensive green spaces, generous internal gardens and roof terraces.

Green Bridge, Mile End Park, London

The Green Bridge carries Mile End Park over the busy Mile End Road. Designed by Piers Gough the bridge successfully connects the two halves of the park. Underneath the bridge a new hub of shops and restaurants have been created next to the underground station.

The Green Bridge provides an example of how to connect across the railway lines and link the proposed greenspace in Old Oak with Wormwood Scrubs.

Wormwood Scrubs

Given the scale of development planned in Old Oak, it is recognised that there will be an increase in new users and there is a need to consider the potential impacts on the biodiversity of Wormwood Scrubs. Retaining Wormwood Scrubs as a predominantly natural green space - more wild than tamed - will be a key objective.

Wormwood Scrubs will be required to fulfil the role of a District Park for Old Oak, as defined in the London Plan Public Open Space Categorisation. This is defined as a large area of open space, at least 20 hectares in size and within 1.2 kilometres of homes. The size of Wormwood Scrubs, close to 70 hectares, already places it as a Metropolitan Park in the hierarchy.

Development in Old Oak to the north of the area should contribute to the delivery of coordinated, new walking and cycling connections to the Scrubs and the existing and proposed communities.

One of the key design challenges will be to connect the proposed greenspace along the High Street in Old Oak, across the major proposed rail infrastructure, into Wormwood Scrubs. This could be achieved by the use of a Green Bridge such as in Mile End Park (refer to case study on previous page).

The portions of Wormwood Scrubs designated as a Local Nature Reserve and Sites of Borough Importance will require sensitive conservation and management to ensure that any potential impact due to an increase in visitor numbers is mitigated. This can be partly achieved by onsite environmental education and interpretation. The routing of footpaths, and the use of boardwalks will also relieve pressure.

The Scrubs are already a popular venue for outdoor sport and recreation both for individuals, teams and events. The projected increase in demand for active and passive recreation from the new residents of Old Oak will need to be carefully managed to ensure there is no net loss in biodiversity or loss of amenity for existing users.

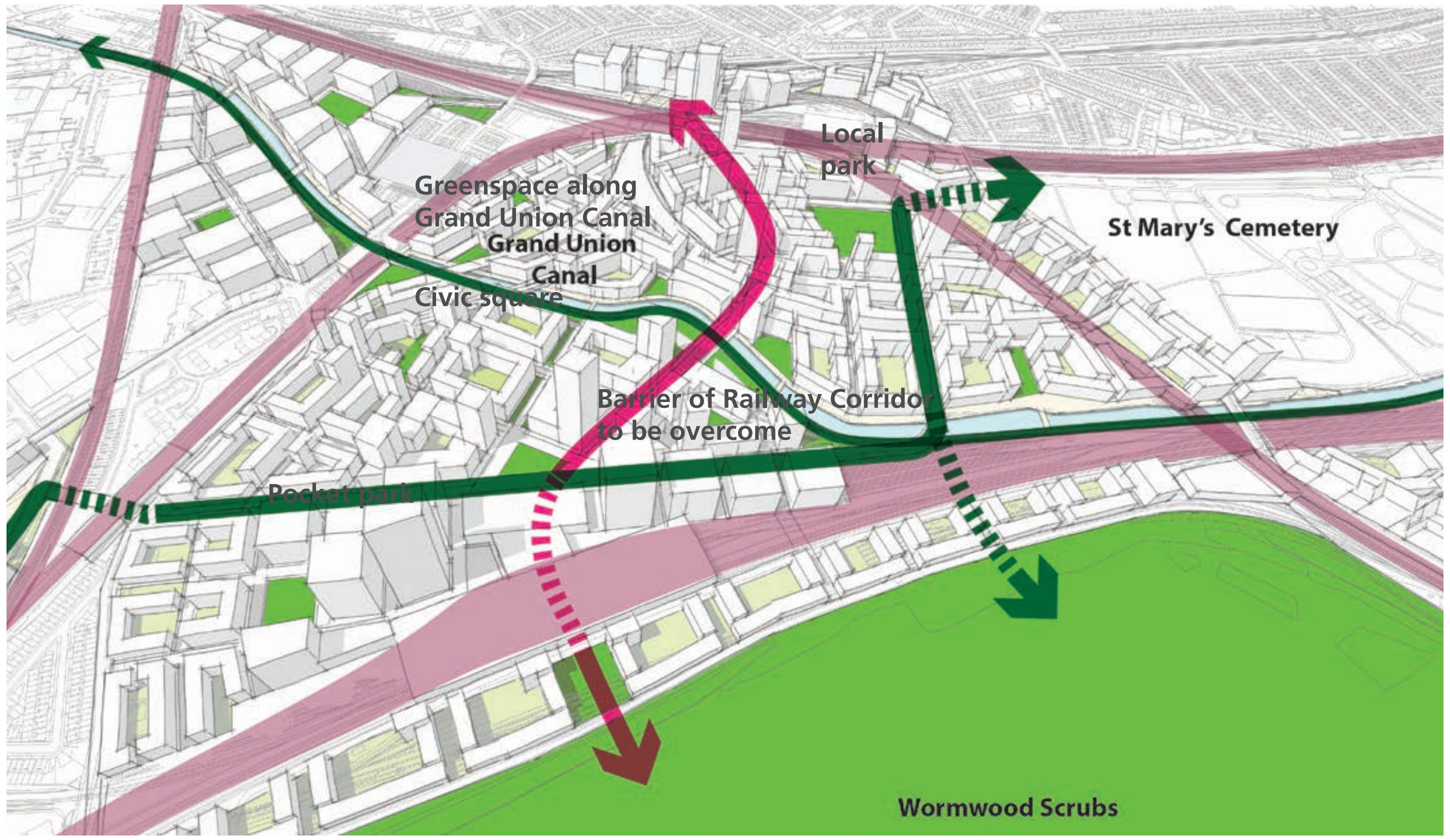
The existing sports and play facilities on the Scrubs will need to be enhanced to accommodate the projected increase in visitors.

One solution could be to change a couple of the existing football pitches to all-weather 5G pitches. This would allow more intensive use to be made. Small 5-side multi-use games areas also allow greater intensity of use within a smaller area.

Adventure play facilities for older children (over 12s) could also be provided. The play facilities in the Queen Elizabeth Olympic Park are a good model.

A Green Loop – walking and cycling trail could be created around the perimeter of Wormwood Scrubs. This would be similar to the successful Tasmin Trail around Richmond Park. (See adjacent case study).

Breaking down the barriers



Royal Parks Management and Operational Plans

The 2,000ha of historic parkland that make up London's eight Royal Parks are among London's most well-known green spaces. A good example of GI in action, the Royal Parks deliver vital benefits for the capital that often go unnoticed, including water management, important sites for biodiversity and climate-change adaptation and mitigation.

The Management Plans, produced for each of the Royal Parks, are used to capture the strategic vision and the way that is transferred to actions at a local level.

The Tasmin Trail provides a 12 kilometre car-free circuit of Richmond Park in South West London. It connects with National Cycle Route 4 and the Thames Path. The path is shared by cyclists, joggers and walkers. A similar circular trail could be introduced around Wormwood Scrubs with connections to the Grand Union Canal.

Tasmin Trail, Richmond Park

Private and Semi Private Amenity Space

Private open space

The provision of private open space can be accommodated through sky gardens, roof terraces, balconies and internal courtyards, but these elements will not be sufficient to ensure that all residents and workers have access to open space. As a result tall buildings will be required to proportionately contribute to the provision of a high quality public realm.

Every home shall have the benefit of some private or communal amenity space. Private outdoor space can be provided in a variety of ways:

- Balconies
- Communal gardens within perimeter blocks at podium level
- Roof terraces.

A minimum of 5 sqm of private outdoor space should be provided for all 2 person dwellings and an extra 1 sqm for each additional occupant.

Apartments will comprise the majority of any higher density development. Private open space will therefore mainly be provided by balconies. Balconies need to be positioned where they are comfortable to use and of sufficient size to enable them to be used as outside living space and should:

- Preferably have a southerly aspect but in any case receive direct sunlight for part of the day
- Be positioned away from sources of noise and poor quality air that would make them unpleasant to use
- Enclosing balconies as glazed, ventilated winder gardens is a good option in many circumstances and is recommended for all dwellings, particularly at high level. Winter gardens should be thermally separated from the interior and the floor should be drained
- The required minimum width and minimum depth for all balconies and other private external space is 1500mm.

Semi-private roof space

The lack of open space in densely built areas can be partly mitigated in tall buildings through the use of sky gardens, atrium spaces and roof terraces. These spaces can successfully extend high quality amenity space.

The provision of semi-private roof gardens should be considered on all developments and especially where the private, communal and public space standards are difficult to meet.

Roof space can meet the need for not only green roofs but also amenity (seating, viewing points, catering) and sports and recreation facilities (covered ball courts, running tracks, exercise equipment). Although these ‘recreation’ roofs have less potential for biodiversity and sustainable drainage, they are an increasingly important element where open space is at a premium.

Semi-private courtyards

The Illustrative Masterplan accompanying the Draft Local Plan includes approximately 10 ha of open space within perimeter street blocks. It is assumed that these areas have limited or restricted access to the public and for the purposes of this assessment are classified as private open space.

The courtyards should be designed to be the social, outside private living space for the residents of a street block and need to be:

- of sufficient size to be useable and inviting
- designed to maximise access to sunlight (refer to section on Microclimate)
- secure and private
- well-designed and integral to the character of the development.

Courtyards and terraces shared by people living in affordable and private housing provide particular management challenges and should be designed as accessible, socially inclusive places in accordance with the following principles:

- benefiting from a degree of overlooking and natural surveillance
- accessible to wheelchair users
- safeguarding the privacy and amenity of neighbouring homes by good site planning and the careful use of planting and screening
- introducing a private threshold space between dwellings and the adjacent open space.

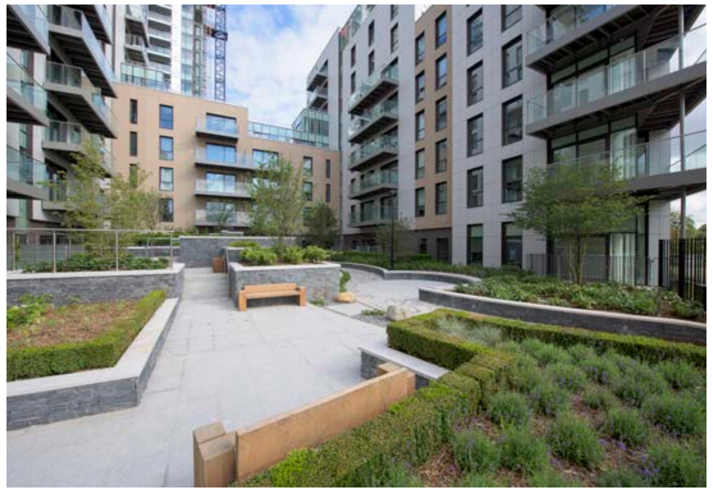
St Andrew’s, Bromley-by-Bow

© Atkins

Bermondsey Spa

© Levitt Bernstein/Tim Crocker

Woodberry Down



© Berkeley

Urban Greening

Street Trees

Trees are an important component for biodiversity positive and healthy neighbourhoods. They:

- Filter fine particles from the air – which are associated with mortality from cardiac and respiratory causes
- Absorb pollutants such as ozone, nitrogen dioxide and sulphur dioxide – these gases can affect people with asthma and chronic lung disease
- Absorb carbon dioxide and release oxygen
- Give shade in the summer, and protection from the sun, which can reduce the incidence of skin cancer
- Reduce the heat island effect
- Slow wind speed
- Provide habitats for birds and other wildlife
- Can slow down urban water run-off after a storm, reducing likelihood of flooding
- Visually soften the hard urban form
- Add seasonal change and interest to streets.

Choice of species is crucial to the provision of a healthy tree that is appropriate to its urban design location and intended function, with space grow to maturity with minimal intervention or management.

Tree species must be selected that can survive the urban conditions and avoid excessive maintenance requirements. Selecting native species will maximise their habitat potential, however urban conditions favour some exotics.

The 'Right Place, Right Tree' approach promoted by the London Tree and Woodland Framework is designed to ensure that these factors are considered. The Mayor, the Royal Horticultural Society and Forestry Commission have jointly produced the 'Right Trees for London's Changing Climate' database of tree species and their climate sensitivity. Refer to Trees and Design Action Group (TDAG) for requirements in relation to canopy cover and quality of new tree planting. The requirements for street trees and related SuDS features should be an integral part of the street design.

Regent's Place - street planting grouped in blocks to maximise impact

© Atkins

Native Planting

Development sites adjacent to, or in the vicinity of a designated nature conservation area, green corridor or green / blue infrastructure, should use native plant species, preferably of local provenance in landscape schemes. Where possible a green buffer should be planted between the Grand Union Canal and future development.

The very high density of development proposed at Old Oak means that space for biodiversity will be very limited. It is therefore important that new open spaces created as a result of development are multifunctional and are designed to be capable of providing functional habitat for a diverse variety of species. The landscape designs for new development should aim to:

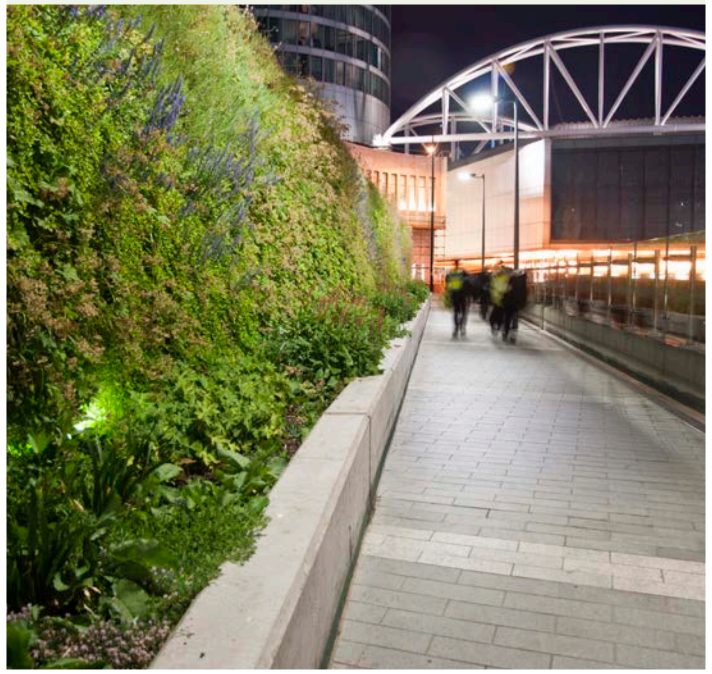
- Create habitat niches for a range of wildlife species
- Use selected plant species that provide food and shelter for local wildlife
- Are conducive to biodiversity friendly management regimes concerning pruning, mowing, fertilising, pesticide and water use
- Provide flowering periods spread throughout the year and have food sources accessible to native fauna
- Use at least 50% of native plants and preferably of local provenance. Where non-native plants, grasses, shrubs and trees are used in landscape schemes, they should be valuable for wildlife and non-invasive.

Developed from LBHF SPD Sustainability Policy 21

Birmingham New Street Station, Green Wall

The Birmingham New Street Station Gateway project is the remodelling and refurbishment of the station at the heart of the city of Birmingham – one of the busiest in the UK, with a new train arriving every minute during peak times. The project creates a world class gateway to the UK's second largest city, improving passenger facilities and the station environment, as well as access and city links.

The installation of a green living wall as part of the project improves the urban environment and public realm and will help to support the regeneration of the areas around the station. The selected living wall system includes a high density of planting (112 plants per m^2) with no bare areas on the face. All the planting was pre-grown in the planting panel modules prior to mounting on the wall support framing. It is 76 metres long and with an average height of 4 metres it incorporates $300m^2$ of planting consisting of over 33,000 plants.



© Atkins

ATKINS

Local Food Production

Green infrastructure presents a range of opportunities for food production, from privately managed allotments to community managed gardens. In certain instances public green areas can be used for food production, such as edible herbs, fruit trees and berry plants. In addition to its economic value, and reducing 'food miles', local food production is recognised as providing several other benefits including community cohesion, health and education.

Making use of local organic waste via local compositing facilities can help increase the intensity of food production with supply of essential nutrients. Transport of waste is also reduced.

The opportunity exists to support healthier and more sustainable eating by creating space for farmers' markets and drop-off points for locally sourced food. Public spaces could be planted with food-growing plants and roof top mini-allotments and community gardens integrated into higher density housing.

The following initiatives should be included:

- **Rooftops -** Intensive green roofs are designed to be accessible for either food growing or other recreational activities and require deeper soil levels to support shrubs, perennials and even trees. Beds for growing are best designed as part of the roof construction. Loading capacity for green roofs should be addressed at the design stage.
- **Balconies -** Design of balconies can provide small spaces for individuals to grow a limited selection of plants and are particularly suited to high density apartments. The microclimate and aspect are critical factors, north facing balconies overshadowed by tall buildings are unlikely to be suitable for food growing. Planting containers/window boxes can be incorporated into balcony design. Railings and structures joining neighbouring balconies can also be designed to support climbing. It is important to address loading capacity for containers at the design stage.
- **Walls -** Vertical growing on external and internal walls, the latter usually in atriums or courtyards, can be adapted for food production. Green walls can be used to increase build performance, and are typically planted with non-productive climbing plants. Green walls require technical considerations such as irrigation and maintaining the plant and the growing medium in place. Maintenance of productive green walls is high, as they will require harvesting and seasonal replanting, and therefore will need to be accessible.
- **Internal Atriums/courtyards -** Atriums or courtyards with adequate sunlight can create opportunities for food growing. These sheltered locations will allow high value tender plants such as tomatoes and citrus fruits to be cultivated. Ground level beds or planters can be used, as well as living walls. Care must be given in internal spaces to provide irrigation systems and allow for water run-off.
- **External Edible Planting -** Amenity planting can include fruit, nut trees and vines, together with edible perennials such as currants, herbs, rhubarb and fruit alongside ornamental plants. Larger areas of external space or rooftops can be used for beds or even mini allotments and communal gardens, which will require more maintenance by either residents or contractors.

Management of Growing Spaces

Edible plants need to be harvested, regularly maintained and the resulting produce used. Within high density, residential development this can be undertaken by residents organising themselves into Residents Associations and growing collectively in community gardens and rooftop allotments.

One Brighton

The One Brighton development in central Brighton has a rooftop allotment site, consisting of 28 mini-allotments, which are rented out to residents who manage their own individual plots. A 'Green Caretaker' oversees the overall running of the development. The allotments bring residents together with a common interest and helps build a sense of community.

© Tim Crocker

Green Roofs

Policy 5.11 of the London Plan requires major development proposals to be designed to include green roofs and deliver the following objectives:

Adaptation to Climate Change

The most effective way of combating the urban heat island is to reduce the area of dense materials that are exposed to sunlight by exposing or importing soil and re-vegetating the city. This is often not easy to achieve at street level in high density urban areas due to the lack of space. Green roofs have been shown to reduce ambient temperatures by increasing albedo (reflectivity), shielding building materials from the sun and storing water in substrates, which provides evapo-transpirative cooling.

Aiding Energy Efficiency

Most of the potential energy savings associated with roof greening come from albedo, shading and evaporative cooling effects which reduce the demand for air conditioning. Green roofs can also save energy in winter by adding to the insulation of a roof. The amount of energy saved depends on weather conditions and how saturated with water the green roof becomes. Most designs include layers that trap air and provide extra insulation, even when the substrate is saturated.

Sustainable Urban Drainage and Rainwater Harvesting

Green roofs can assist in intercepting water run-off and form part of a biological roof system that includes rain water harvesting. The stored rainwater is best suited for landscape irrigation. The comparatively small area of roof area available per household in tall buildings means that only a small percentage of a household's water need can be met from rainwater.

Enhancement of Biodiversity

Green roofs can support a variety of vegetation types which in turn support a wide range of species. Sedum roofs have been shown to support a number of invertebrates, including unusual species normally associated with dry or coastal habitats. When sedums are in flower in June and July they are also a nectar source for bees.

Types of Green Roof

Green roofs are of two basic types: extensive and intensive. Extensive green roofs have a relatively shallow soil base, making them lighter, less expensive and easier to maintain than intensive green roofs which have a deeper soil base and are not limited in terms of plant diversity. Extensive green roofs have restricted access (except for maintenance) whilst intensive roofs can provide accessible garden and recreational spaces. The extra weight of intensive roofs requires a substantial building structure and results in a roof that is more expensive to construct. Retrofitting a green roof or placing a green roof on existing buildings, for example in Park Royal, is not straight forward and not recommended unless increased structural supports are accommodated.

Brown roofs are a variant of extensive roofs using low maintenance gravels and aggregates. They provide low-nutrient, well-drained habitats that offer an opportunity to replicate ecological characteristics of brownfield sites. Plants are allowed to colonise naturally rather than being planted. A brown roof has the lowest embodied energy and carbon. Local recycled materials, such as crushed bricks, should be used if possible as substrate.

All suitable new buildings should be designed to incorporate green roofs, either extensive or intensive, or brown roofs. Green and brown roofs can be combined with renewable energy generation such as photovoltaics. The proportion of intensive and extensive will partly depend on the amount of daylight. Intensive roof top planting, including mini-allotments, will require sunlight and protection from high wind speeds. Non-accessible extensive green roofs are better suited for partly-shaded areas. Roofs in deep shade are not suited for planting.

See Climate Resilience Section below for more evidence on the benefits of green roofs.

Regent's Place, London

One of British Land's major green roof installations is at Regent's Place, close to London's Warren Street station. This new quarter of the capital comprises a series of buildings - a mix of offices, retail space and apartments - with some 4,700sqm of green roof space and gardens. The green roofs include:

- Sparsely-vegetated ground and sedum
- Wildflower mix and organic substrate for birds and butterflies
- The largest insect hotel for a London commercial building
- 24 habitat walls on 20 Triton Street building, installed by occupier Lendlease
- Studies have found the roofs add significant biodiversity value
- The approach has been popular with occupiers and is now being repeated on other British Land developments

© Farrells

Biodiversity and Access to Nature

The London Plan makes reference to the protection or enhancement of biodiversity in a number of separate policies:

- Policy 7.19 – Biodiversity and Access to Nature
- Policy 2.18 – Green Infrastructure – The network of open and green spaces
- Policy 5.3 – Sustainable Design and Construction
- Policy 5.10 – Urban Greening
- Policy 5.11 – Green Roofs and development site environs

Existing Nature Conservation Areas

The majority of Old Oak falls within the London Borough of Hammersmith and Fulham. The areas of nature conservation importance within, or neighbouring the OPDC area, identified in the Borough's Core Strategy are set out below:

a) Areas of Metropolitan importance

- The Grand Union Canal
- Kensal Green Cemetery

b) Areas of borough-wide importance (Grades I and II)

- Grade I
  - Wormwood Scrubs
  - Old Oak Common sidings
- Grade II
  - St Mary's Cemetery

These sites are illustrated in Figure 5.1: Existing Nature Conservation Areas. Reference should be made to the evidence for why these sites are designated on the London Boroughs of Brent and Ealing website and London Ecological Unit Handbook 25 which London Borough of Hammersmith and Fulham cites as evidence for their sites.

Impact on nature conservation areas

Proposals for major development close to the nature conservation areas of Wormwood Scrubs and the Grand Union Canal, will require an Ecological Management Plan (EMP). An EMP should include:

- Details of ecological surveys undertaken and the results of these surveys
- Measures to protect species and habitats during site preparation, construction and occupation
- Measures to increase the ecological value of the site once the development is complete, to ensure a net gain for biodiversity
- Measures to ensure the biodiversity value of the site is maintained for the long term (5 years +) after development is complete, including a monitoring programme. The developer and/or site manager must ensure the EMP is handed over and explained to any maintenance company or staff responsible for maintaining landscape and/or gardens and buildings

Developed from LBHF SPD Sustainability Policy 19

Biodiversity Positive

The development should aim to result in a net gain in biodiversity, in which biodiversity rich, multi-benefit, multi-functional green spaces and water bodies are highly interconnected and closely integrated with the wider green infrastructure network in a clear functional hierarchy. To be biodiversity positive, the site's existing biodiversity will need to be optimised, enhanced and complemented with new areas of biodiversity value. These enhancements will include:

- Protection and enhancement of existing sites of ecological value where possible and improving ecological connectivity and resilience
- Creation of new habitats that complement the ecology of existing ecological assets
- Establishment of a biodiversity network of habitats, ecosystems and green spaces
- Conservation and enhancement of Birchwood Local Nature Reserve
- Establishment of the Grand Union Canal Linear Park

The species below are present in Wormwood Scrubs

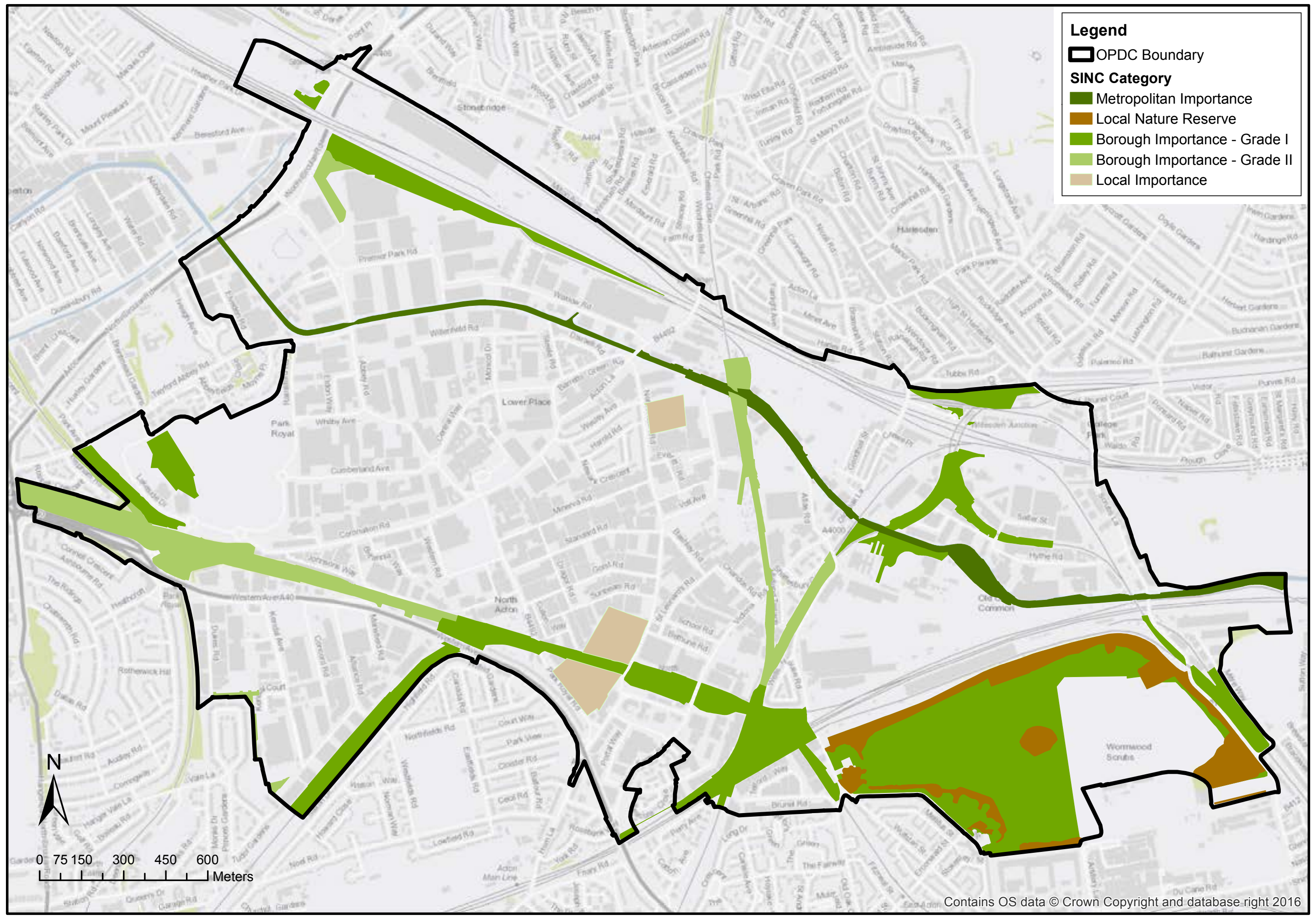
Slow Worm

Common Lizard

Reed Bunting

Meadow Pipit

Figure 5.1: Existing Nature Conservation Areas



- Conservation and enhancement of Little Wormwood Scrubs Site of Borough Importance for Nature Conservation based on the principles of the existing management plan.
- Conservation and enhancement of existing ecological features including Scrub's Lane Wood, Martin Bell's Wood, Braybrook Wood, Central Copse, Southern Copse and Heron Copse.
- Ensuring the careful choice of more drought-resistant plants to maximise water efficiency, but balancing this with the requirement for native species in order to encourage diversity of wildlife.
- Planting of large canopy trees to create areas of shade to maximise cooling.

Accessible Natural Green Space

London Plan Policy 7.19 Biodiversity and Access to Nature requires development proposals to improve access to nature and plan for nature from the beginning of the development process.

The Natural England Accessible Natural Greenspace Standard (ANGSt) advocates that natural greenspaces are very important to our quality of life and provide a wide range of benefits for people and the environment. The standard is based on three underlying principles:

- Improving access to greenspaces
- Improving naturalness at greenspaces
- Improving connectivity with green spaces

The ANGSt model can assist with the strategic planning for green infrastructure, in particular the requirement to have a 2 ha site within 300m of people's homes. The Natural England guidance does, however, recognise the challenge of meeting ANGSt, particularly in dense urban areas.

Of particular relevance to Old Oak and Park Royal is the importance of providing access and connectivity to the natural and semi-natural areas in Wormwood Scrubs and along the Grand Union Canal. This must be balanced with the potential impact increased visitor numbers can bring to wildlife habitats and the need to create new, additional natural greenspace.

London 2012 Olympics: Queen Elizabeth Park

The largest urban park to be built in the UK for over a century, Queen Elizabeth Olympic Park provides a valuable example of what can be achieved by establishing Green Infrastructure frameworks.

The park provided the setting for the major games venues at the 2012 Summer Olympic Games. The landscape design led approach has weaved biodiversity and nature into the major regeneration projects and is planned to have a significant impact on the health and well being of the communities in the east of the city.

Strategically, the parklands extend the north-south route of the Lea Valley Regional Park, a key ecological corridor for London, south towards the River Thames. The design of the parklands has created more than 100ha of Metropolitan Open Land and 45ha of new ecological habitat, ensuring that there is no net loss of biodiversity habitat.

© Atkins

Green Space Factor

The Green Space Factor (GSF) is an innovative and flexible urban planning tool which aims to increase green infrastructure in the built environment by establishing new minimum requirements for new development projects. After it proved successful in Berlin, more cities, such as Malmö, Seattle, Stockholm and Southampton have included it in in their environmental planning toolkit.

Southampton City Council created its own GSF tool, based on Berlin and Malmö. The tool is used as part of the Sustainability Checklist to demonstrate sufficiency of green infrastructure in the proposed development. The Sustainability Checklist is used by applicants who wish to obtain planning permission by demonstrating compliance to key principles of sustainable development.

A GSF is not currently applied in London but it is being considered for inclusion in the new London Plan. The Green Infrastructure Taskforce Report recommended that the Mayor should develop a version of the Green Space Factor as a means to address deficiencies in access to open space and access to nature in the most densely developed parts of the city.

It is recommended that a 'Green Space Factor' is adopted to attain minimum quantities of greenery, and special green and blue attributes for the green spaces within residential areas in Old Oak. It is a tool that can be used to measure the ecologically effective land area of a development. This approach has been successfully adopted in new developments in Malmö. See case study opposite.

Bo01, Malmö, Sweden Green Space Factor

Bo01 is an innovative district built on reclaimed land at Malmö's Western Docks. Housing includes a combination of houses, flats and terraces, with the district's green space largely consisting of communal courtyards, with smaller private gardens and balconies. The landscape architects responsible for Bo01's green and blue infrastructure proposed a 'Green Space Factor' to attain minimum quantities of greenery, and special green and blue attributes for the courtyards.

The aim of the 'Green Space Factor' is to secure a certain amount of green cover, it is also used to assess the quality of the green space that is provided; for example, how permeable surfaces are and to what extent specific green roof designs can absorb and hold water as part of an attenuation scheme. Each developer had to select 10 out of 35 Green Points, including:

- Walls covered with climbing plants
- Green roofs on all buildings
- A bird box for every flat
- Amphibian habitats with space for hibernation
- Food for birds all year round in the courtyard
- Bat boxes in the courtyard
- Façades to have swallow nesting facilities
- Vegetation selected to be nectar giving
- A habitat for specified insects in the courtyard

© Atkins

MICRO CLIMATE

Climate responsive urban design

Objectives

- Light, comfortable, healthy, vibrant open space / public realm
- Light, comfortable, healthy building internal environments
- High quality, liveable built environment for diversity of residents, employees and visitors

Introduction

Microclimate is a term that refers to the climate of a local area that differs from the climate of the surrounding areas. Climate responsive urban design focuses on the localised effects of building form and mass and the built environment more generally on factors like daylight, wind and temperature. Design should seek to create as far a possible environments that are light, comfortable and are not exposed or prone to overheating.

Good spatial design should review the impact of development on the micro climate and consider how best to optimise building form, mass, height, street widths to balance amenity, aesthetics, density and environmental quality.

A good microclimate strategy would start with early stage design decisions regarding building density, scale, orientation, shape, internal configuration and location relative to open spaces.

This section covers:

- Daylight, Sunlight and Overshadowing
- Wind / Natural Ventilation Design

Issues surrounding microclimate are considered in the London Plan through policies on architecture, location and design of tall and large buildings and through other guidance such as Site Layout Planning for Daylight, A Guide to Good Practice (2011) and Guidance on Tall Buildings (2007). This policy area will be particularly relevant in areas of high density, with tall buildings impacting on sunlight, overshadowing and wind.

Key Issues

The Value of Daylight and Sunlight

In housing, the main requirement for sunlight is in living rooms, where it is valued at any time of day but especially in the afternoon. It is viewed as less important in bedrooms and in kitchens, where people prefer it in the morning rather than the afternoon.

Sunlight is also of value in non-domestic buildings. The requirement for sunlight will vary according to the type of non-domestic building and the extent to which the occupants can control their environment. People appreciate sunlight more if they can choose whether or not to be exposed to it, either by changing their positions in the room or using adjustable shading. Where prolonged access to sunlight is available, shading devices will also be needed to avoid overheating and unwanted glare from the sun. This can apply to housing as well. In the winter, solar heat gain can be a valuable resource, reducing the need for space heating. Good design can make the most of this.

Orientation and Overshadowing

A south-facing window will, in general, receive most sunlight, while a north-facing one will only receive it early morning and late evening in summer. East- and west-facing windows will receive sunlight only at certain times of the day. Apartments with no main window wall within 90° of due south is likely to be perceived as insufficiently sunlit. Sensitive layout design should attempt to ensure that each individual dwelling has at least one main living room which can receive a reasonable amount of sunlight. Where possible, living rooms should face the southern or western parts of the sky and kitchens towards the north or east.

For apartments forming the perimeter of street blocks, it will not be possible to have every living room facing within 90° of south. This can be partly mitigated by:

- Having pedestrian access ways and corridors on the north side, and living room windows on the south side
- Where apartments are grouped on both sides of a central corridor, having ancillary areas such as stairwells, lift cores and bicycle storage on the north side of the building
- Organising the apartments so that the living rooms are placed at the end corners of the buildings and therefore dual aspect
- Arranging the apartments with a long north-south axis so that living room windows face east and west, and can all receive some sun.

The overall access to sunlight in high density residential schemes can be enhanced if the layout is designed to maximise access to sunlight by:

- Placing the tallest buildings to the north of the site
- Opening out courtyards to the southern half of the sky
- Reserving the sunniest parts of the site for gardens and sitting out, while using the shadier areas for cycle parking and waste recycling.

Gardens and Open Spaces

Overshadowing of public and private amenity spaces is a key issue in dense urban environments. The scale and massing of buildings has a large part to play in this, particularly when it comes to positioning taller buildings. The interiors of perimeter blocks can be shady and claustrophobic. Maximising light penetration into blocks through breaks between buildings or variations in building height can help improve the quality of amenity space.

Sunlight in the amenity spaces between high rise buildings is valuable for a number of reasons, to:

- Provide attractive sunlit views throughout the year
- Make outdoor activities like sitting out and children's play more pleasant, mainly during the warmer months
- Encourage plant growth in spring and summer
- Dry out the ground, reducing moss and slime, mainly in the colder months
- Melt frost, ice and snow in winter
- Dry clothes all year.

BRE guidance recommends that at least half of amenity areas should receive at least two hours of sunlight on 21 March. This target will be difficult to achieve in the highest density parts of Old Oak.

Solar Dazzle

Glare or dazzle can occur when sunlight is reflected from a glazed façade or area of metal cladding. This can affect the occupants of adjoining buildings and users of the public realm. The problem can occur when there are large areas of reflective glass or cladding on the façade, particularly when these slope back so that high altitude sunlight can be reflected along the ground. Photovoltaic panels tend to cause less dazzle because they are designed to absorb light. At the design stage, solar dazzle can be remedied by reducing areas of glazing, reorienting the building, or replacing areas of tilted glass by vertical glazing.

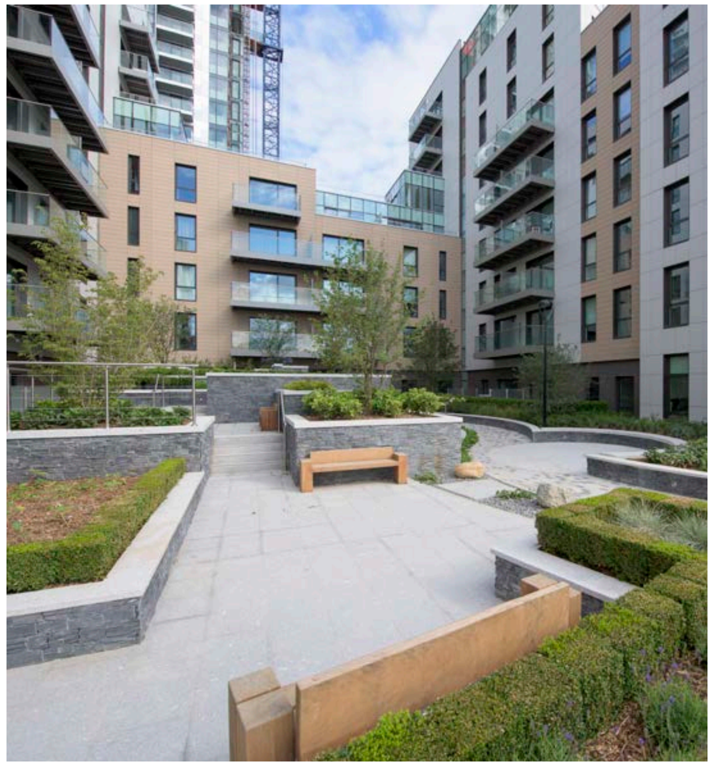
Summertime Shade

Summertime shade can be provided in a number of ways. Buildings can incorporate shading devices such as overhangs which block high angle summer sun. Making building surfaces a light colour will reduce absorbed radiation and improve reflected light. Deciduous trees give shade in summer but allow access to sunlight and daylight in winter.

Hale Village - Daylight allowed into linear park by resticting width/height ratio to 1:1

© Atkins

Woodberry Down - Daylight allowed into courtyard by using U-shaped block open to the south



© Berkeley

Central St Giles - Importance of allowing sunlight into courtyard amenity space

© Atkins

Summary of Policy Recommendations

Based on review of mayoral policies and guidance, high level microclimate modelling testing the level of provision in the draft masterplan and a review of best practice case studies, climate responsive design policy recommendations for Old Oak and Park Royal have been developed and are set out in Table below.

Table 5.2: Climate Responsive Design Policy recommendations

Policy area	Policy Recommendation	Rationale	Policy Context
Climate responsive design	Development of Old Oak Common and Park Royal should promote **climate responsive urban design** to create high quality, attractive, open spaces and streetscapes as well as healthy, comfortable and energy efficient buildings. The future masterplanning process will need to define a street layout and hierarchy which takes into account the microclimate and climate sensitive design principles. This should include: A. Maximising the site's solar potential through careful consideration of the orientation, geometry and height/width (H/W) ratio of streets. It is desirable to design 'street canyons' to maximise convective cooling of buildings and street surfaces; B. Reducing the amount of unpleasant windflow, particularly at the base of tall buildings. Where tall buildings are proposed, windbreaks should be incorporated to deflect downdrafts and provide shelter from rain. Clusters of towers should be composed with the tallest at the centre of the group, falling away to the edges to deflect wind upwards; C. Limiting overshading of open spaces and adjacent buildings. Sunlight to areas of public and private open space should be maximised. At least half of the area should be sunlit for at least 2 hours on 21 March or up to 4 hours for smaller spaces such as pocket parks; A. Maximising green infrastructure to provide shade and cooling in the summer, to the buildings and external environment (see Urban Greening policy). B. Incorporating design measures including shading, controlling solar gain, mixed mode and cross ventilation strategies to reduce overheating of indoor spaces.	The interaction between design measures aimed at improving thermal comfort, daylighting, energy efficiency and air pollution dispersion, and reducing urban heat island (UHI) effects requires adopting an integrated design approach which encompasses objectives relating to energy and carbon, materials, green infrastructure, water resources and transport. The very high density urban form proposed at Old Oak will require the microclimate of the urban design to be modelled in three dimensions with a number of options tested before an optimum urban form is achieved. This will need to be an iterative process. The performance based goals established at the outset may need to be adjusted. The urban form should be configured to limit over shading of open spaces and adjacent buildings. Public spaces, according to BRE site daylight guidance, to get a minimum 2 hours solar exposure on the 21st of March. In order to achieve this, it is recommended that tall buildings are placed on the northern side of the public spaces and internal block courtyards. Also, u-shaped blocks should be facing south where possible.	NPPF paragraphs 56-58, 99; London Plan policies 5.1, 5.3, 5.9, 5.10, 5.11, 6.1, 7.5, 7.6 and 7.7; The Mayor's Sustainable Design and Construction SPG; The Mayor's Climate Change Adaptation Strategy; Site Layout Planning for Daylight and Sunlight, A Guide to Good Practice, 2011 London Borough of Hammersmith and Fulham Proposed Submission Local Plan 2016 Policy DC3; Guidance on Tall Buildings, 2007.

Evidence

This section sets out evidence supporting the policy recommendations listed in Table 5.2. Evidence comprises the following:

- The analysis of the microclimate modelling.
- The proposed strategy for an integrated climate responsive design approach.

Analysis of the Microclimate Modelling

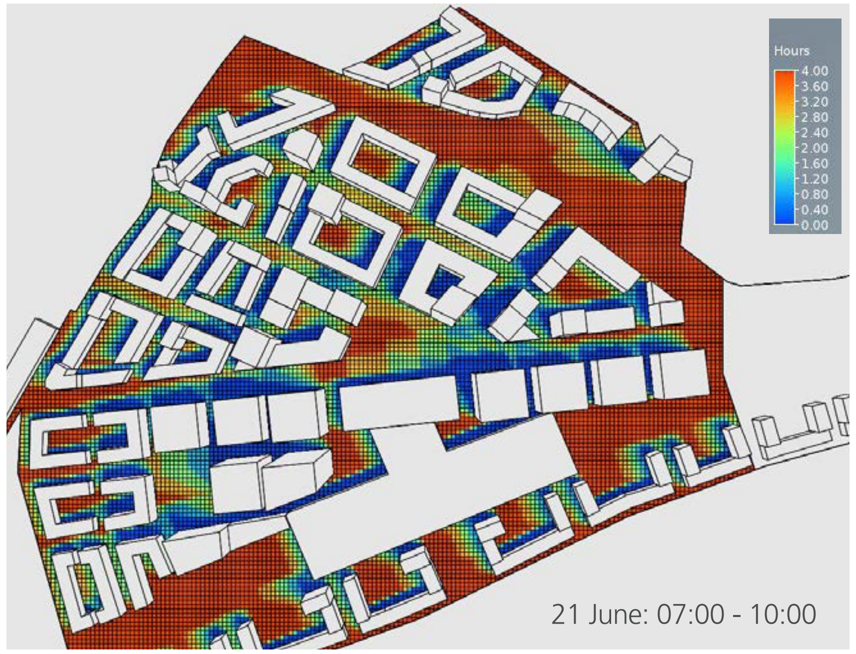
Selected Study Area

A 22 hectare area within Old Oak South has been selected to explore and test the opportunities to improve the micro-climate and environmental quality of the public realm. The area selected provides a cross-section of residential densities and a mix of land uses. It includes the HS2 station and the main cluster of tall commercial buildings and a section of the High Street. The study area also includes a range of green space and the frontages onto the Grand Union Canal and Wormwood Scrubs.

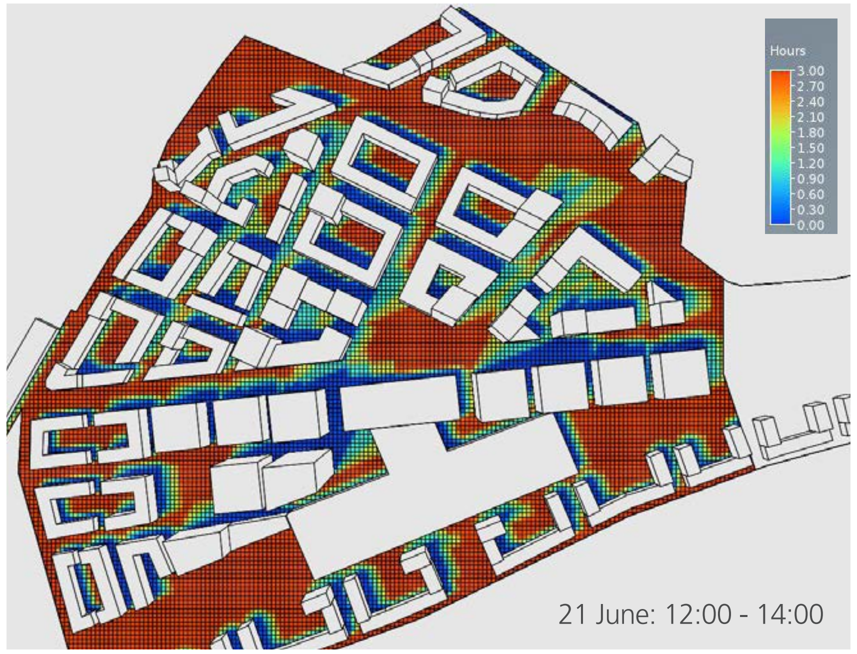
A transect through the study area has been prepared to illustrate the uses and opportunities together with more detailed consideration of a typical residential plot based on Plot 43 which overlooks the Grand Union Canal.

Base Scenario

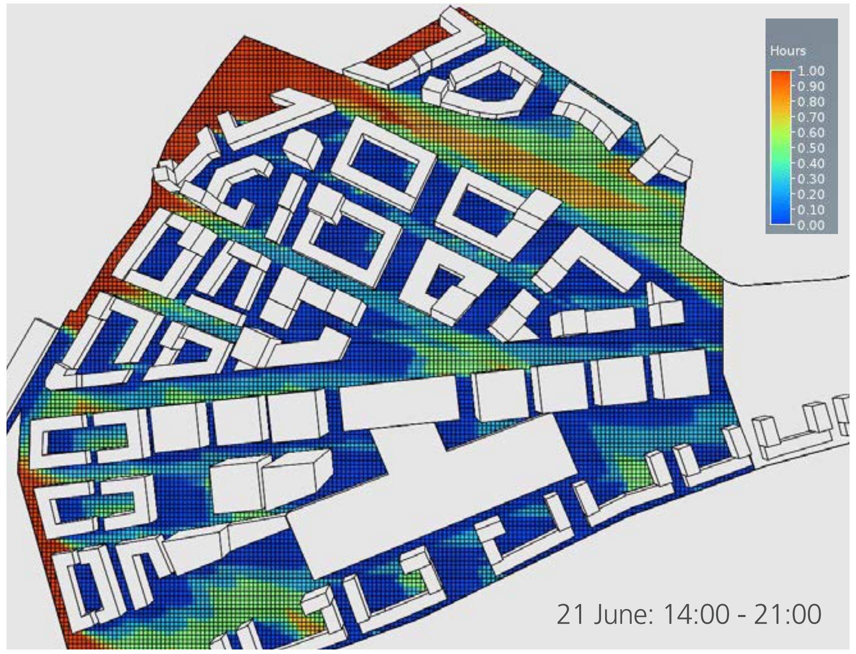
Solar Access, Early Morning

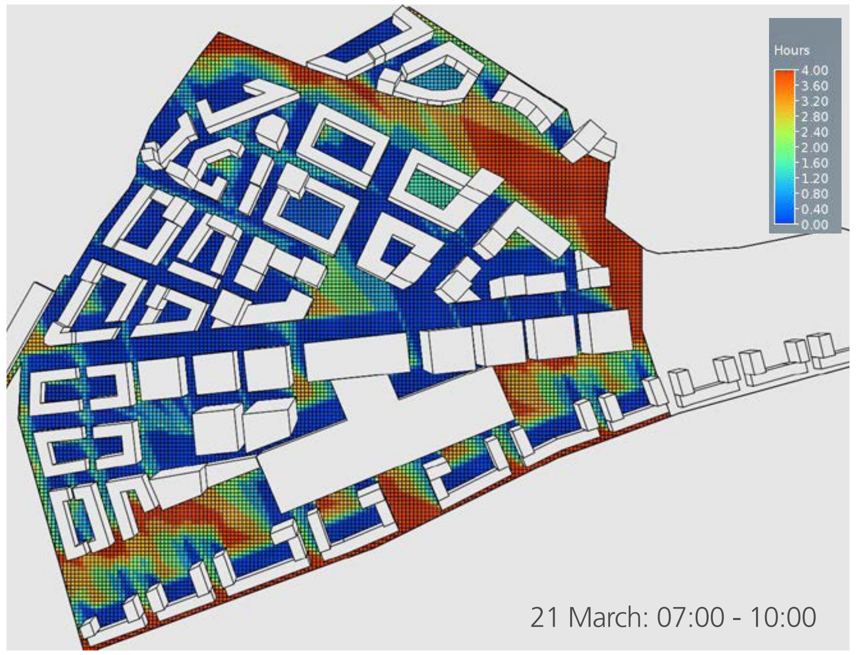


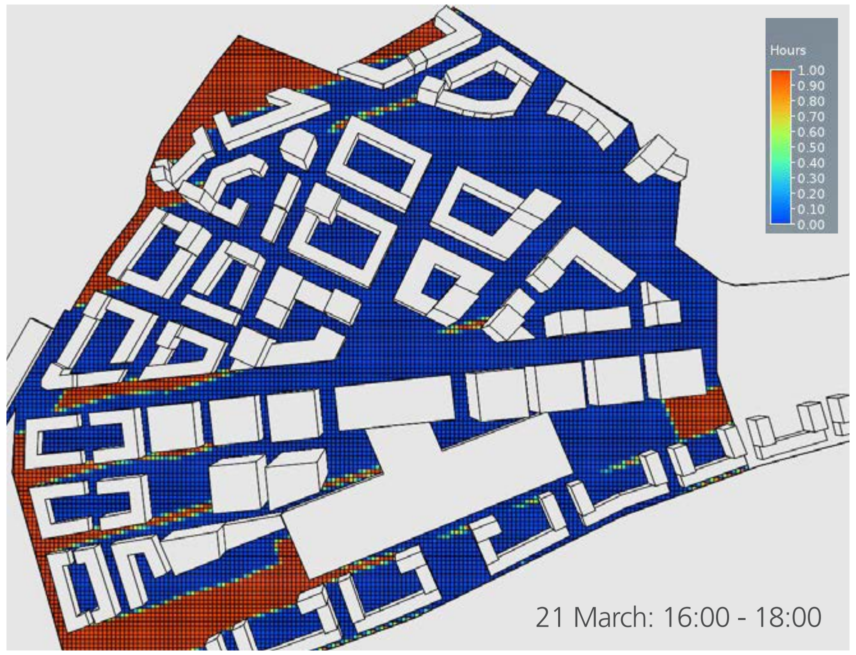
Solar Access, Early Afternoon



Solar Access, Evening







Identified issues:

- Streets with less than two hours of sunlight
- Dark semi private spaces in block courtyards. This effect is particularly noticeable on the blocks adjacent to Wormwood Scrubs
- Towers placed on the south side of blocks result in darker courtyards

Notes based on Baseline - 21st June

- Tower placed on the northern side of the block results in brighter semi-private space
- Tower placed on the southern side of the block results in darker semi-private spaces
- Public spaces with potential solar exposure lower than 2 hours a day all year round

Notes based on Baseline - 21st March

- Over-shaded façades of buildings located to the north of towers

ATKINS

Potential Improvements

Block 43:

- Massing broken up to allow for more sun light into the central courtyard and surrounding local streets
- Massing articulation for better ventilation
- South West blocks lowered to allow better natural lighting penetration into the courtyard
- Corner building increased in height to compensate for floor area reduction elsewhere

Block 48 remodelling:

- Removal of mid-rise block to the NW corner to allow more light through to the local street
- Opportunity to gain additional semi-public space in the inner block
- North wing lowered allows better sunlight penetration to the adjacent plot 43
- Tower integration to the south west of the plot to accommodate target floor area

Block 49:

- School allocated on a NS oriented wing over 5 storeys allows the lowering of the building massing overshadowing the local street

Blocks 68 to 77:

- Alternative arrangement
- Tall buildings concentration distributed on the perimeter of the high density area - "Amphitheatre effect"

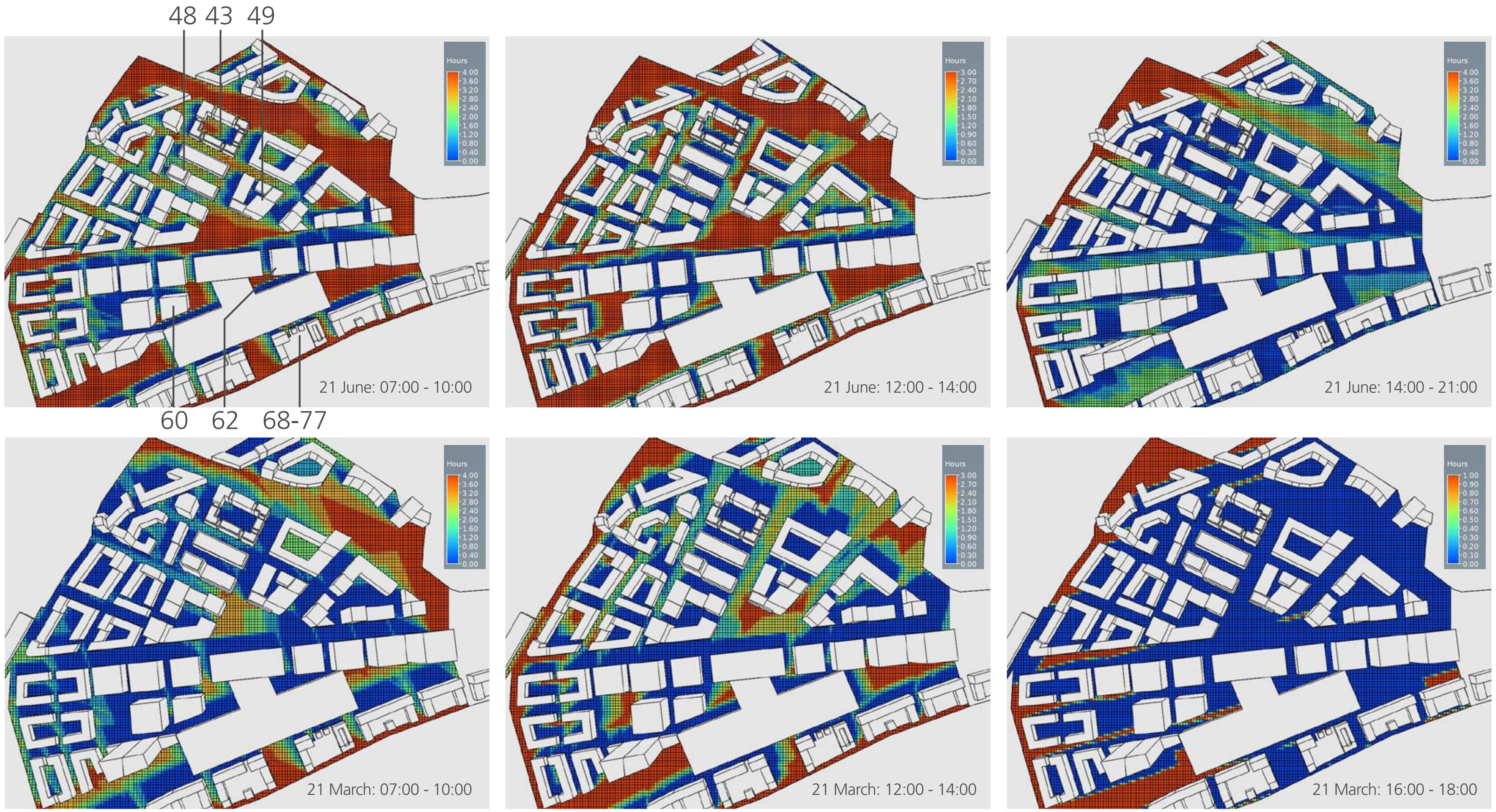
Tall Building Strategy:

- Mitigation of tallest buildings shadow overcast (60 and 62) onto north neighbourhood
- New layout for southern blocks to be open overlooking Wormwood Scrubs

Solar Access, Early Morning

Solar Access, Early Afternoon

Solar Access, Evening

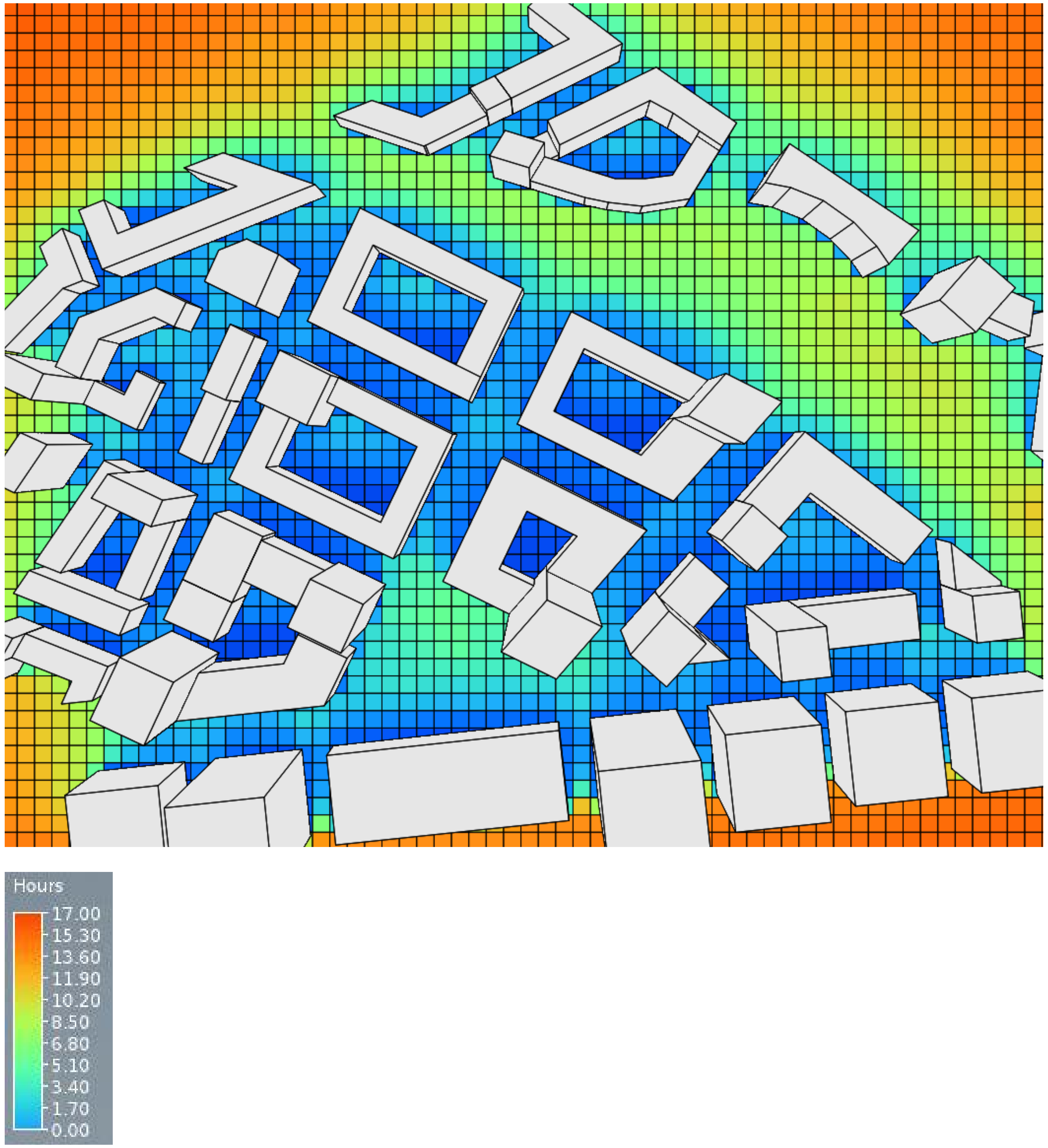


Solar / Daylight Design Guidance

The design of buildings in relation to the public realm requires careful consideration of factors such as building shape, scale, building layout and separation. The aim is to design for optimal daylighting, thermal comfort and energy efficiency across the built environment.

- **Building scale, location and massing:** These factors should be configured to limit over-shading of open spaces and adjacent buildings. Taller buildings should be located to the north of key open spaces in OPDC development to reduce over-shading.
- **Building façade glare:** Glare from high reflectance building façades and other surfaces can cause comfort issues for both building occupants and people at street level.
- **Building layout and shape:** These factors will also have implications on the availability of direct sunlight, both within the building and the spaces surrounding it.
- **Building aspect ratios:** As a rule of thumb, daylight can effectively penetrate into rooms by twice the height of the window. A room can have a day lit appearance if the area of the glazing is around 10 % of the total room area.
- **Orientation:** Where possible, orientate dwellings so that the main elevation is south facing to provide a controllable, sunny façade. Where dwellings face south and west and have large areas of glazing, include external shading devices.
- **Tall Buildings:** The way tall buildings meet the ground is important. The arrangement should allow sunlight to penetrate and upward views to the sky. The form of tower structures therefore needs to be slender with adequate space between. Carefully consider the relationship between buildings to avoid overshadowing of lower buildings by their taller neighbours so that the provision of 'living roofs' and roof top open space can be maximised.

The interaction between thermal and lighting effects, and between internal and external spaces, is best explored via specialist modelling software, which facilitates optimisation of performance across the range of design parameters.



ATKINS

Solar Exposure
Plots 43 & 48

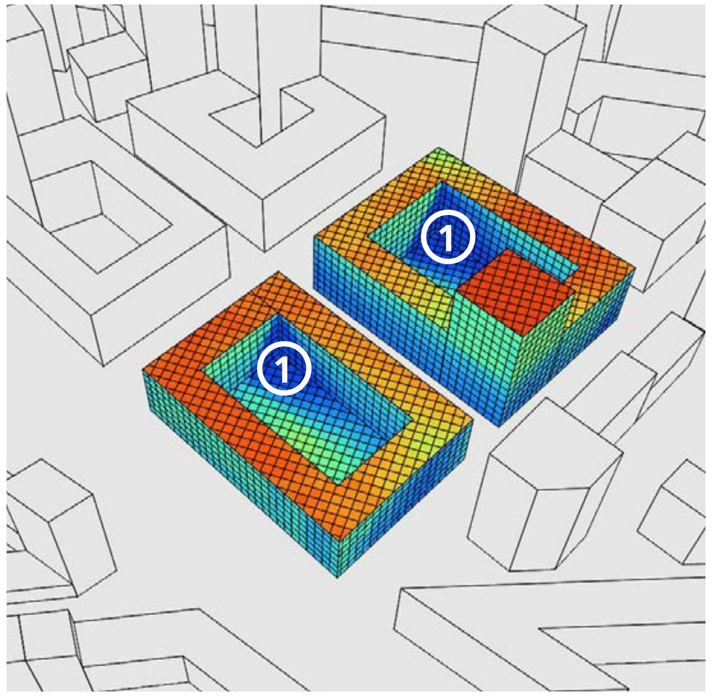
1. Dark zones in corners on continuous perimeter blocks
2. Alternative layout and semi-open massing mitigates over shadowing effect generating brighter zones both private and semi-public
3. Potential for photovoltaic panels compromised by adjacent tower
4. Opportunities for solar power generation

Plots 72 & 74

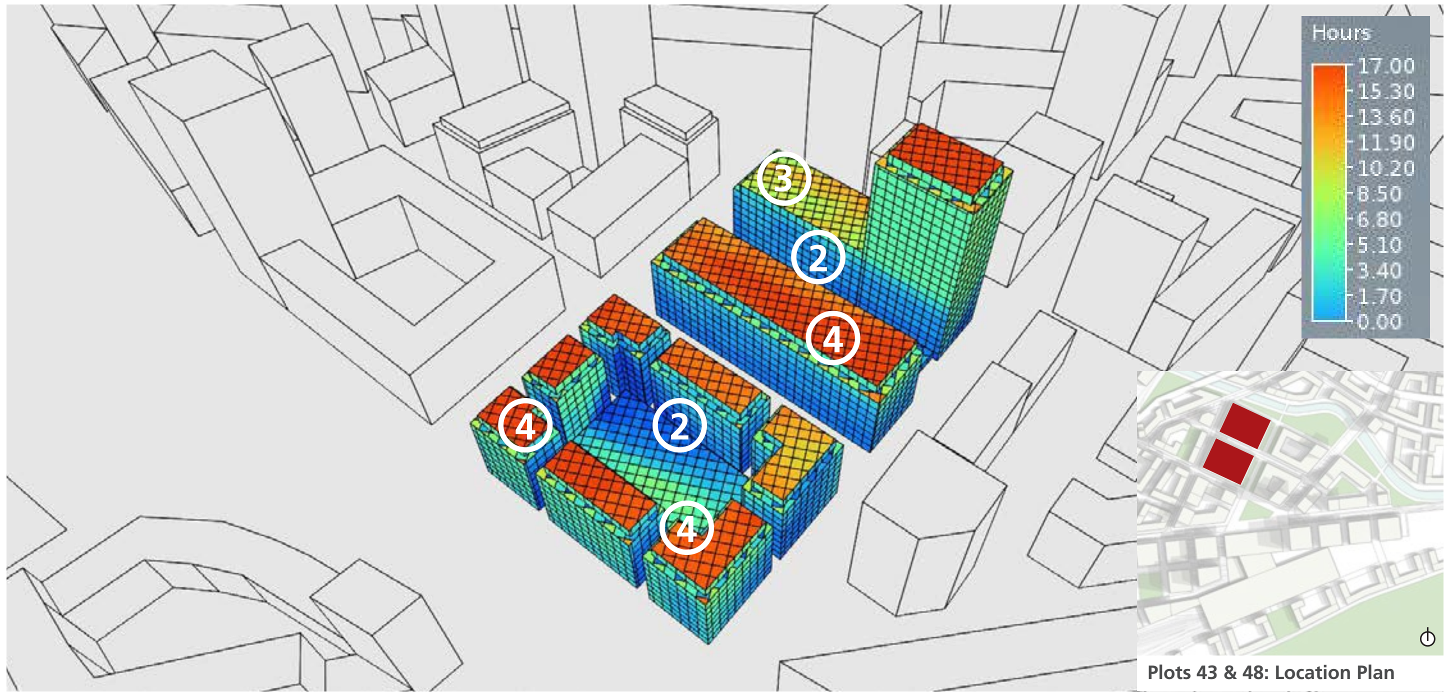
5. Semi-private spaces likely to have less than 2 hours of day light
6. Alternative allows for brighter semi-private spaces resulting from turning U-shaped blocks to face south

Plots 43 & 48

Baseline - 21 June

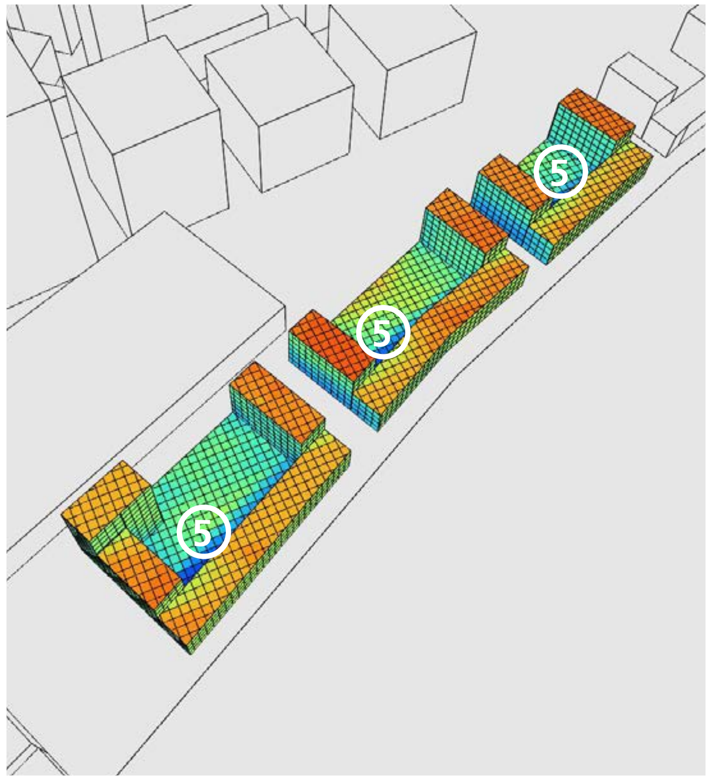


Potential Improvements - 21 June

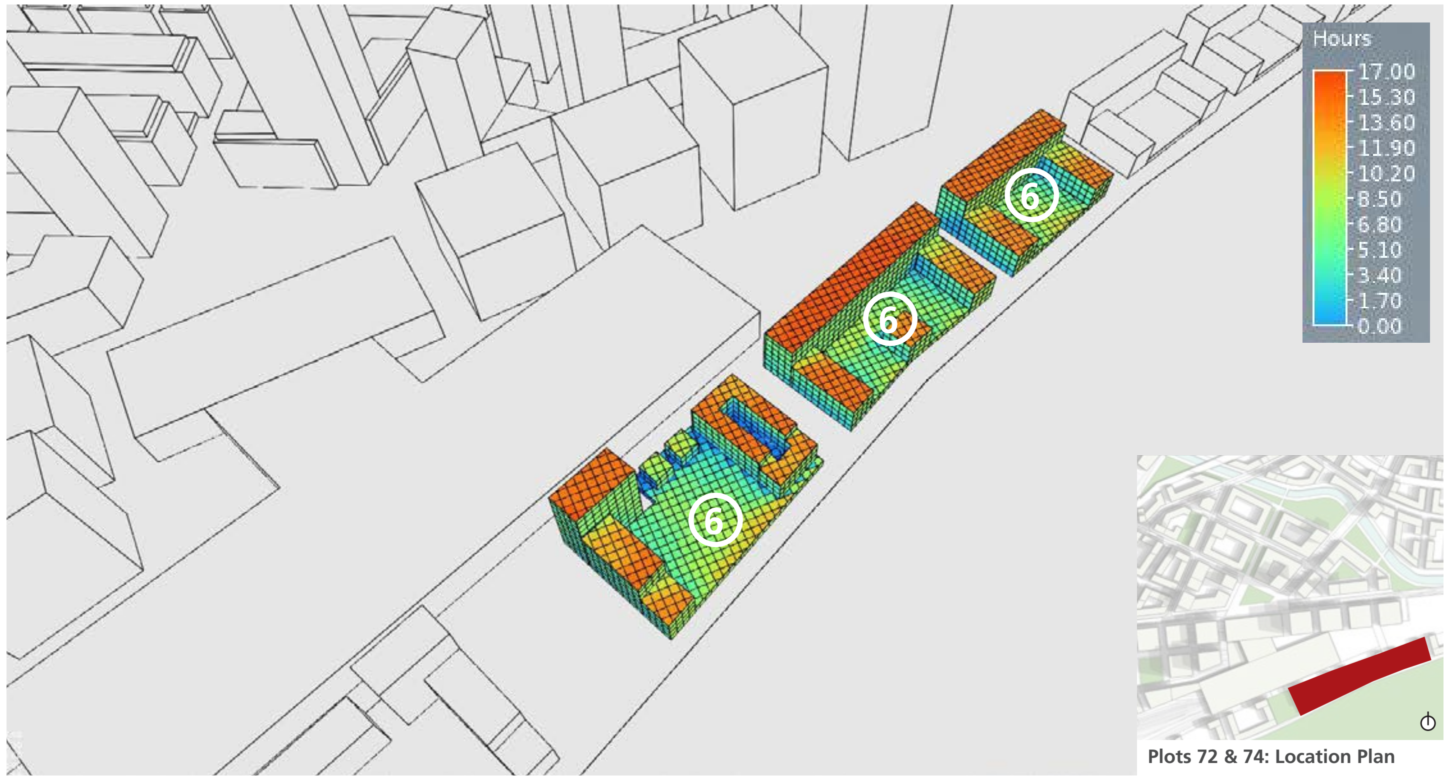


Plots 72 & 74

Baseline - 21 June



Potential Improvements - 21 June



Wind / Natural Ventilation Design Guidance

Urban Geometry

Urban geometry affects wind behaviour in both open spaces and within buildings. In proximity to open spaces and streets, building height, separation and relative position can induce air movement resulting in higher average wind speeds and greater turbulence winds. Such effects are particularly associated with urban forms incorporating 'street canyons'.

Higher wind speeds can reduce perceived ambient temperatures (wind chill factor), which with high ambient temperatures in summer can aid outdoor thermal comfort and the amenity value of the spaces between buildings, but have the opposite effect in winter.

Urban breezeways can be used to flush the heat from surfaces that have been heated by the sun and to drive down the radiant heat from the surfaces that surround street users.

Promoting breezes within built up areas can also help disperse localised air pollution, e.g. from road traffic, as well as increasing evaporation and vegetation transpiration, both of which help to cool air, although turbulence can sometimes complicate effects.

The most common pollutants in urban environments are CO_2, ozone, NOx, SOx and Particulate Matter. Pollution dispersion is a function of street width, height, length, orientation, wind speed, building geometry, upwind building configuration, intersection location and geometry. Wind behaviour will have significant implications on pollution accumulation. In general, there is a negative correlation between concentration and wind speed.

Within buildings, the potential for natural ventilation may be compromised due to reduced wind pressures, outdoor pollution and noise. Particularly in Old Oak, the high density proposed may intensify some of these issues.

Windswept spaces at the base of tall buildings can be avoided through the use of architectural devices such as awnings and terraces as well as through set-backs in the façade of the buildings. Overshadowing can be minimised through appropriate siting of the building and through the manipulation of orientation and floor plate dimensions and overall building height.

Reducing wind sensitivity of buildings and open spaces:

- **Building shape:** Avoid flat roofed buildings and large cubical forms, large flank walls facing predominant wind direction, and buildings pierced at ground level.
- **Building configuration:** Avoid funnel-like gaps between buildings, and long parallel rows of faced buildings.

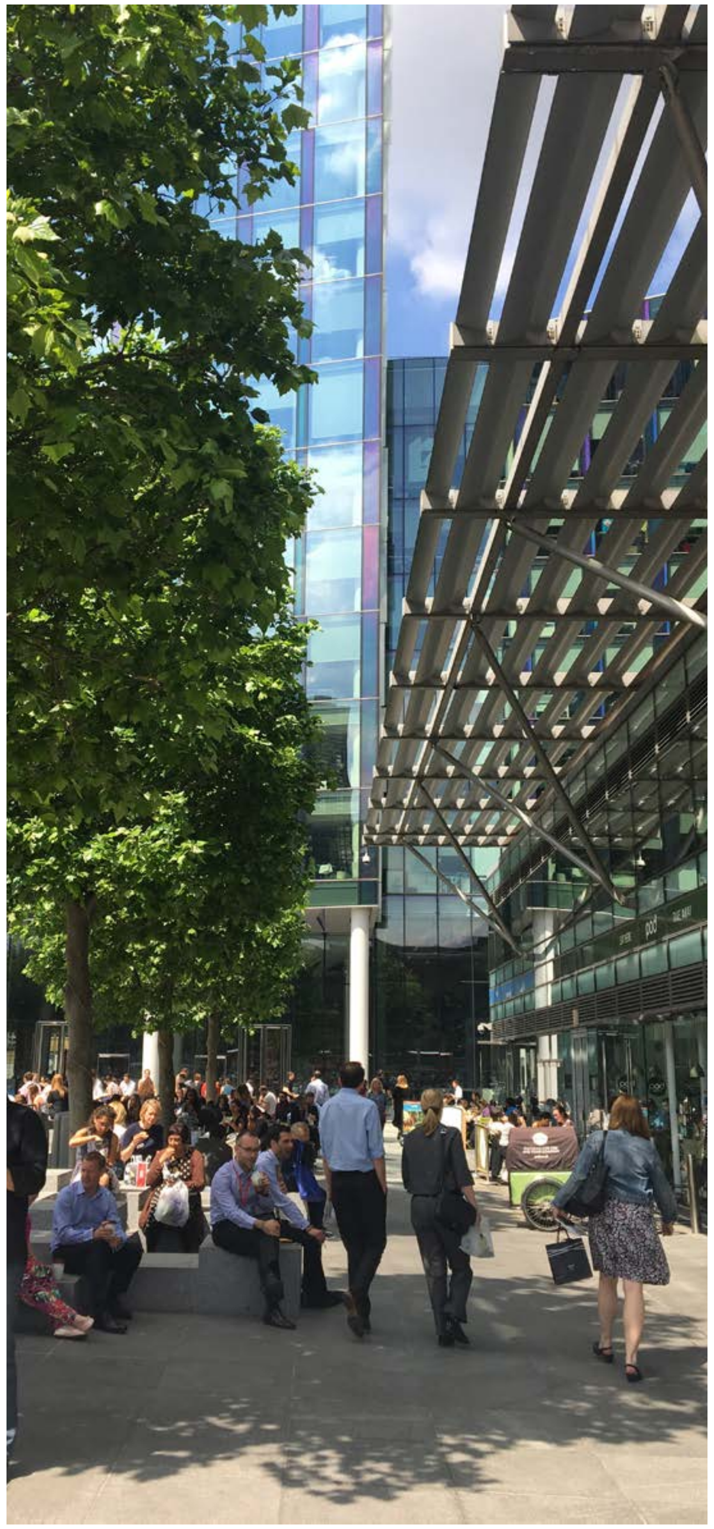
Street canyon orientation:

- **Perpendicular:** If the street canyon orientation is perpendicular to the prevailing wind direction, it can be expected lower concentrations at the windward side of street canyons and higher concentrations at the leeward side of street canyons.
- **Parallel:** In parallel canyon-to-prevailing wind configurations, wash-out and accumulation effects can occur.

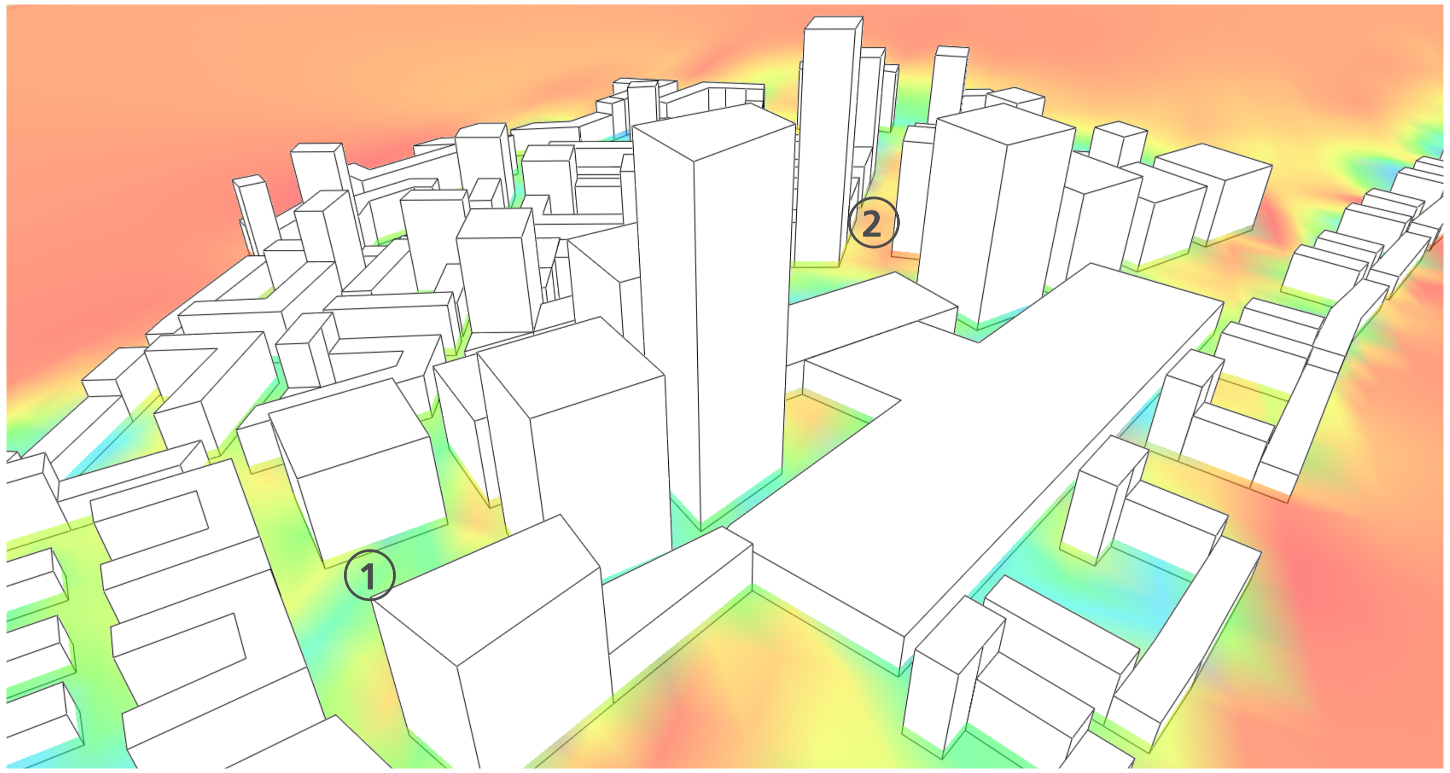
Tall buildings:

- Where tall buildings are proposed, windbreaks should be incorporated to deflect downdrafts and provide shelter from rain. Clusters of towers should be composed with the tallest at the centre of the group, falling away to the edges to deflect wind upwards.

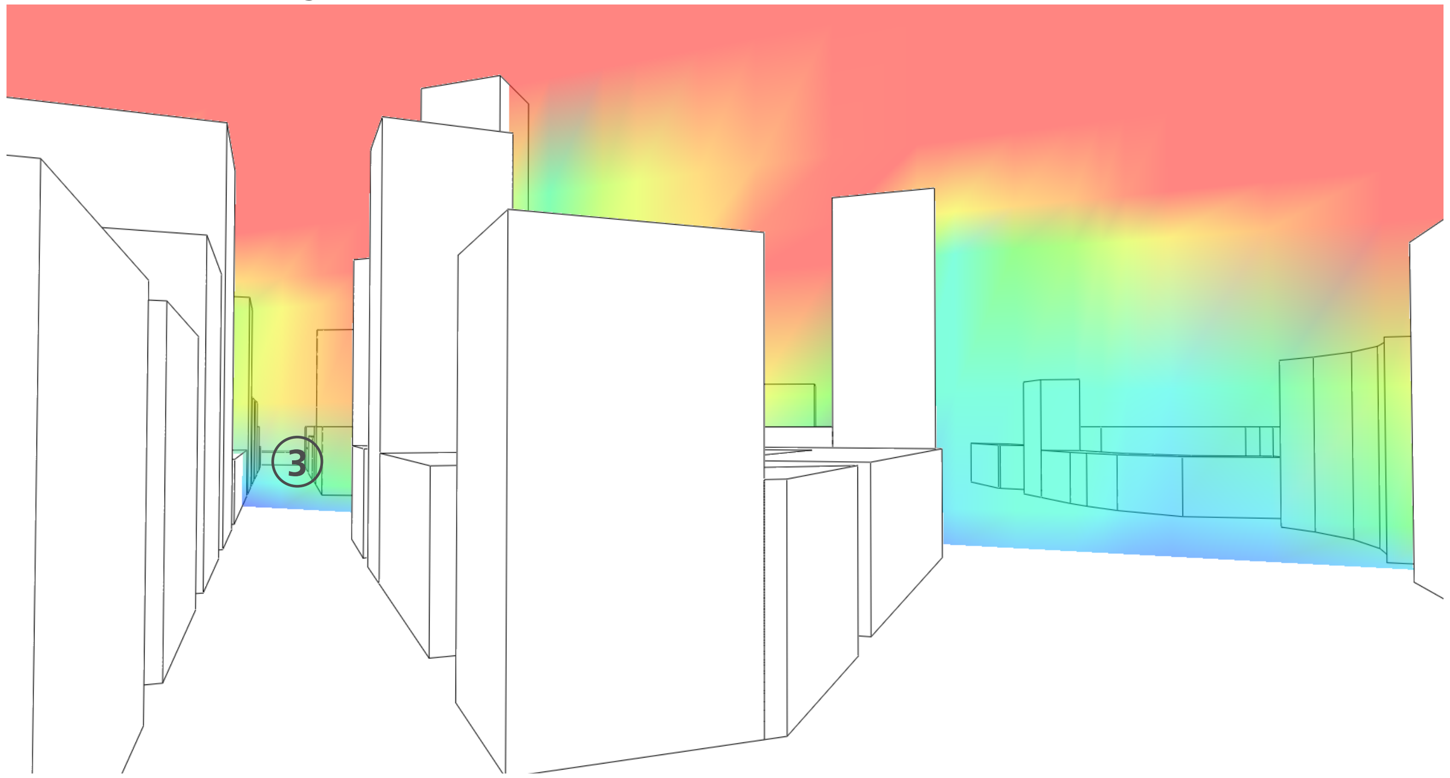
Regent's Place - windbreaks incorporated to deflect downdrafts and tree planting to provide shade and shelter



Pedestrian Velocity Vectors



Vertical Velocity Vectors

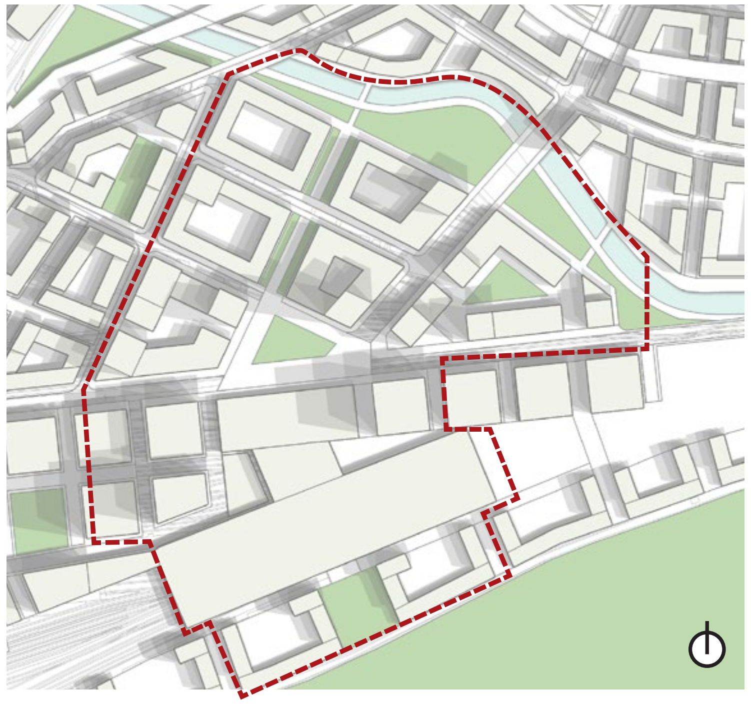


The two diagrams above show filed velocity contours, representing a moderate wind speed scenario from a South East wind direction.

An horizontal slice at pedestrian level is represented on the top-left image in order to identify potential issues affecting pedestrian comfort. A vertical slice sectioning high rise buildings and representative urban canyons is represented on the top-right image in order to identify wind turbulence and stagnation effects derived from the urban form.

Notes

1. Turbulence expected on the windward side of large cubical forms. This suggests potential for pollution accumulation
2. Higher wind speed for street canyons with long parallel rows of faced buildings
3. Higher pollution concentrations expected at the leeward side of street canyons due to stagnant and turbulent wind behaviours.



Wind Speed

High

Low

Strategy for an Integrated Design Approach

The interaction between design measures aimed at improving thermal comfort, daylighting, energy efficiency and air pollution dispersion, and reducing UHI effects requires adopting an integrated design approach which encompasses objectives relating to energy and carbon, materials, green infrastructure, water resources and transport.

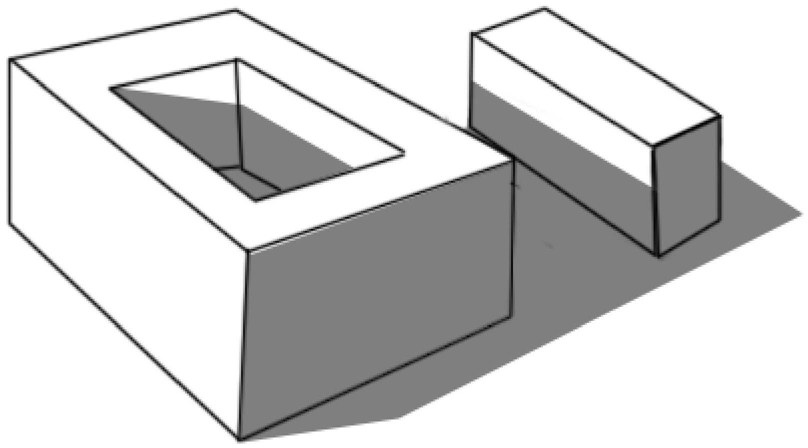
Optimising design performance and outcomes across both buildings and open spaces, taking into account seasonal variations in microclimate factors, can sometimes involve trade-offs. Integrated software modelling can inform effective approaches for exploring and testing interacting design measures and their trade-offs in seeking optimal design performance.

Microclimate performance criteria such as solar radiation, overshadowing, thermal comfort and wind flow should be established at the outset of the urban design process. Clearly stated goals which are measurable and understood by the client design team, developers and the architects responsible for the design of individual buildings will be the most effective in the long term.

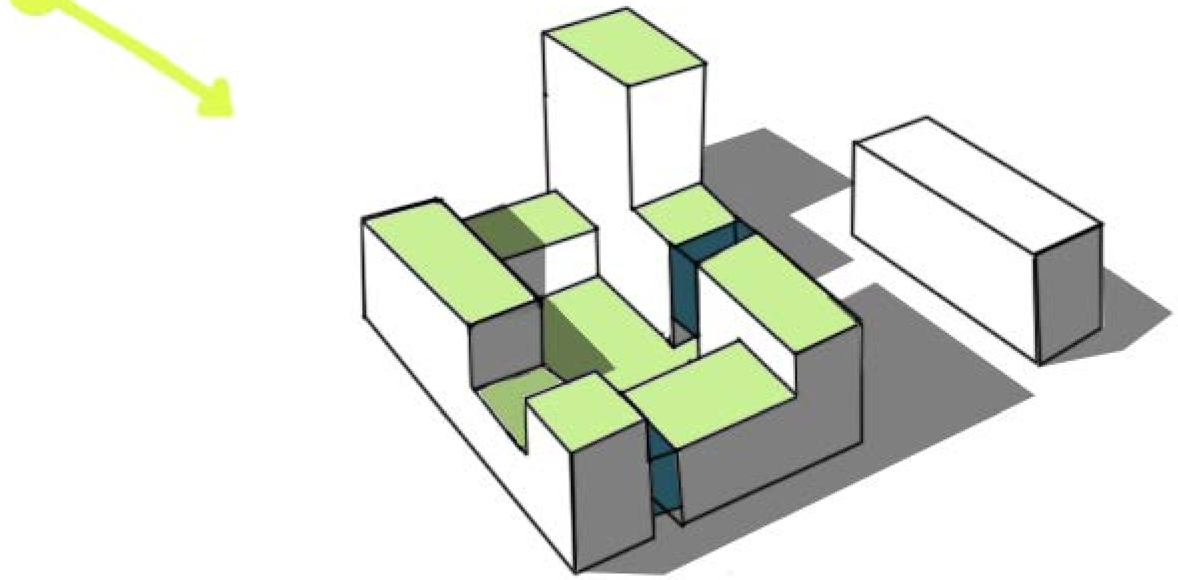
The illustration opposite shows how a conventional perimeter street block with consistent building heights can be remodelled to improve solar access, ventilation and daylight. Stepping building heights allows daylight into internal courtyards and the potential for roof terraces and accessible green roofs. Creating breaks between buildings allows daylight into courtyards. These spaces can be enclosed as winter gardens or atrium’s. Placing tall buildings on the northern side of the block prevents overshadowing.

Of course this is only one dimension, design also needs to take account of location and surrounding buildings, roads, views, streets, amenity, character areas, architecture and heritage, accessibility and DDA compliance.

Conventional street block



Street block after applying principles of climate responsive urban design



Microclimate and Urban Form

The very high density urban form required at Old Oak will require the microclimate of the urban design to be modelled in three dimensions with a number of options tested before an optimum urban form is achieved. This will need to be an iterative process. The performance based goals established at the outset may need to be adjusted.

Early stage design decisions should aim to:

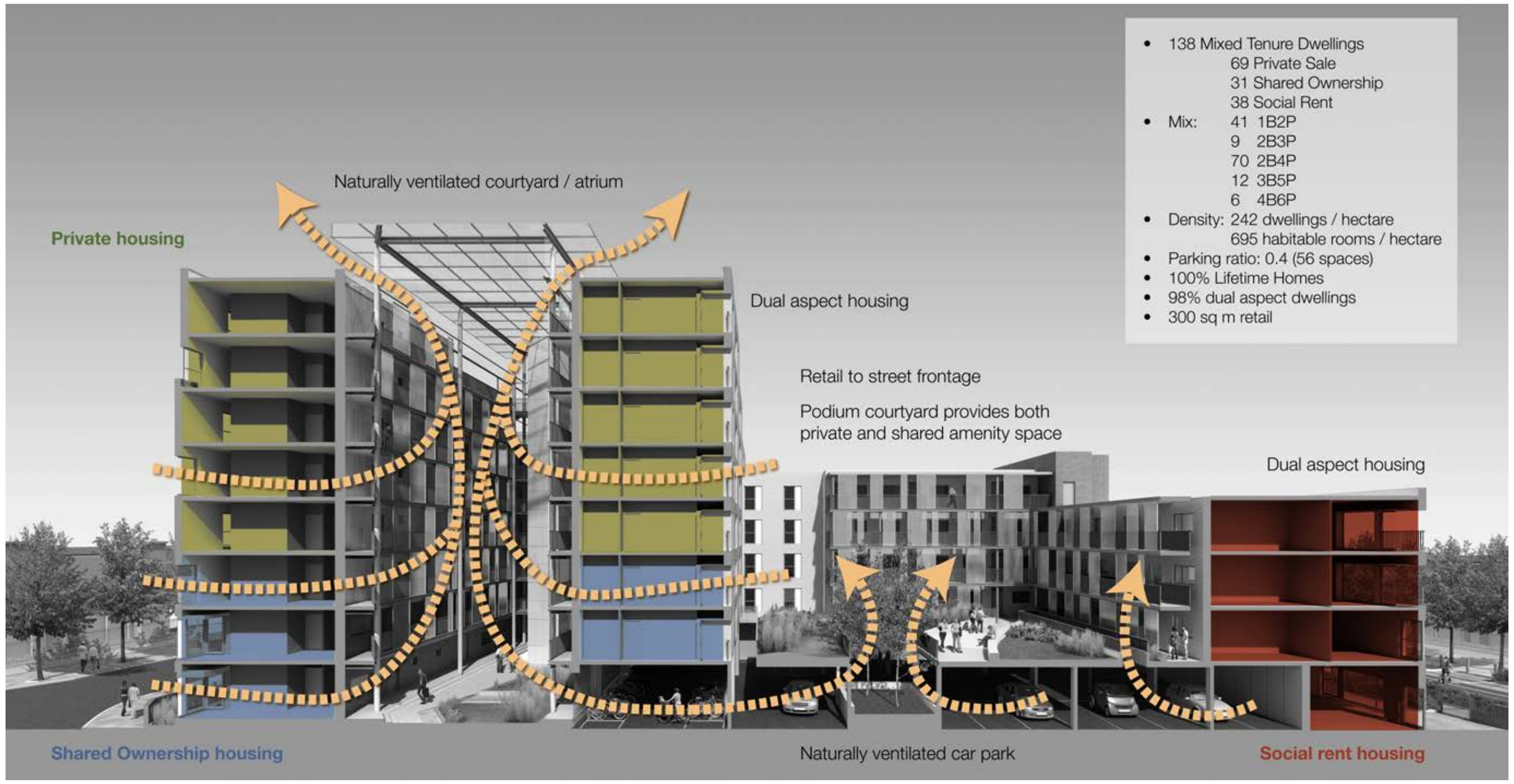
- Maximise quality availability of sunlight and natural light in outdoor spaces, particularly in winter.
- Minimise winter overshadowing between buildings, which can compromise naturally-lit buildings and reduces solar gain.
- Avoid building sunlight reflection in open spaces and streetscapes that can generate discomfort.
- Minimise excessive winter wind speeds induced by canyon and other building related effects.
- Promote localised air movement, particularly in summer, to encourage dispersion of air pollution.
- Minimise Urban Heat Island effects to reduce summer overheating.

Once the overall masterplan is fixed in three dimensions it is important that architects responsible for individual or groups of buildings adhere to the urban geometry and height framework to ensure the environmental performance goals are achieved.

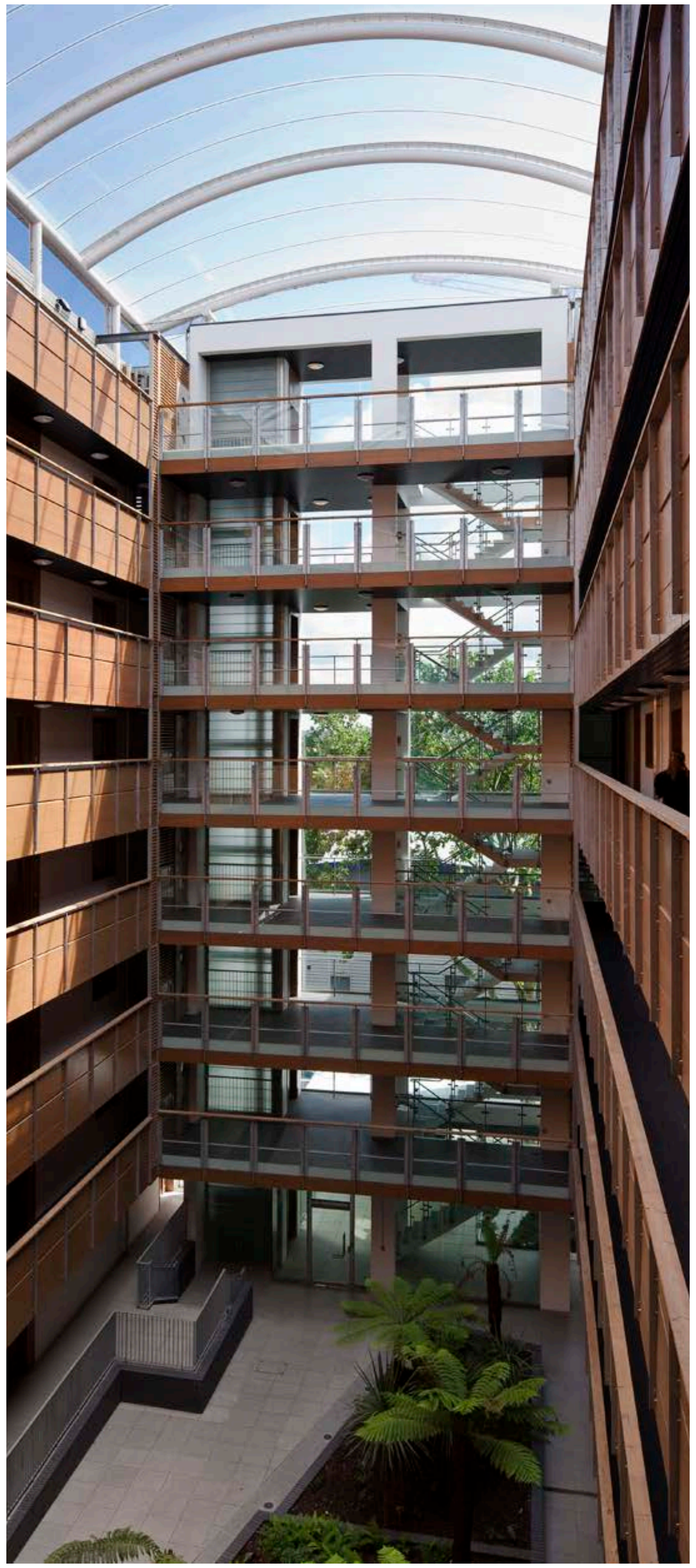
Application of Guidance

Chapter 6 illustrates the spatial application of the design guidance to the streets and the public realm in Old Oak and Park Royal.

Bermondsey Spa - Design measures to promote localised air movement and natural ventilation



Bermondsey Spa - Naturally ventillated atrium



CLIMATE RESILIENCE

Reducing overheating and minimising flood risk

Objectives

- Mitigating the urban heat island (UHI) effect
- Prevent overheating of outdoor areas and indoor spaces
- Minimising flood risk

Overheating

Introduction

The Mayor's Climate Change Adaptation Strategy identifies three key risks for London from the effects of predicted climate change: overheating, flooding and drought.

As summers become hotter, the overheating of buildings and the outdoor environment, i.e. to point where temperature rises affect human health and wellbeing, is expected to become an increasingly serious problem.

The low natural drainage capacity and the constrained sewer network present a particular risk of surface water flooding on the site. The area's sewer network is old and has insufficient capacity in places to serve the planned growth.

A key means to reduce drought risk is reducing overall water demand, this is addressed in more detail in the Water section of Chapter 4 which proposes a water neutrality target.

Urban Heat Island

The Urban Heat Island (UHI) is a microclimate phenomenon that occurs in urban areas where average ambient temperatures are higher than surrounding rural areas due to human activities. It is caused by several factors, including: the higher absorption of short-wave and long wave-radiation (intensified by darker surfaces); reflection and absorption generated from buildings and other surfaces; transpiration, anthropogenic heat release (including from road traffic); reduced wind velocities and pollution accumulation changing the radiative properties of the atmosphere.

Though overheating and the Urban Heat Island (UHI) phenomenon is not directly considered by the NPPF, many related aspects are reflected in sustainability and climate change policies. The London Plan, the Mayor's Sustainable Design and Construction SPG and Climate Change Adaptation Strategy include policies and guidance related to overheating and the UHI effect. Building orientation, passive design measures and mixed mode ventilation methods are encouraged to reduce overheating within buildings, whilst street orientation and urban greening reduce UHI at a neighbourhood and city level.

Site Analysis

Old Oak

Overheating of outdoor areas

The high density proposed for Old Oak presents potential for significant local enhancement of the Urban Heat Island (UHI) effect. The following are key measures for reducing the UHI effect and outdoor overheating in Old Oak:

- **Widespread deployment of green infrastructure,** particularly incorporating large tree canopies, which provide shade and cooling from evapotranspiration (see the Green Infrastructure section above for more information).
- **Optimally reducing cooling loads.** In summer, due to the high cooling demand from office and retail buildings in particular, significant heat rejection from cooling equipment may be anticipated from buildings. This will contribute to the UHI effect. Minimising cooling load using passive design measures can help reduce this. Locating heat rejection equipment away from areas of outdoor use can help reduce localised overheating of outdoor amenity areas.
- **Urban design measures** can be used to help enhance air movement in the public realm, with the creation of breeze pathways that enhance natural ventilation. In particular, avoiding 'street canyon' effects with building height to right-of-way width ratios greater than one can help encourage convective cooling and avoid stagnant air. Wider streets also allow more room for large canopy trees. The orientation of streets and buildings, together with building height and massing, can provide significant over-shadow shading for areas of open space.
- **Reducing combustion engine vehicles.** Heat from vehicle exhausts and engines can contribute significantly to the UHI effect and localised overheating, which can be exacerbated in high density, compact urban environments where air movement is restricted. This also improves air quality and noise reduction strategies which support natural ventilation strategies (e.g. windows that open).

Overheating of indoor spaces

Some of the passive measures envisaged to substantially reduce to building energy consumption, such as some of those incorporated in the Passivhaus standard, have the potential to exacerbate indoor overheating, e.g. in relation to air tightness. Such issues can be addressed with good design and close attention to specific aspects of energy efficient performance, such as:

- Optimising use of green roofs
- Orientation of occupied spaces, avoiding due east and west orientations
- Controlling and avoid unwanted solar heat gains by implementing shading and solar control glazing
- Avoiding high glazing-to-opaque proportions in building envelopes, mostly east and west orientations in tall buildings
- Optimising mixed-mode ventilation strategies
- Encouraging cross ventilation
- Maximising vegetation and reducing the thermal mass of hard landscape will help minimise UHI effects
- Increasing the reflectivity properties of roofs (albedo) reduces absorption. Implementing green/blue roofs will help with this.

Park Royal

Overheating of outdoor areas

High cooling process loads associated with industrial buildings in Park Royal will lead to substantial heat rejection. This, as well as potentially heat intensive processes, may have potential overheating effects in outdoor areas during summer.

The overall lower density, lower height development, relative to that proposed for Old Oak, will help enhance air movement and convective cooling. The current lack of green space and tree cover will contribute to enhanced UHI effect and localised outdoor overheating. Green space and tree cover should be increased throughout the area, focusing on greening the streetscape.

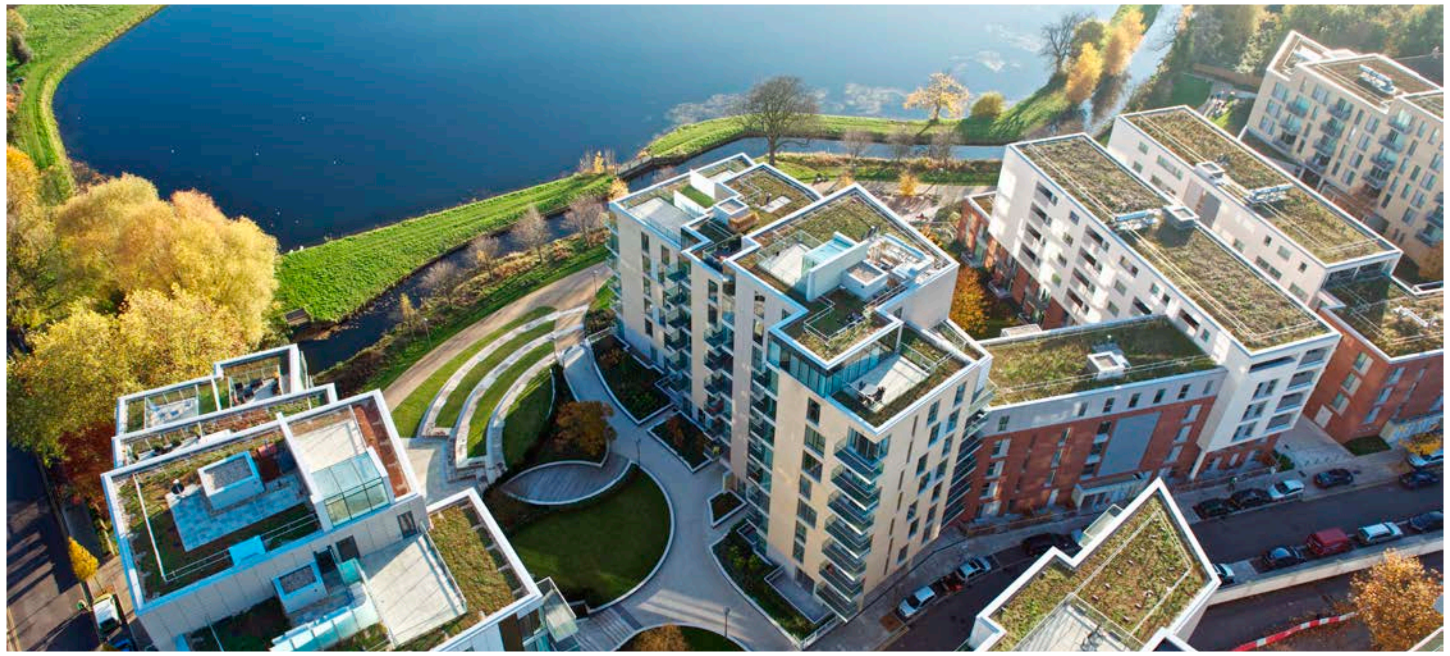
Overheating of indoor spaces

For existing and new-build non-industrial buildings in Park Royal, the points set out above for Old Oak also apply.

For the industrial buildings there is likely to be a reliance on mechanical cooling for those enclosed areas which are more regularly occupied. Through retrofitting it should be possible to introduce some elements of passive design, particularly insulation.

The introduction of solar energy (PV or solar thermal) collectors on the roofs of industrial buildings should aid in reducing overall cooling due to shading of roofs. Due to lower roof heights it might also be possible to use solar collectors as shading devices if overhanging building walls.

Woodberry Down: Approximately 80% of roof space occupied by green / brown roofs.



© Berkeley

King's Cross Central: 9,000m² green/brown roofs.

© John Sturrock

Imperial College London Preliminary Urban Heat Island Study

Modelling technique

As part of the Climate-KIC sponsored Blue-Green Dream (BGD) project (bgd.org.uk), a prototype urban microclimate model was developed by Imperial College London to support this study and to quantify the Urban Heat Island Effect. This report is set out in Appendix C.

The preliminary Urban Heat Island study indicates that:

- In the high-rise area, green roofs reduce the maximum temperatures in the surface layer and canyon by 2.1°C and 0.8°C, respectively. For reflective paints, the maximum temperature reduction for the surface layer and canyon is approximately 1°C and 0.4°C, respectively
- These temperature reductions, in particular those in the canyons which is where the people live, are significant given the concerns of UHI effects for the high density sections of Old Oak Common
- Green roofs and reflective paints can reduce significantly the roof temperature and the energy requirements for the building
- For the cases considered, green roofs are more efficient in reducing temperatures than reflective paints. From a practical perspective, reflective paints are much cheaper to install than green roofs and also easier to retrofit; however they lack the additional benefits for ecology and water management that green roofs provide. It is crucial that the green roofs have sufficient moisture to evaporate during UHI events, otherwise they will not be able to reduce the UHI.

Multifunctional roof plots on the Eastside building at Imperial College London

At Imperial College London, a living lab has been established, focussed around three multifunctional green roof plots, for measuring and modelling water-energy interactions.

The data collected was used to create new, or improve existing water and energy balance models, for describing the interaction of the multifunctional roof with its environment. Precipitation, runoff and temperature data were used to assess/model benefits of green roof plots. These benefits comprise reduction of flood risk due to delayed, reduced peak storm water runoff and cooling due to transpiration by plants and related evaporative processes.

Water retention capacity was assessed for the three experimental green roof plots, of which two are extensive (A – 70/25mm and B – 70/32mm substrate/drainage layer depths, respectively) and one is intensive (C – 150/45 mm substrate/drainage layer depth). Observed data showed that for the London climate, rainwater retention is high (>45 per cent of incoming rainfall captured), with intensive green roofs retaining as much as 82 per cent of rainwater. In addition, the high temporal resolution of the logged data (i.e. measurements are recorded at frequent intervals over each hour of operation) enables the modelling of multifunctional roof dynamics, which is important for analysis of flood management processes.

The simulations of the evaporative cooling effect of the green roofs using the Urban Energy Balance model, showed that the cooling effect of the roof surfaces in summer is considerable. Vegetated surfaces are 10°C colder than a conventional roof on a daily mean, and up to 30°C colder during the hottest hours. The heat transfer through green roof is thus reduced considerably compared to a conventional roof, leading to substantial energy savings due to reduced demand for air conditioning and ventilation.

Annual rainwater retention for year 2015 of the roof plots with varying substrate/drainage layer depths

Type	Average annual water retention
Extensive A 70/25mm	46 per cent
Extensive B 70/32mm	59 per cent
Intensive C 70/45mm	82 per cent

The roof is equipped with instruments to measure weather conditions (1), rainfall (2), water quality (3), runoff (4), soil moisture (5), and soil and roof temperature (6).

Flood Risk

NPPF policies promote resilience and mitigating climate change through innovative design measures, water recycling, green infrastructure and strategic water networks to manage flood risk and promote water efficiency. The EU Water Management Directive, The Mayor's Climate Change Adaptation Strategy and the Drain London Project also inform the approach being promoted to manage flood risk.

Site Analysis

The low natural drainage capacity and the constrained sewer network present a particular risk of surface water flooding on the site. As the OPDC site is clay based infiltration is not possible, which means that surface water will need to be stored onsite in open water features such as ponds and wetlands and then released at a controlled rate. Some surface water could be stored in tanks or cellular storage before release.

The Strategic Flood Risk Assessment carried out as part of the Integrated Water Management Strategy (IWMS) study prepared by AECOM, recommends that areas of green space proposed within the draft Old Oak Common masterplan could be re-configured to coincide with areas of existing ponding to act as areas of dispersed attenuation storage. The IWMS also indicates that, through retrofit of the Park Royal section of the site, there are opportunities for Blue Corridors (via raised kerbs), particularly around the high risk areas and associated roads identified to the south of the canal within the current industrial areas.

The IWMS recommends a cohesive, integrated approach to managing surface water quality across the development, focusing on the provision of green sustainable drainage infrastructure, delivered to maximise benefit for amenity and biodiversity. AECOM is currently investigating the level of attenuation required for the site and the subsequent scale of SuDs needed onsite.

Providing for sustainable drainage (SuDS)

Sustainable drainage systems (SuDS) use infiltration and attenuation to manage the quantity and quality of storm runoff generated during rainfall.

A wide range of SuDS can be employed to manage storm runoff, which can include rainfall harvesting techniques for water use purposes, and are required to varying degrees in new and existing developments to ensure the proposals satisfy planning requirements. These can vary, but in the case of the OPDC area will be centred on reducing runoff to the required discharge rate. (See Water Section in Chapter 4 for more detail).

The general principle is to implement these measures as close to source as possible. The mix and configuration of the techniques employed can vary and is very much dependant on the existing constraints and development proposals.

The Construction Industry Research and Information Association (CIRIA) provide guidance, including case studies on their website: www.ciria.org.

Storing Rainwater for Later Use

As a first step, when assessing SuDS measures, consideration should be given to storing rainwater onsite for later use. Rainwater harvesting systems can be used to collect and store water for internal use as well, for example to feed WCs. As well as diverting surface water from the sewer system rainwater re-use also reduces the use of potable water for basic uses such as garden watering and toilet flushing.

Infiltration Techniques

As the site is covered by impermeable clay soils, infiltration measures such as soakaways are of limited value and unlikely to be capable of making a significant contribution to reducing surface water flows from new developments.

An alternative to soakaways is permeable paving, where surface level paved areas are installed with permeable components which can either allow runoff to soak in to the ground (if it is suitable) or collect it and channel it to an underground storage tank or soakaway. Porous surfaces can be used which allow water to infiltrate across its entire surface (e.g. gravel, porous concrete/asphalt).

Areas of soft landscape can be easier to integrate into sites and can serve as useful means to attenuate surface water flows. Where space is at a premium green roofs can also be used to attenuate and store water.

Surface Level Attenuation

Larger landscape features such as ponds, filter strips and shallow vegetated channels called 'swales' may not be feasible within very high density development sites such as Old Oak.

Surface level attenuation features such as swales may be feasible in Park Royal where there are large outdoor storage areas which could be retrofitted to store runoff water during heavy downpours.

Rain Garden, Malmö Western Habour

© Atkins

SuDS basin Woodberry Down

© Berkeley

Underground Attenuation

If there is inadequate space for surface level SuDS measures, then it is likely that underground pipes and storage tanks will be required. These can be used to store surface run off during heavy storms, attenuating the flows into the public sewer to levels that significantly reduce the risks of flooding.

Storage can take the form of structures such as oversized pipes, concrete tanks or plastic modular geocellular tank systems. Using underground storage as a SuDS measure can be useful on constrained urban sites where space is at a premium.

Retrofitting SuDS

Permeable surfacing materials include gravel, permeable concrete block paving or porous asphalt can be used to retrofit SuDS into the extensive outdoor storage, parking and service areas within Park Royal.

SuDS Maintenance

Most SuDS measures that are implemented in new developments will need to be regularly inspected and maintained to ensure their efficient operation. Surface level measures such as swales, basins, and green roofs should be maintained as part of the overall landscape maintenance. Measures that have required the installation of underground SuDS components such as storage tanks set beneath streets and public realm will need to be maintained in line with the component manufacturer's requirements.

Policy Recommendations

The policy recommendations and guidance provided within the previous Green Infrastructure and Microclimate sections are cross-cutting and incorporate recommendations to address overheating and flood risk.

Old Oak

The high density proposed in Old Oak will very likely lead to enhanced UHI effect in the outdoor spaces and increased surface water run-off, which will exacerbate flood risk during heavy storms. One of the most effective ways to address this is to maximise green infrastructure across the site. Creating 'breezeways', introducing shading devices, minimising cooling loads and associated heat rejection from buildings, reducing tall building reflection, avoiding use of heat absorbent paving and cladding and reducing combustion engine vehicles will all help reduce outdoor overheating and enhance overall thermal comfort in the summer.

Carefully balanced passive building design measures aimed at minimising unwanted heat gains during summer would be required in order to minimise the overheating of indoor spaces. Optimal deployment of green roofs and SuDS, closely coordinated via an overall site wide green infrastructure strategy, would form one of the key measures to reduce indoor overheating and flood risk.

Park Royal

The dominance of industrial buildings in Park Royal requires an approach to indoor overheating which focuses on opportunistic introduction of passive design measures as part of gradual refitting, which could include the use of reflective paints to reduce significantly the roof temperature and the energy requirements for industrial buildings. Large scale deployment of roof-mounted solar energy equipment would also be likely to help reduce indoor overheating via extensive roof shading.

UHI effect can be minimising by maximising vegetation and reducing the thermal mass of the public realm, increasing the reflectivity properties of roofs (albedo), enhancing wind convective cooling and where practical implementing green/ brown/blue roofs.

Permeable surfacing materials can be used to retrofit SuDS into service and storage areas within Park Royal.

Application of Guidance

Chapter 6 illustrates the spatial application of the design guidance to the streets and the public realm in Old Oak and Park Royal. The case studies on the opposite page illustrate examples of best practice.

Sonder Boulevard, Copenhagen

The broad central reserve of the Sonder Boulevard in the Vesterbro district of Copenhagen was transformed in 2007 into a linear park with a range of facilities for sports and play, combined with shops and cafés.

The street has been traffic calmed and has innovative SuDS solutions which form part of Copenhagen's 'Cloudburst Management Plan'. It provides a good reference for the proposed High Street in Old Oak.

© Ramboll Studio Dreiseitl

A Stronger, More Resilient New York City

New York City's $19.5 billion plan to adapt to climate change may be the world's most ambitious climate adaptation plan. It was developed in response to superstorm Sandy, which struck 1000 miles of the Atlantic coastline in 2012 and cost $19 billion in damage and economic losses to the city of 8.2 million people.

The plan suggests more than 250 initiatives to reduce New York's vulnerability to coastal flooding and storm surge. The plan was founded on local climate models specific to the city. The models come from the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report, which provides forecasts of future climate in more detail and on a smaller scale than former models.

© Shutterstock

Rotterdam Climate Proof Strategy, Rotterdam, Netherlands

'Rotterdam Climate Proof' was launched in late 2008 by the Rotterdam Climate Initiative, a joint programme by the city government, the regional environmental protection agency, the port authority and the port employers' association.

The adaptation strategy aims to make the city of 1.3 million people 'fully' resilient to climate change impacts by 2025 and to maintain Rotterdam's status as one of the safest port cities in the world. The strategy encompasses five themes: flood management, accessibility for ships and passengers, adaptive buildings, urban water systems, and quality of life. The city set aside approximately $40 million for implementation of the plan's near-term projects.

Water Square Benthemplein

© Ossip van Duivenbode

Kidbrooke Village, London

Kidbrooke Village in south east London is one of the largest regeneration projects in the UK and has been planned to transform the former Ferrier Estate into a new mixed-used community including homes, schools, shops, health facilities, restaurants, offices and community facilities.

A new park (Cator Park), creates a central spine through the development. From the park spreads tree lined streets and smaller pocket parks, providing robust and visual links through the development. The green spaces range from new large parks through to small scale aspects such as green roofs and planted beds, providing a diversity of green infrastructure through the development.

To help minimises the risk of flooding and help cope with anticipated changes in climate, sustainable urban drainage system (SuDS) have been incorporated through the development. The features include ponds, swales, brown roofs and permeable paving.

© Atkins

NOISE

Minimise adverse noise impacts on future occupants

Objectives

- Plan for comfortable and healthy homes and open space / public realm
- Reduce the negative noise effects of dense urban environments
- Reduce exposure to infrastructure/ industrial generated noise

Introduction

There are several regulations and guidance to comply with when addressing noise issues, both at a site-wide/external level and at indoor building level. The NPPF states that planning policies and decisions should aim to avoid noise generating developments that will have significant adverse impacts on health and quality of life. Tranquil areas and positive soundscapes are also valued and should be retained for their amenity value. The London Plan acknowledges the importance of noise on wellbeing through a number of policies and through the SPGs Sounder Cities and the Noise Action Plan: Agglomerations. Building regulations also play a central role in mitigating adverse impacts of noise through design and materials.

Definition

Noise pollution is commonly defined as the "harmful or annoying levels of sustained and unnatural noises, either in their volume or their production, that may harm the activity or balance of human or animal life". In the urban environment, human beings are naturally exposed to varied noise pollution levels. Psychologically, the tolerance to outdoor noise levels is higher than for indoor spaces.

The level of noise is measured in "decibel - db (A)". Common international guidance and research set at 45 (night) - 55 (day) dB(A) the acceptable noise threshold in predominantly residential areas, whilst it is considered 60 dB(A) the upper limit of noise in open spaces to carry out normal activities.

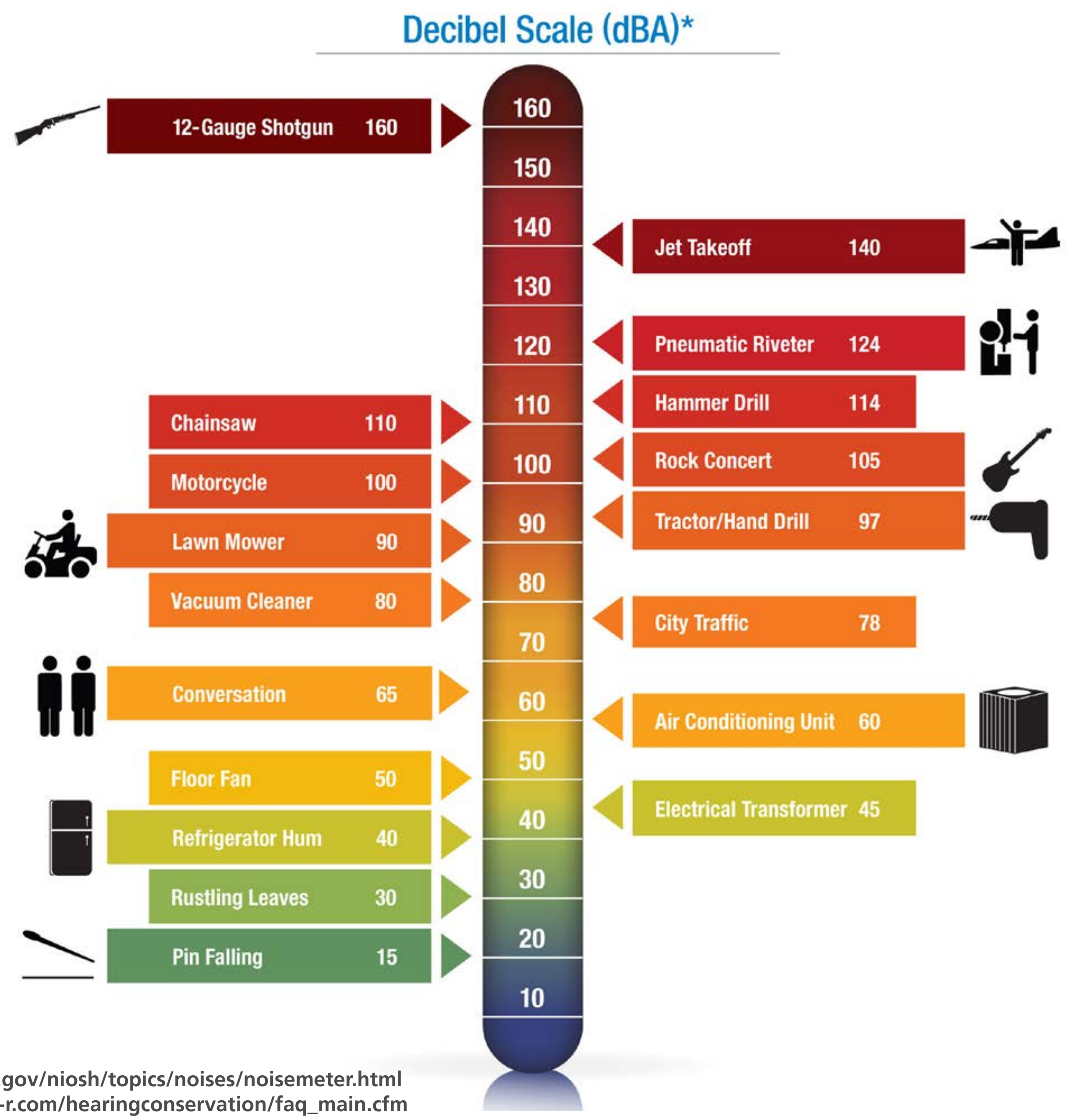
The Effects of Noise Pollution

Causes of noise pollution include: traffic (road and rail), poor urban planning, industrialisation, construction, events and poorly designed buildings. Research and surveys tend to suggest that noise levels found in lively urban areas range between 65 and 75 dB(A) with peaks of up to 85dB(A) caused by cars, buses or trains.

The effects of noise pollutions are multi-fold and sometimes not immediately evident.

Health - prolonged exposure to higher noise levels can cause serious long term harm to health. Higher noise levels cause increased levels of stress and affects the body's chemical balance, interferes with attention, concentration and can, indirectly, contribute to heart disease and high blood pressure.

Social Interaction - in open spaces, excessive noise hampers social interaction, which in turn leads to less attractive spaces and streets. This effectively influences lifestyle and willingness to venture in a neighbourhood or street. Decreases in the number of people in streets mean less active life, less safe neighbourhoods and ultimately, and importantly, less pedestrian footfall to support local business.



*Sources:
www.cdc.gov/niosh/topics/noises/noisemeter.html
http://e-a-r.com/hearingconservation/faq_main.cfm

Summary of Policy Recommendations

Based on a review of mayoral policies and guidance and the British Standard, *BS 2833:2014, Guidance on sound insulation and noise reduction for buildings* (February 2014), and some initial site analysis set out below, noise and vibration policy recommendations for Old Oak and Park Royal have been developed and are set in Table below.

Table 5.4: Noise Policy Recommendations

Policy Area	Policy Recommendation	Justification	Policy Context
Sensitive Uses and noise	Noise and vibration sensitive developments should be appropriately located and protected through careful design measures. Noise generating developments will not be permitted where this would be liable to materially increase the noise experienced by occupants and users of existing or proposed noise sensitive uses in the vicinity. Development and infrastructure proposals should be required to submit a noise and vibration assessment that demonstrates: a. How design has minimised adverse noise impacts from both surrounding and internal uses on future occupants; and b. Where development is proposed close to existing noise generators such as waste sites, cultural facilities, strategic roads or uses within Strategic Industrial Locations (SIL), how it will ensure the continued effective operation of those uses. Development that exceeds recommended Noise and Vibration thresholds will not be permitted. OPDC will only grant permission for plant or machinery if it can be operated without causing harm to amenity and does not exceed our noise thresholds. OPDC will seek to minimise the impact on local amenity from the demolition and construction phases of development. Where these phases are likely to cause harm, conditions and planning obligations may be used to minimise the impact.	Noise and vibration pollution has a major effect on amenity and health and therefore quality of life. It is a particularly significant issue in high density and mixed use areas. Prolonged exposure to higher noise levels can cause serious long term harm to health. Higher noise levels cause increased levels of stress and affects the body's chemical balance, interferes with attention, concentration and can, indirectly, contribute to heart disease and high blood pressure. The effect of noise and vibration can be minimised by separating uses sensitive to noise from development that generates noise and by taking measures to reduce any impact. Noise sensitive development includes housing, schools and hospitals as well as offices, workshops and open spaces, while noise is generated by rail, road and air traffic, industry, entertainment (e.g. nightclubs, restaurants and bars) and other uses. There will be a need for high levels of acoustic attenuation where residential development is above or close to shops, high streets, busy town squares, pubs and clubs etc.	NPPF Policy 11; London Plan policies 3.2, 5.3, 7.6, 7.15; London Borough of Hammersmith and Fulham Local Plan CC11 Noise Action Plan: Agglomerations The Mayor's Sounder City SPG
Positive Soundscapes and quiet areas	Positive soundscapes and 'quiet areas' will be protected and where possible enhanced.	Sound in the environment, especially that made by other people, has overwhelmingly been considered in negative terms, as both intrusive and undesirable. The strong focus of traditional engineering acoustics on reducing noise level ignores the many possibilities for characterising positive aspects of the soundscapes around us. We are now beginning to acknowledge the relevance of positive soundscapes, moving away from a focus on negative noise to identify a means whereby the concept of positive soundscapes can influence behavioural characteristics of people living within it. The Mayor's Ambient Noise Strategy 'Sounder City' (Para 4F.29) states the importance of considering features of positive soundscape interest, which may constitute 'soundmarks'. City soundscapes can be part of their distinctive historic character and the sounds surrounding water features, such as the canal, can be valued positively.	NPPF Policy 11; London Plan policies 3.2, 5.3, 7.6, 7.15; London Borough of Hammersmith and Fulham Local Plan CC11 Noise Action Plan: Agglomerations The Mayor's Sounder City SPG

Recommended Strategy

This section sets out a strategy to support the policy recommendations listed in Table 5.4. It comprises the following:

- Initial analysis of the draft masterplan
- Outline design and mitigation measures to inform the masterplan
- Illustrative application of design guidelines
- Recommended noise levels taken from the British Standard (BS 2833:2014).

Analysis of Draft Masterplan

Noise Related to Rail Corridors

The existing illustrative masterplan shows the proposed residential neighbourhoods at Old Oak separated and dissected by rail corridors. The rail infrastructure runs both at grade, and/or raised on a viaduct. A preliminary review of the scheme, which takes into account the policy to deliver a car-free development, suggests that the rail corridors will be the key generators of noise pollution on site. The following pages provide outline design guidance and suggest potential strategies to mitigate the negative impact rail generated noise could have on the future residential population in Old Oak.

Possible design and mitigation strategies include:

- The design of mixed use developments should seek to minimise noise to residents
- The use of circulation space to act as a sound buffer between land uses where sound transmission could be an issue
- Sound proofing of transport infrastructure
- Use of sound barriers and mounding with vegetation to act as a buffer
- Radical design approach (ie. decking or boxing of rail corridors).

Noise Related to Mixed Use Development

The proposed town centres within Old Oak will provide a vibrant mix of uses (retail, leisure, entertainment, cultural, business and housing). Housing needs to be integrated with other uses and is best located on upper floors, allowing ground and lower levels of a building to be used for other town centre activities.

Town centres can also be a suitable location for family, student and older people housing, although housing in these locations brings with it environmental issues in particular noise. Flats or offices can be accommodated over shops, restaurants, community or leisure uses. Careful consideration, however, needs to be given to sound installation, venting and location of service and rubbish collection points.

This will require management of servicing arrangements and timing for deliveries and the night-time economy and ensuring that housing does not restrict the future development of neighbouring sites for non-residential development by introducing sensitive receptors (daylight/sunlight, rights of light and noise).

The intensity of use and closer proximity of people impose pressures on acoustic and visual privacy. Large tall buildings, with their downdrafts and shadows, make it more difficult to provide high quality amenity space at the base of tall buildings. Better sound proofing is needed at higher densities.

Example of noise mitigation applied to blocks 72, 73 and 74

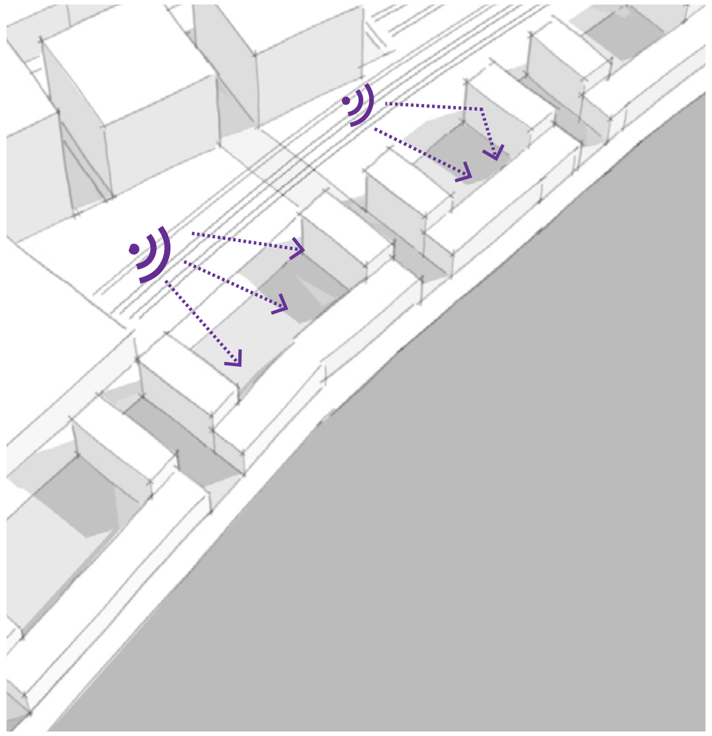
Existing layout

- The current layout shown in the illustrative masterplan generates a courtyard space prone to rail generated noise and vibration
- Access to light is affected by blocks orientation and layout
- There is opportunity for significant improvement.

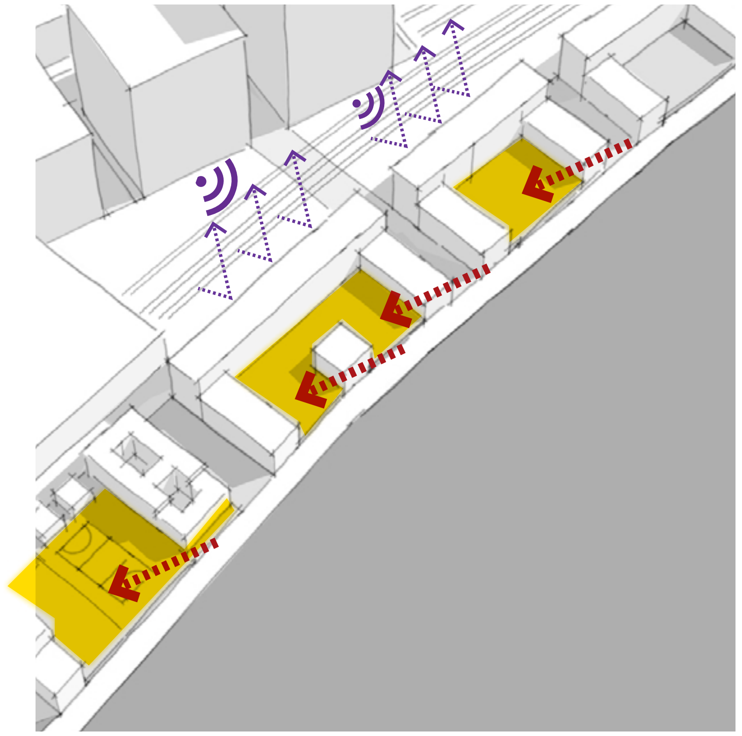
Proposed layout

- By mirroring the blocks, the mass of the building will absorb and/or bounce back the railtrack noise
- Appropriate sound proof insulation to be adopted on the rail facing elevation
- Opportunity to adopt greening strategies to this facade
- On the railway side elevation, locate uses less affected by noise (ie. kitchens and toilets)
- Living rooms to be placed on the parkside
- The semi-private courtyard has better access to direct sunlight and should be significantly quieter.

Blocks 72, 73 and 74: Existing Layout



Blocks 72, 73 and 74: Proposed Layout



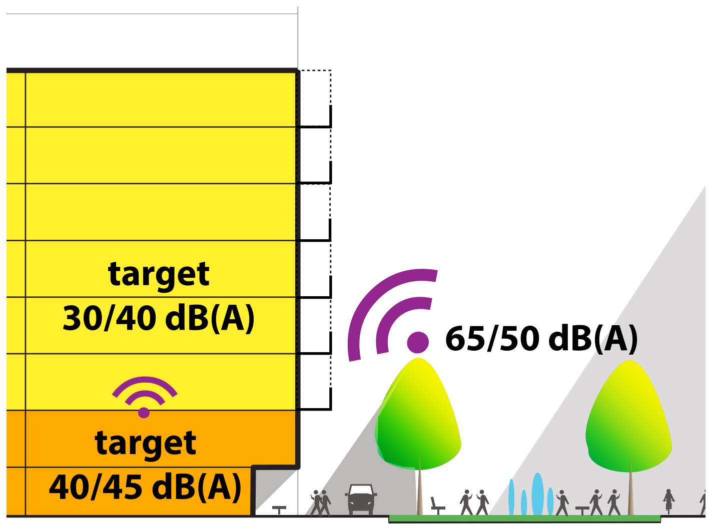
ATKINS

Application of Design Guidelines

Mixed use blocks (Old Oak, The High Street)

Recommendations:

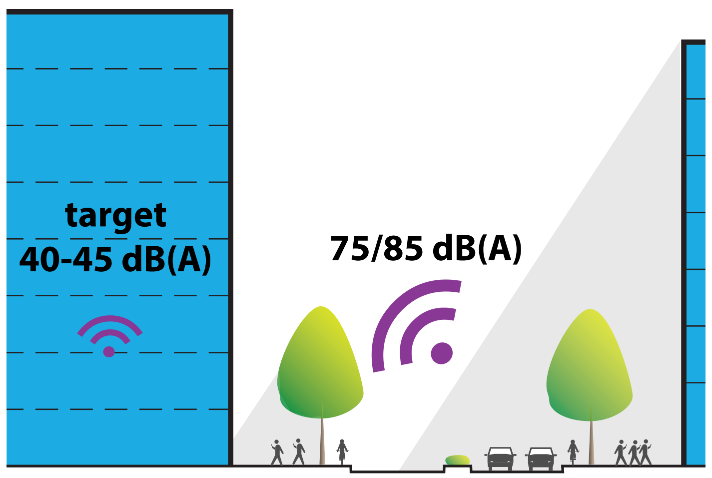
- Careful noise insulation and buffering between residential and commercial uses within the same building
- Adopt design solutions to act as filter such as winter gardens and balconies, that help mitigate or deflect direct exposure to noise vectors.



Mixed use streets

Recommendations:

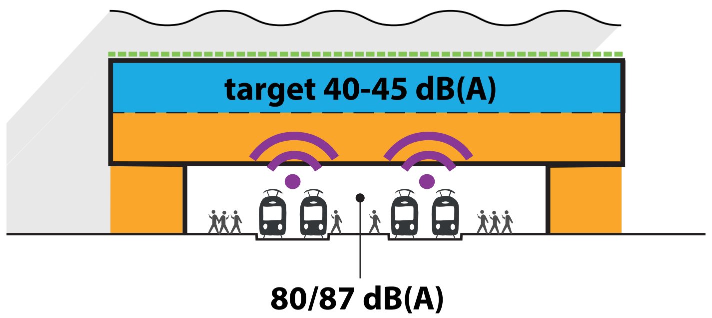
- Buffer the streets with greenery to increase the absorption capability
- Keep the building elevations as varied and articulated as possible to reduce resonance in the street corridor.



Commercial spaces above station

Recommendations:

- Increased level of insulation of the station area to achieve office/commercial level of noise exposure
- Limit direct openings between building uses and station zone
- At grade, provide enhanced insulation of commercial/retail spaces from platform zone
- Adopt internal wall design, shapes and materials that mitigate and absorb noise.



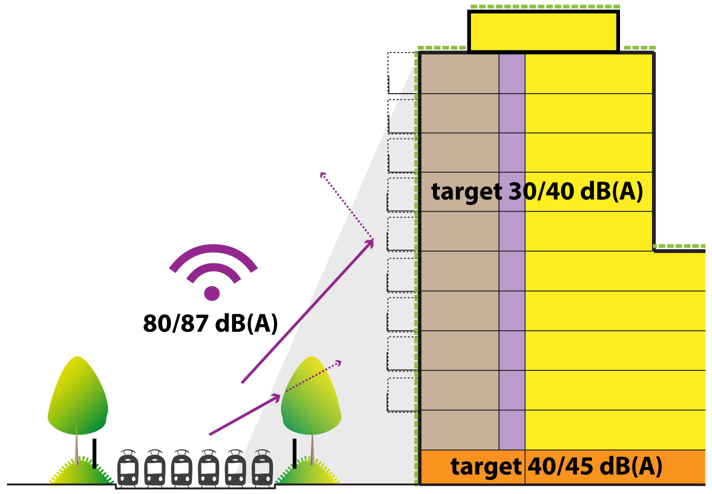
Residential facing railway

Recommendations:

- Buffer the rail corridor with integrated noise barrier including green walls
- Increase insulation of railway elevation of the building by adopting enclosed winter gardens
- Limit to the minimum the number of openings on the rail facing facade
- On the railway side, locate internal uses less affected by noise exposure (ie. kitchens and toilets).

Application of Guidance

Chapter 6 illustrates the spatial application of the design guidance to the streets and the public realm in Old Oak and Park Royal.



*Recommended noise targets are taken from BS 8233:2014. NB Note 7 (section 7.7.2) of BS 8233:2014 states *'Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved.'*

SUSTAINABLE TRANSPORT

Maximise Low / Zero Carbon Movement

Objectives

- Maximise low / zero carbon movement
- Strong walking and cycling networks: integration with green infrastructure
- Restricted parking
- Encourage fossil fuel free vehicles

Introduction

The NPPF encourages sustainable development through locating development near and enhancing opportunities for pedestrian and cycling routes and public transport. The London Plan states the Mayor's commitment to improving the environment by encouraging these modes of travel. The Mayor's All London Green Grid, Accessible London and Improving the Health of Londoners all support sustainable transport options, particularly well integrated and safe walking and cycling routes.

Site Analysis

According to the OPDC Draft Local Plan, the key transport challenges across the development area include:

- A congested strategic and local road network, limited access to public transport services and poor pedestrian and cycle environments mainly due to severance and limited provision of infrastructure
- The provision of the HS2/ Crossrail/ National Rail station will transform accessibility of this part of west London and will provide an opportunity to rethink transport provision in the OPDC area
- There is need to fully integrate new transport infrastructure into the regeneration area to ensure that development potential can be optimised around these new and improved accessible transport hubs
- Coupled with the significant general background growth and the increase in travel demand resulting from the new HS2, National Rail and Crossrail station, the additional homes and jobs created within the development area will add to the existing travel demand, both at the strategic and local level.

There will be a large number of people working, living and moving within the area and to support this it is vital to relieve pressure on the road network and connect key origins and destinations with sustainable transport modes.

Encouraging transport improvements that are both sustainable and technologically innovative will deliver enormous quality of life benefits and deliver a step change in the appeal of walking and cycling as healthy, active travel options.

OPDC's Sustainable Transport Hierarchy (see diagram below) aims to promote a transition to a more environmentally sustainable city.

The priority should be for minimising people's need to travel. This approach is to a large degree facilitated through the creation of a high density and highly compact city form, which can enable the creation of 'five minute living' neighbourhoods, putting local services within easy reach.

Minimising use of private vehicles and levels of car parking and inhibiting through routes for private vehicles will mean that more space can be dedicated to the provision of a high quality public realm and green infrastructure provision, which provides further benefits for health and well-being and the environment.

OPDC Sustainable Transport Hierarchy

Strategy Recommendations

The OPDC Draft Local Plan includes policies to encourage sustainable transport movements, the aim of this section is to start to look at a strategy to help embed the principles of 'five minute living' neighbourhoods.

Old Oak Common HS2 station presents a once in a lifetime opportunity to deliver a step change in public transport access across Old Oak and Park Royal and provide the catalyst for regeneration. Providing quality connections to this transport super-hub through the delivery of state of the art transport infrastructure will be a key aspect in the success of the OPDC area and provides the rationale for the phased implementation of car-free development in Old Oak. This will include:

- A compact form of development with increased density which will bring more facilities within easy walking and cycling distance
- Car free streets which will improve environmental quality and building performance
- Not providing private car parking in commercial premises close to public transport will encourage greater use of sustainable modes of transport
- Introducing services such as car clubs to provide a more convenient, cost-effective and attractive alternative to owning a private car
- Freight consolidation centres together with low/zero carbon vehicle deliveries will minimise freight/goods movement related emissions
- Provision of sufficient greenspace will be challenging, car free streets will help to increase the amount of multifunctional green infrastructure.

Rather than reducing choice, a holistic approach to reducing car dependence actually increases choice. Car clubs could evolve in time to become total mobility clubs with a complete range of vehicles incorporating people carriers, vans, motorhomes and electric vehicles.

Transit Oriented Development (TOD)

The OPDC area will be one of the best connected locations in the UK with the new stations for High Speed 2 (HS2) and Crossrail and potentially two new London overground station. This major new transport hub provides the catalyst for a Transit Oriented Development (TOD). TODs are a major solution to climate change by creating low-carbon lifestyle, sustainable communities.

The main concepts of TODs are:

- Walkable design with pedestrians as the highest priority
- The train station as the prominent feature of the town centre
- High density, high rise clusters of tall buildings including over-station development
- Interchange with zero/low emissions buses and public transport
- Public square fronting the station
- High density, car-free, walkable mixed use district within a 5 minute walk of the transport hub
- Large bicycle parks within stations
- Retail, leisure and entertainment creating a vibrant destination
- Network of car-free pedestrian and cycle routes providing direct connections to residential neighbourhoods.

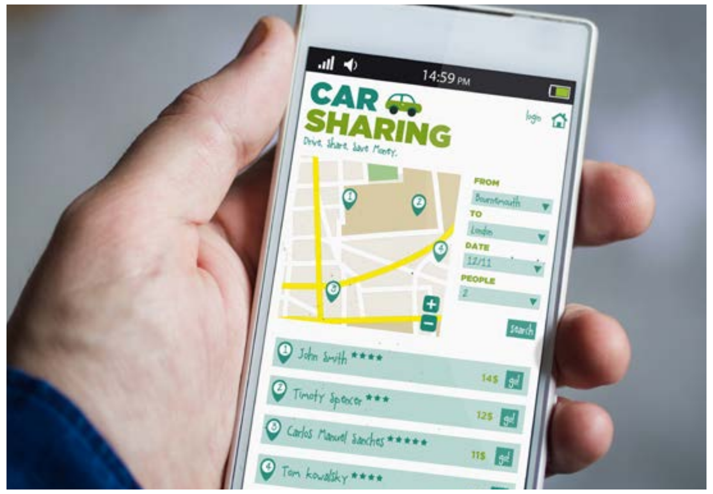
Five Minute Living

To create walkable and cyclable communities, facilities such as shops, schools, offices and public transport need to be located within 400 metres of homes creating compact communities. These are sometimes described as 'five-minute living'. The resulting increase in density allows a reduction in the cost of road infrastructure and introduces new models of personal mobility such as car clubs.

Public bike share stations

© Cyclehoop

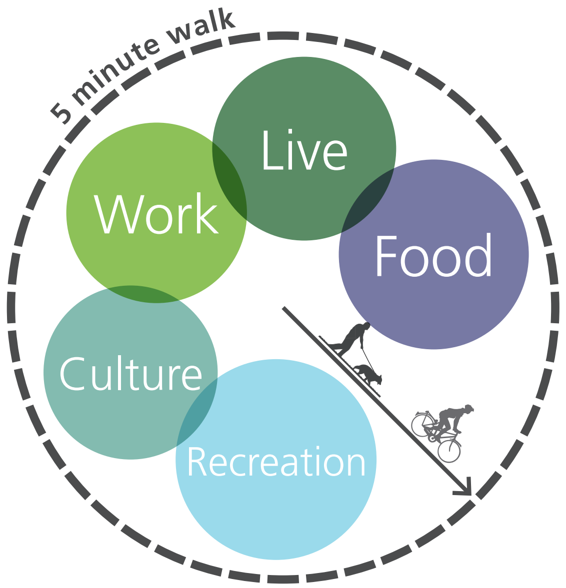
Public carshare parking



© Shutterstock

Public electric plugs

© Shutterstock



Walking

Walking is the most sustainable form of transport and encouraging increased walking will have many advantages including economic and health benefits, more connected neighbourhoods and fewer road traffic injuries.

High quality pedestrian walking routes to Old Oak Common Station will be vital to ensure residents, workers and businesses can benefit from this new transport superhub. By providing a street network that is safe, attractive and easy to navigate, people will be encouraged to walk more, which will have social, economic, environmental and health benefits and support the viability of the development area.

Walking provision should be safe, well lit, direct, comfortable, coherent and attractive and should integrate well with the street environment and desire lines, minimising conflict between different users.

The amenity value of the Grand Union Canal towpath should be enhanced by improving wayfinding and new shared use path signage along the towpath, promoting the heritage aspects of the landscape and improving the connectivity with communities.

Walking – The Five 'Cs'

Connected

- The network of pedestrian routes should be comprehensive, serving all significant desire lines
- It should provide good permeability with a choice of routes allowing pedestrians to go which way they want
- Easy, direct access to public transport facilities is vital. Public transport use is determined by distance to stops
- Green spaces should be linked into the network and provide 'green routes' to major centres of activity

Convenient

- Pedestrian routes should be as direct as possible in order to reduce distance to be walked and increase the pedestrian catchment of facilities
- They should avoid change in level, steps or kerbs that might inhibit less agile people and those with pushchairs or wheelchairs
- Routes should be linked by safe and convenient crossings, with minimum diversion

Comfortable

- Footpaths should be wide enough to allow easy passing and overtaking, without being pushed out into traffic and should be sized based on the intensity of use
- Route should be overlooked by nearby properties, giving a sense of surveillance and safety
- The route should be well lit and feel safe, without dark corners or featureless, unconnected sections which can be intimidating

Convivial

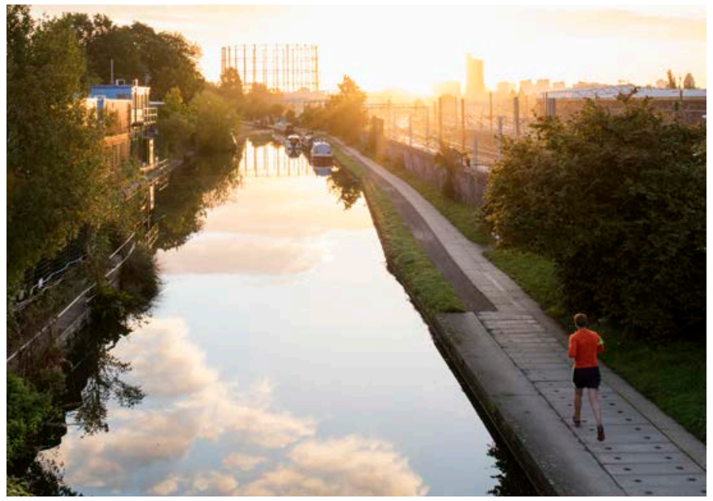
- Routes should be places where people can meet casually and talk in comfort, free from excessive noise or fumes
- They should be designed for aesthetic enjoyment, giving pleasure by the variety of prospects, spaces and landscapes

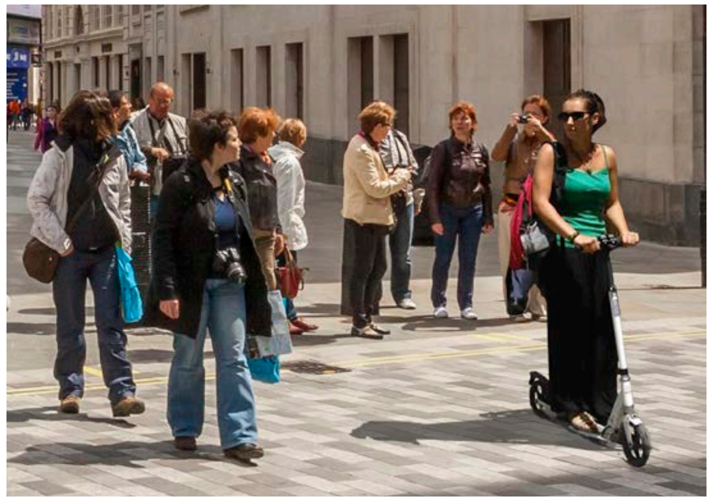
Conspicuous

- Main routes should be easy to 'read', distinctive, and clearly signposted. Landmark features can help give a sense of place

Legible London Wayfinding should be implemented throughout the area to provide clear, comprehensive and consistent wayfinding information and enable pedestrians to complete more journeys on foot. New connections and wayfinding to both existing and proposed strategic walking routes and to key destinations such as Harlesden, Park Royal and North Acton should also be provided. (Refer to case study opposite).

Grand Union Canal





Legible London Wayfinding

Atkins refined and implemented a pioneering pedestrian wayfinding system across the central London areas of South Bank and Bankside.

Legible London aims to deliver a consistent approach to walking wayfinding information throughout London.

The system was originally piloted in and around Bond Street and was then refined and extended to the popular tourist areas of South Bank and Bankside, specifically chosen as they offer complex wayfinding challenges, as well as being home to the UK's busiest transport interchange in Waterloo Station.

Cycling

The Mayor's Vision for Cycling and the London Cycling Design Standards, encourage a bold approach to making better, more attractive streets and spaces for pedestrians and cyclists. Higher levels of cycling can be achieved through the delivery of infrastructure that is safe, direct, comfortable, coherent, attractive and adaptable.

State of the art cycling infrastructure should be provided to benefit everyone who lives and works in the area. Adoption of best practice from the mini-Holland projects should be the norm, with connections to existing and proposed commuter routes such as the proposed East-West cycle superhighway and to Quietways.

The Park Royal Transport Strategy shows that the vast majority of employees live within 8km of Park Royal with a significant concentration within 5km or less. This distance is well within cycling distance subject to the appropriate infrastructure and safety measures being in place. It is important to realise a shift towards cycle usage for commuters through good design of cycle routes, connections to existing and proposed cycle networks and better cycle infrastructure.

A future extension of cycle hire into Old Oak and Park Royal would represent a logical expansion westwards. A network of docking stations could be designed across the new development areas from the outset.

Developments must be designed to encourage cycle ownership and use. To do this, schemes should consider the needs of cyclists in regard to:

- Parking facilities at destination
- Routes between destination
- Storage close to home

Cycle parking should cater for future demand, in line with the quantitative and qualitative requirements set out in the London Cycling Design Standards (2014), with provision in excess of London Plan minimum standards. This will include private cycle parking for residents and employees as well as generous provision for visitors and cycle parking hubs at public transport interchanges. These hubs can also offer a range of related facilities which may include cycle maintenance, secure long-stay parking and cycle hire.

There should be sufficient places to leave a cycle at shops, stations and community facilities. Streets must incorporate short stay parking at frequent intervals located close to building entrances and integrated into the overall public realm design.

Connections between home and destination should be as safe as possible. The better and more convenient these are the more likely they will be used by cyclists.

Facilities for cycle storage close to home can be made in a variety of ways, all stands must, however, be secure, sheltered and adequately lit, with convenient access to the street. Cycle storage identified in habitable rooms or on balconies will not be considered acceptable.

© Atkins

© Bikestation

© Cyclehoop

Use of cargo bikes for efficient and sustainable delivery


© Shutterstock

Delivering Healthy Streets

The concept of the 'Healthy Streets' approach is introduced in Chapter 8 of Improving the Health of Londoners: transport action plan (Transport for London, 2014).

The 'Healthy Streets' approach takes a public health perspective on the street environment. This approach has ten key ingredients of what makes a street 'work' for people in terms of improving health, enhancing liveability and nurturing community spirit.

Streets provide the opportunity for people to stay active, to interact with others and to access employment, education, leisure and green spaces. The health benefits delivered by streets extend beyond the physical activity that people get walking and cycling. If designed carefully streets can also help reduce noise pollution, help address air pollution, reduce road traffic injuries and become the back-bone of a neighbourhood.

It is recommended that a 'Healthy Street' survey, using the TfL methodology, is undertaken for Park Royal to identify opportunities to positively enhance the existing street network and a 'whole-street' approach is adopted for the design of the new street network in Old Oak.

Car Parking

A compact city form will result in reduced road infrastructure. This provides the space for a better public realm with more green space. This in turn can encourage more walking and cycling and better physical health. All of these benefits can lead to a better quality of life.

A neighbourhood served by a smart and reliable public transport network and attractive and safe walking and cycling routes will be an attraction for residents, workers and visitors. For most people it is often easier, more convenient and more pleasurable to make local trips on foot or by bicycle, rather than by other modes, and everyday amenities are provided locally to make this possible.

Managing car parking will play an important role in controlling the number of cars generated from the overall development and minimising the development's impact on the surrounding highway network.

Car parking provision should be based on the Draft Local Plan Preferred Policy Option T7 which seeks to promote a modal shift towards more sustainable modes by:

a. Old Oak:

i. Limiting car parking to 0.2 spaces per unit for residential developments;

ii. Promotion of car free development close to public transport hubs; and

iii. Securing zero car parking for non-residential developments, except for blue badge holders.

b. Park Royal:

i. Limiting car parking to 0.2 spaces per unit for residential developments; and

ii. Allowing limited car parking for non-residential development taking into account access to public transport and operational or business needs.

New Green Bridge

A second pedestrian and cycle crossing of the major rail corridor is required to connect the new communities in Old Oak North and South with Wormwood Scrubs. The only access currently planned is through the HS2/ Crossrail station and not everyone who wants to get to the park will want to go via the second busiest station in London.

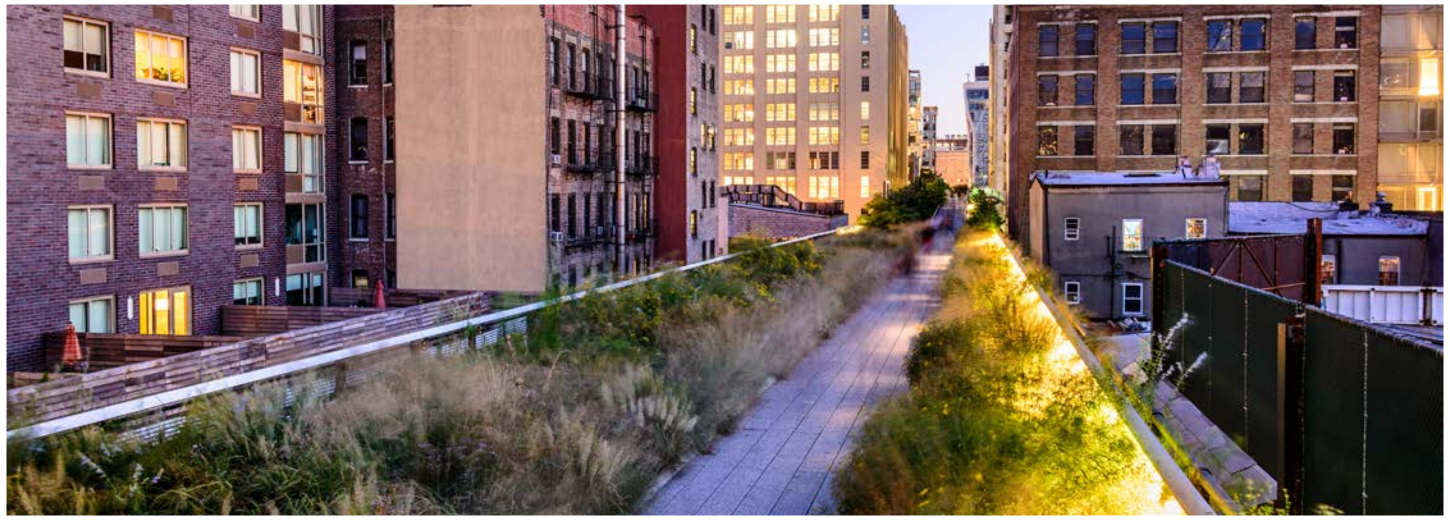
The new bridge could take the form of a green bridge similar to the bridge which spans the A11 at Mile End Park. An even more ambitious solution could be an elevated park similar to the High Line in New York.

The green bridge would have a number of benefits by providing safe and convenient access:

- To the 68 hectares of publicly accessible greenspace which will act as a Metropolitan/District Park for the new residents
- To the extensive sports pitches on the eastern side of Wormwood Scrubs and the running track and all-weather sports facilities at the Linford Christie Stadium, which is used by one of the UK's leading athletic clubs, the Thames Valley Harriers
- Directly south across Wormwood Scrubs to the Queen Charlotte's and Chelsea Hospital, Hammersmith Hospital, the Imperial College Faculty of Medicine and the Burlington Danes Academy.

By providing direct access to the sport facilities and green infrastructure, the new bridge will encourage active lifestyles. It will also act as a wildlife corridor connecting the habitats along the Grand Union Canal with those in Wormwood Scrubs.

The High Line, New York



Freight, Servicing and Deliveries

Park Royal

It is recognised that businesses in Park Royal will require vehicle movement by road, particularly for servicing and deliveries and this should continue to be supported but also carefully planned so as to mitigate potential negative impacts from increased traffic. There are opportunities to optimise the number of journeys on more sustainable modes in particular for employees travelling to work, which will in turn free up capacity for essential freight movements and deliveries.

Freight activity is a significant feature of the development area due to the needs of the Park Royal industrial estate, the proximity to Heathrow Airport and the strategic road network (A40 and A406) providing links to Central London.

The significant HGV activity in the development area has negative impacts on the environment in terms of noise and air quality and causes congestion, particularly on Scrubs Lane. The volume of freight and servicing movements also raises challenges in terms of maintenance and management of the road network and the safety and environment for other road users. Coordination of HGV activity across the development area will be important in order to mitigate those impacts. This will require the negotiation of Secure Delivery and Servicing Plans and the establishment of consolidation centres.

Bus Infrastructure

Bus stops should be situated near places of particular need such as local shops, health facilities, schools or sheltered housing. Precise locations will need to be determined by London Buses in consultation with highway authorities and the police. A distance of 400 metres/five minutes' walk should be used for assessing the proximity of bus stops.

Design considerations include:

- Providing adequate footway width to allow for waiting space as well as uninterrupted pedestrian flows
- Locating bus stops close to (on the exit side of) pedestrian crossings
- Where bus stops interchange with other modes they should be sited to minimise walking distance between stops
- Provision for seamless cycle interchange (including cycle parking, crossings and good signage of cycle routes for onward journeys)
- Incorporation of Legible London signage to improve wayfinding.

Smart Transport Solutions

The scale of development at Old Oak and Park Royal offers an opportunity to deliver transport improvements that are at the forefront of sustainability and innovation. Whilst advances in technology can have wide-ranging impacts, some major advances in transport are already happening very quickly including: smart information, intelligent mobility, zero emission and connected/ autonomous vehicles.

Intelligent Mobility

Intelligent Mobility (IM) should be anticipated and provided for in the design of the street network at Old Oak. IM has the potential to achieve the following:

- Change traveller behaviour (social media, real time apps)
- Dynamic and responsive scheduling (rather than fixed bus behaviour)
- Demand responsive delivery and movement (freight management/holding bays optimisation/last mile connectivity)
- Improved healthcare transport services.

© Shutterstock

Connected and Autonomous Vehicles

Connected and Autonomous Vehicles (CAVs) are no long a question of 'if' but rather of 'when'. There are significant economic and social benefits associated with their take up, including:

- Increased safety
- Reduced congestion
- Reduced emissions and real time monitoring
- Reducing social isolation
- Maximising the value of land by reducing the space required for road infrastructure
- Removing barriers to road crossings/ changing the landscape of the public realm
- Reuse of parking areas
- Management of school transport and drop off/pick up pressure points.

Application of Guidance

Chapter 6 illustrates the spatial application of the design guidance to the streets and the public realm in Old Oak and Park Royal.

© Venturer

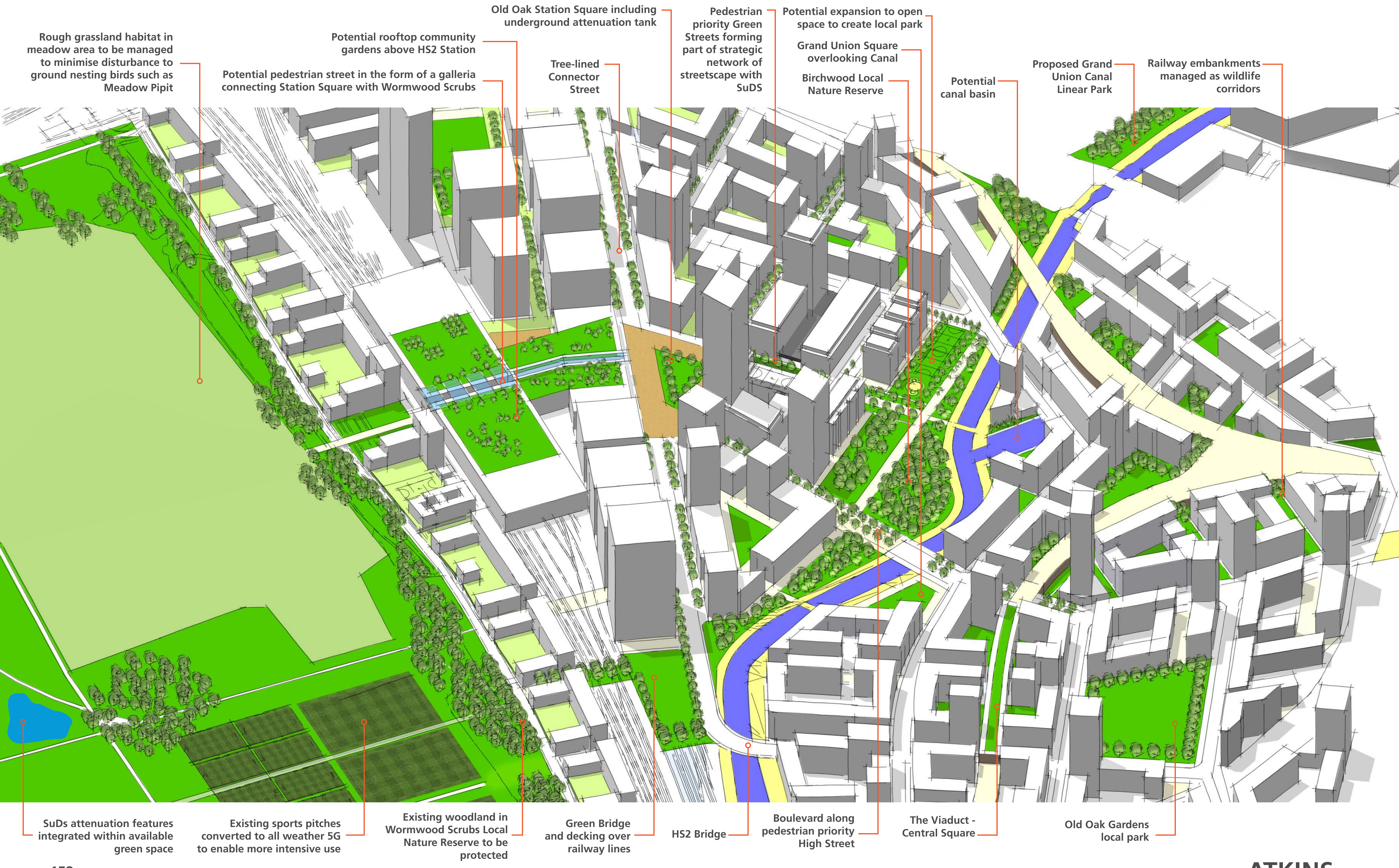
HafenCity, Hamburg, Germany

Currently one of Europe's largest inner-city development project, HafenCity is located in the heart of the maritime city of Hamburg, Germany's second largest city, on the northern flank of the River Elbe. The project transforms an underused industrial harbour into a walkable and bikeable mixed use 'knowledge-economy' area with new offices, community facilities, residential and leisure areas and a high number of public spaces.

HafenCity has hired a variety of developers and architects through public competitions, and deliberately mixes social and cultural institutions, commercial structures and residential buildings, and high and low-income housing to foster diversity and add to the excitement of urban life.

The development has its own HafenCity Ecolabel, which looks beyond energy performance and proposes a fine-grained mixture of uses, a high degree of walkability, excellent public transport (subway line and fuel-cell buses), district heating with 90% renewable energy and the reduction of individual car-ownership by station-based car sharing systems.

6. Application of Guidance


Rough grassland habitat in meadow area to be managed to minimise disturbance to ground nesting birds such as Meadow Pipit
Potential rooftop community gardens above HS2 Station
Potential pedestrian street in the form of a galleria connecting Station Square with Wormwood Scrubs
Old Oak Station Square including underground attenuation tank
Tree-lined Connector Street
Pedestrian priority Green Streets forming part of strategic network of streetscape with SuDS
Potential expansion to open space to create local park
Grand Union Square overlooking Canal
Birchwood Local Nature Reserve
Potential canal basin
Proposed Grand Union Canal Linear Park
Railway embankments managed as wildlife corridors
SuDs attenuation features integrated within available green space
Existing sports pitches converted to all weather 5G to enable more intensive use
Existing woodland in Wormwood Scrubs Local Nature Reserve to be protected
Green Bridge and decking over railway lines
HS2 Bridge
Boulevard along pedestrian priority High Street
The Viaduct - Central Square
Old Oak Gardens local park

6. Application of Guidance

Development of the OPDC area will promote climate responsive urban design to create high quality, attractive, open spaces and streetscapes as well as healthy, comfortable and energy efficient buildings.

The following pages show the spatial application of the environmental performance strategies and design guidance (provided in Chapters 4 and 5) to the streets and the public realm in Old Oak and Park Royal. This includes:

Green Infrastructure

- Biodiversity
- Urban Greening
- Children's Play
- Local Food Production

Microclimate

- Daylight, Sunlight and Overshadowing
- Wind / Natural Ventilation Design

Noise Mitigation

- Health
- Mixed Use Development
- Social Interaction

Sustainable Transport

- Walking
- Cycling
- Car Free Development
- Smart Transport Solution
- Intelligent Mobility
- Freight Servicing and Delivery

Overheating

- Mitigating the urban heat island (UHI) effect
- Measures to prevent overheating of outdoor areas
- Measures to prevent overheating of indoor spaces

Flood Risk

- Integrated Water Management Strategy (IWMS)
- Implementing SuDS Measures in Old Oak
- Retrofitting SuDS in Park Royal

London's Street Family

The hierarchy of street types is based on the Mayor's Roads Task Force (RTF) Street Family Matrix which categorises streets by their 'place' and 'movement' functions. The different street types take into account the 'whole-street' approach advocated in TfL's Healthy Streets guidance.

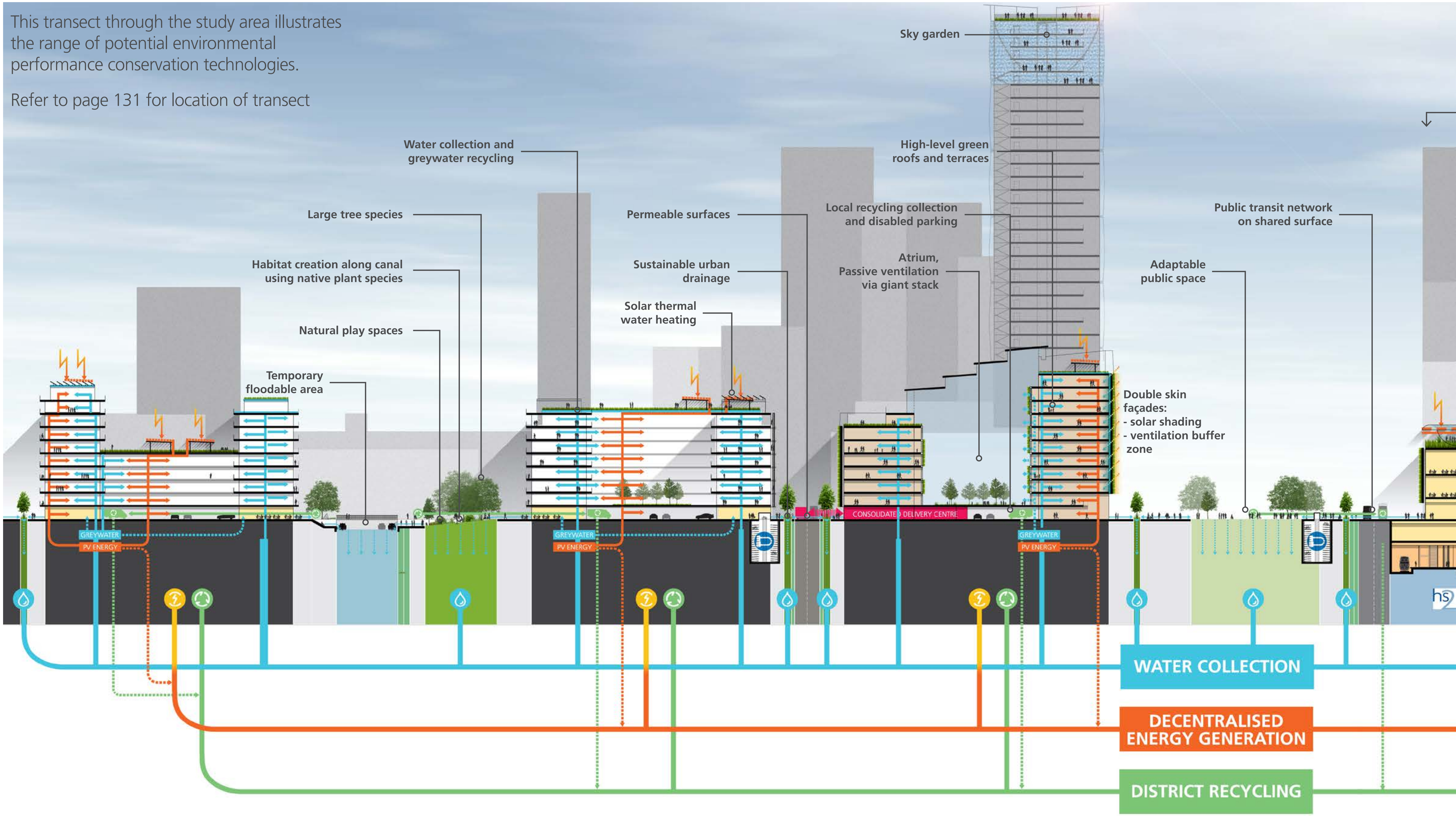
The recommendations also take into account Policy 7.18 of the London Plan in relation to the quality of the public realm and its influence on a range of health and social factors.

Plan showing street hierarchy

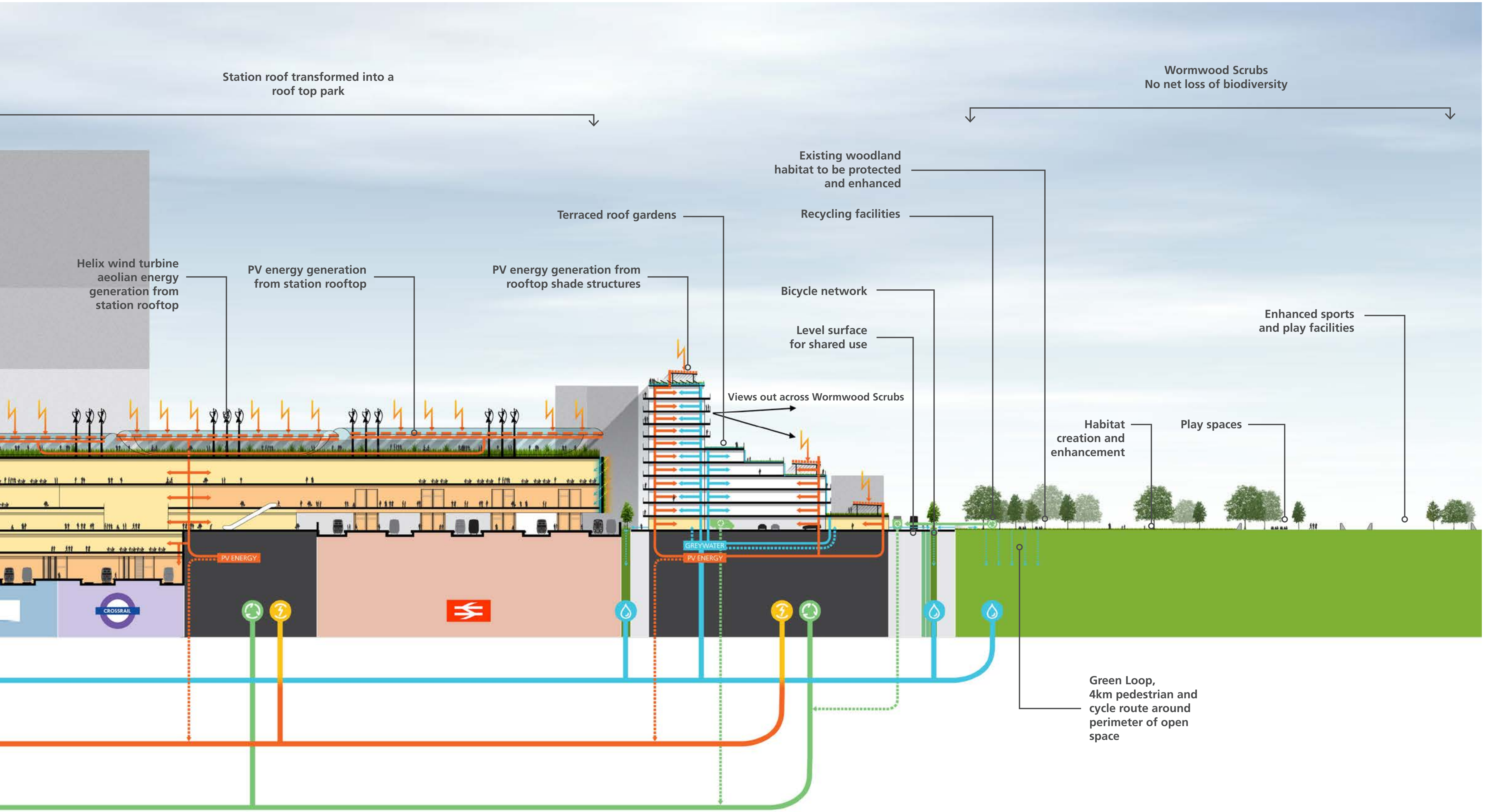
Study Area Transect Old Oak South

This transect through the study area illustrates the range of potential environmental performance conservation technologies.

Refer to page 131 for location of transect



ATKINS


Station roof transformed into a roof top park
Wormwood Scrubs
No net loss of biodiversity
Existing woodland habitat to be protected and enhanced
Terraced roof gardens
Recycling facilities
Helix wind turbine aeolian energy generation from station rooftop
PV energy generation from station rooftop
PV energy generation from rooftop shade structures
Bicycle network
Level surface for shared use
Enhanced sports and play facilities
Views out across Wormwood Scrubs
Habitat creation and enhancement
Play spaces
PV ENERGY
GREYWATER
PV ENERGY
CROSSRAIL
Green Loop, 4km pedestrian and cycle route around perimeter of open space

Main Station Square

Thousands of people will arrive at, or cross, Station Square every day and it will form the first impression and gateway to Old Oak. It will be the hub serving the HS2 and Crossrail stations and will have prominence in the hierarchy of new open spaces. Key pedestrian movements will be from people arriving by bus or taxi, entering and crossing between the station. Given the intense activity from people walking into the square, the space should be open and designed to allow unhindered pedestrian movement.

Capacity and Character

- Memorable, world class space / public art
- Designed for variety of activities, gathering, relaxing, outdoor eating
- Square bound by high density, high rise development
- Challenge of ensuring vehicle speeds are kept low
- Designed for high pedestrian flows

Microclimate and Urban Form

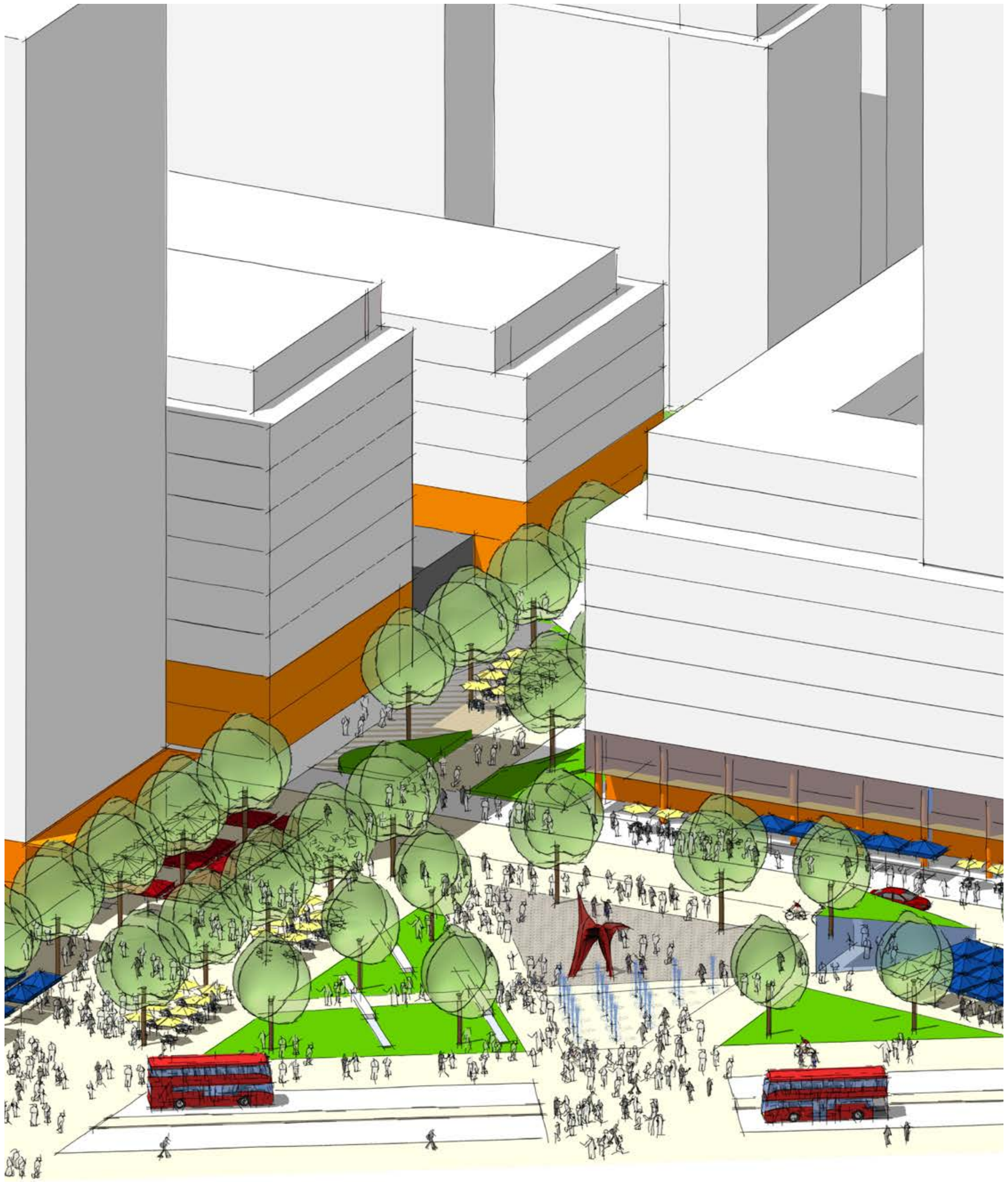
- High rise buildings to be placed on the northern side of the block to allow more daylight into the space
- Buildings fronting onto square should activate the public realm
- The square requires sufficient pavement space for external seating / cafe space
- The square should provide clear routes for main pedestrian movement

Sustainable Transport

- Minimum 4m wide footpaths
- Underground bike parking system
- Large raised table crossings to accommodate large pedestrian flows and desire lines
- Bus corridors to be clearly defined

Green Infrastructure

- Large canopy tree planting
- At least 30% of square to be green space/ soft landscape
- Uses and activities like: outdoor seating, cafe tables, children's play, floor fountains, public art and performance spaces to be located in areas with maximum daylight/sunlight
- Square used for temporary storm water storage and underground water storage.



The High Street

The most important street in the new development will be Old Oak High Street. The street will create a new link connecting Harlesden and Willesden Junction in the north, through Old Oak Park, to the HS2 Old Oak Common Station and Wormwood Scrubs in the south. The new High Street will range in width depending on location and topography and be lined with shops and cafes at ground level with offices and apartments above.

The green corridor will be designed primarily for pedestrians and cyclists with vehicles restricted to buses and emergency vehicles. The opportunity exists to create a linear green boulevard along the centre of the street. This would be framed by large canopy deciduous trees. The trees and high proportion of planted space will help mitigate the heat island effect and provide a more comfortable living and working environment.

The boulevard could contain outdoor seating, children's play and floor fountains, public art and performance spaces and cafe tables. This vibrant space will provide the social heart of Old Oak.

The Sonder Boulevard in Copenhagen (refer to case study in Chapter 5) provides a good example of the type of green street that can be achieved. It also contains innovative SuDS and stormwater drainage solutions.

Capacity and Character

- Linear green boulevard
- Wider street cross section bound by high density development. Overall right of way 25-40m

Microclimate and Urban Form

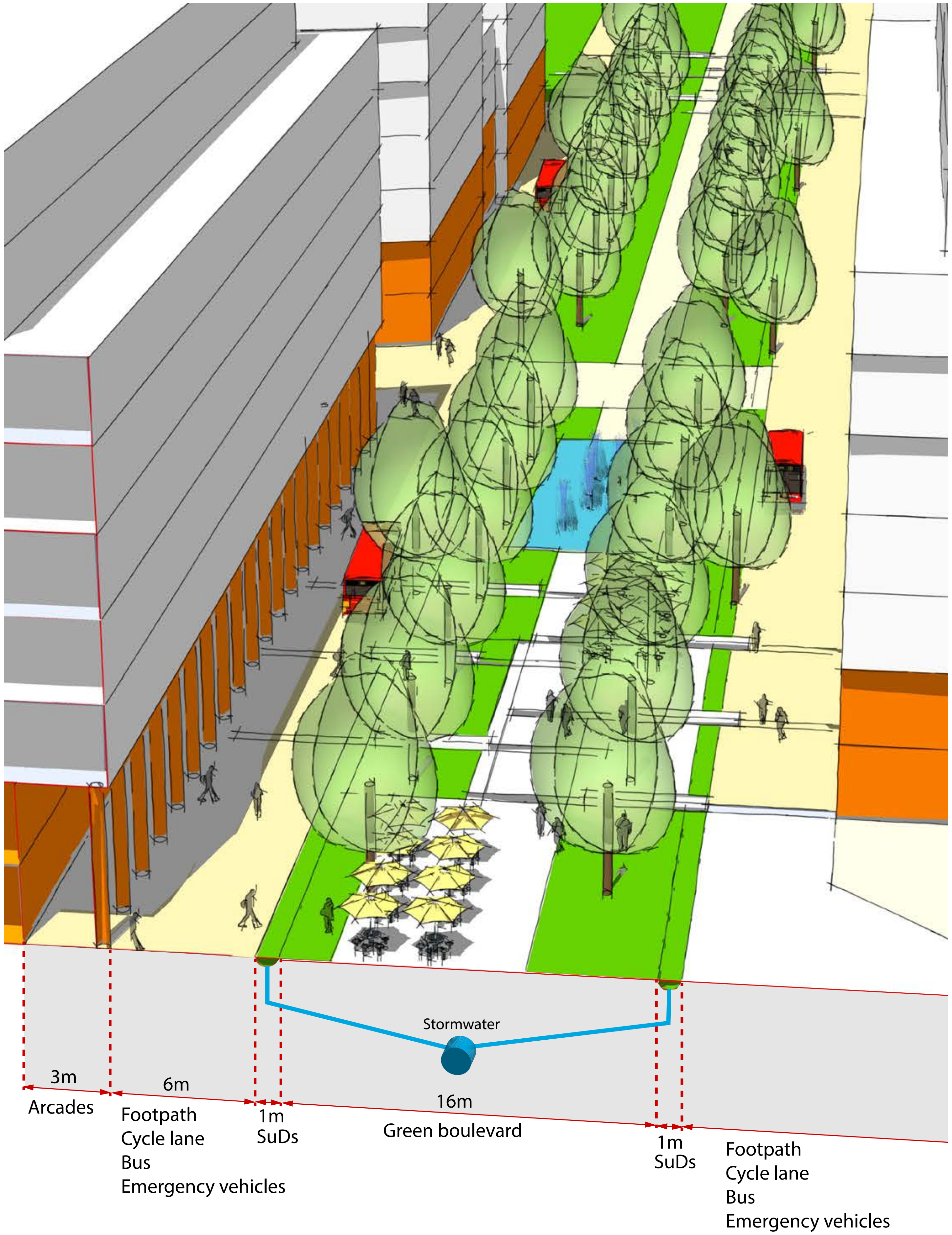
- Street section to ensure street is adequately sunlit throughout the year
- Street section ratio generally not exceeding width/height ratio of 1:1.5
- Taller buildings to be placed on the northern side of the block to allow more daylight into the space
- Regular seating opportunities to provide places for people to rest and experience the street.

Sustainable Transport

- Priority to be given to pedestrians and cyclists
- Integrating public transport infrastructure into a cohesive streetscape
- Shared surface carriageway restricted to buses and emergency vehicles only
- Wide pedestrian crossings surfaced in a contrasting coloured material, with median strips where appropriate to facilitate additional informal crossing

Green Infrastructure

- Large deciduous tree planting
- Outdoor seating, cafe tables, children's play, floor fountains, public art and performance spaces to be sited in areas of the street with maximum daylight and sunlight
- SuDS features such as bio-retention pits should be integrated into the design of the public realm.



Green Streets

The opportunity exists to create a Green Grid of pedestrian and cycling routes set within continuous green corridors providing safe and convenient access between residential areas and stations, schools and community facilities.

Capacity and Character

- Linear green corridor
- Wider street cross section bound by high density development
- Optimise width to ensure high levels of daylight and sunlight
- Sufficient footway space for external seating / cafe space that does not impinge on clearway widths
- Designed for high pedestrian flows
- Forms part of connected 'green grid' of pedestrian and cycle routes

Microclimate and Urban Form

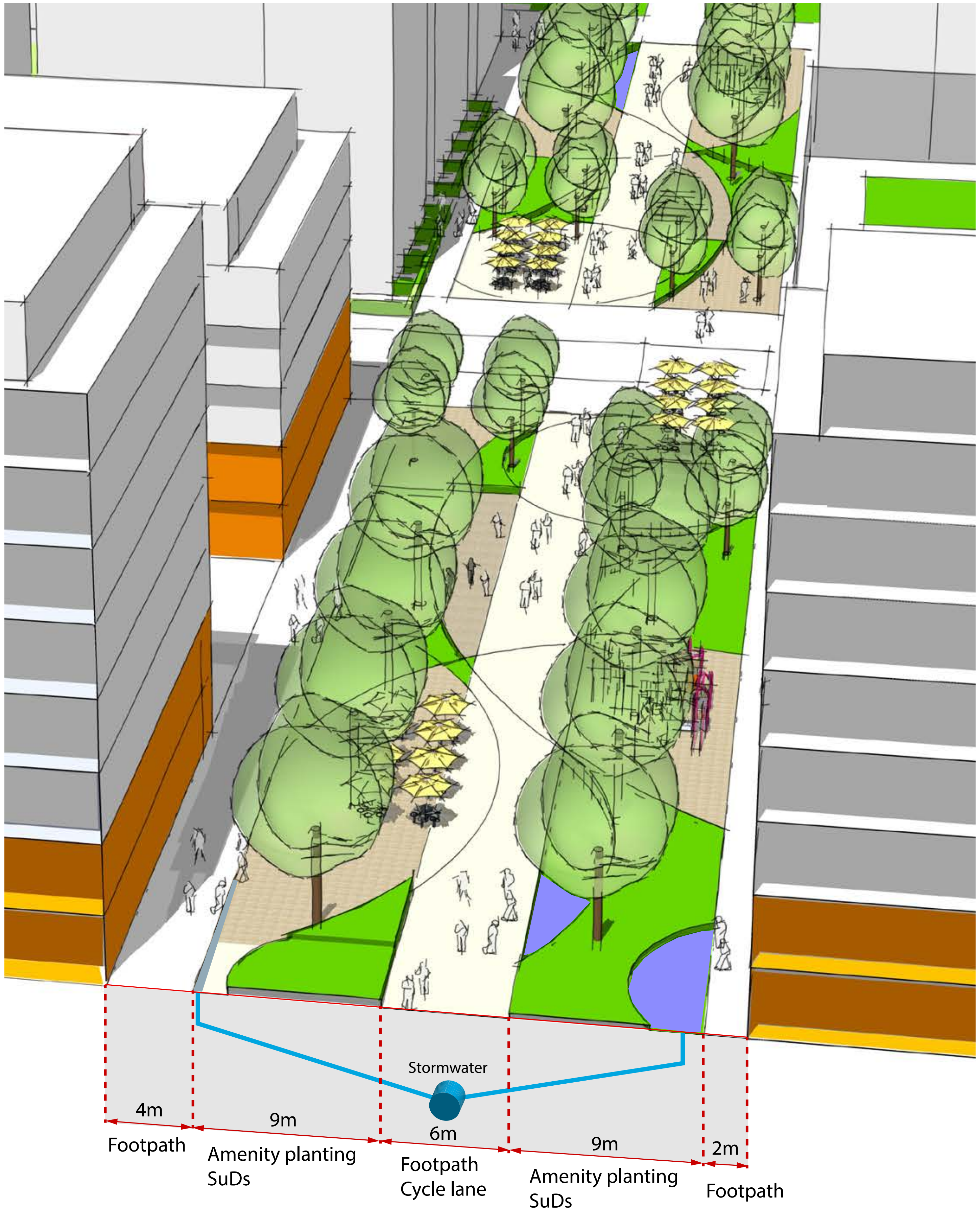
- Street section to ensure street is adequately sunlit throughout the year.
- Street section ratio generally not exceeding width/height ratio of 1:1
- Taller buildings to be placed on the northern side of the block to allow more daylight into the space
- Buildings fronting onto Green Streets should seek to activate the public realm, for example schools, local shops

Sustainable Transport

- Pedestrian and cyclist only, but with controlled access for emergency vehicles and refuse collection
- Clear definition of pedestrian priority, especially at junctions with adjoining streets where crossings should be surfaced to prioritise pedestrian and cycle movement
- Raised table crossings used to retain continuity of the green space

Green Infrastructure

- Large deciduous tree planting to form continuous green corridor
- Outdoor seating and children's play to be sited in areas of the street with maximum daylight and sunlight
- SuDS to drain away surface water to under drain system
- Rain gardens and bioswales form part of connected SuDS
- Minimum of 50% green space.



Connector Street

Connector Streets provide reliable corridors for vehicular movement while performing some important functions for local daily life. They support a range of uses including retail, residential, employment and civic functions by encouraging on-street activity while allowing for a relatively high movement function.

Capacity and Character

- Providing for all modes of traffic and key vehicular connectivity within Old Oak
- General through-traffic for private vehicles across Old Oak is likely to be restricted on these routes
- One lane of traffic in each direction with potential for bus stop and parking bay integration into landscape / footpath zones

Microclimate and Urban Form

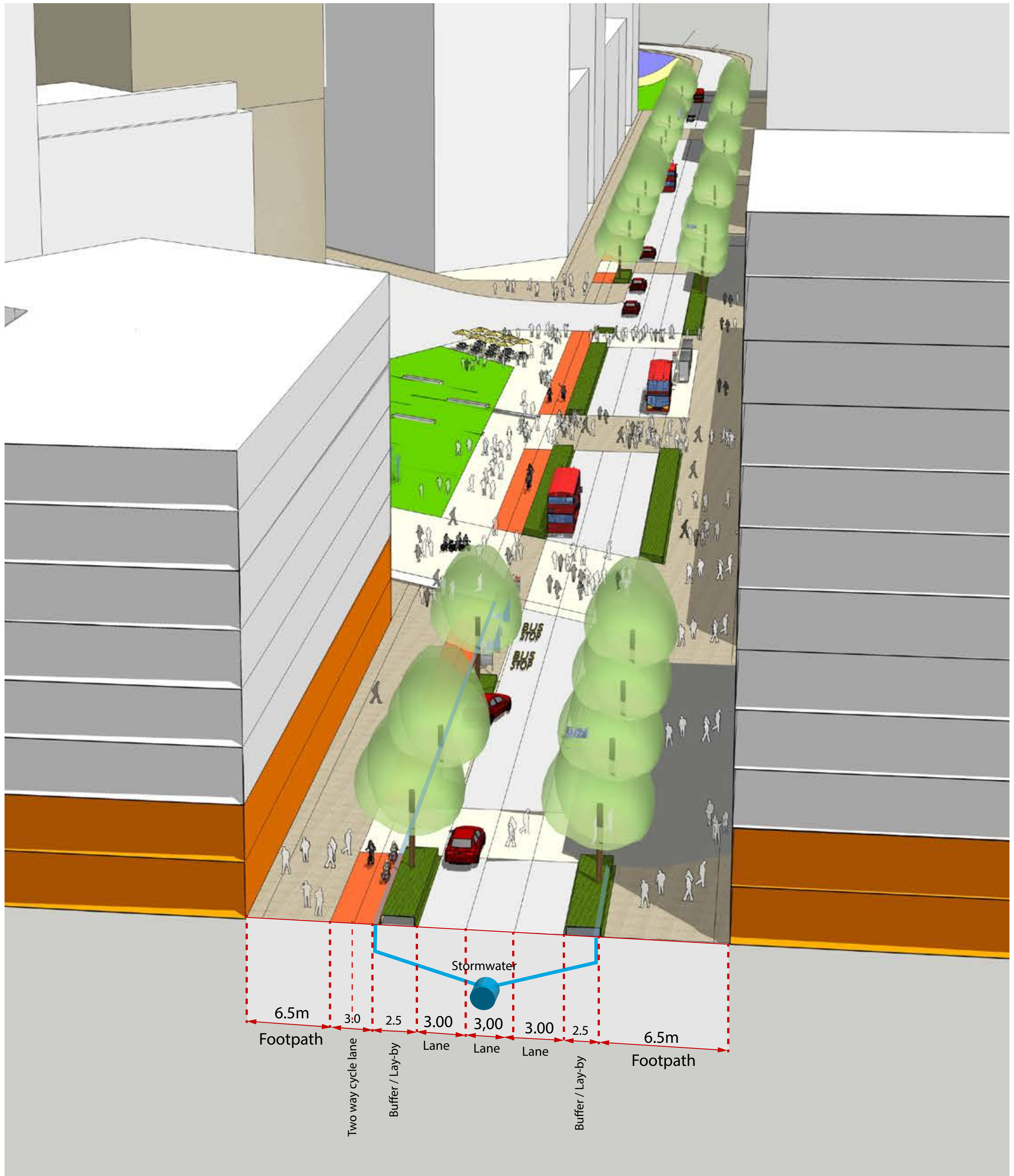
- Street section ratio generally not exceeding width/height ratio of 1:2
- Taller buildings to be placed on the northern side of the block to allow more daylight into the space
- The street requires sufficient footway space for external seating / cafe space that does not impinge on clearway widths. These areas should be located in areas with maximum daylight/sunlight

Sustainable Transport

- The street should provide generous walking route provision with wide footways and regular crossings
- Frequent and wide formal crossings to be provided on pedestrian desire lines
- Dedicated two-way cycle lane to provide safe route for cyclists with high quality cycle parking
- High-quality bus stops with large shelters and live service information
- On-street servicing to take place within controlled hours

Green Infrastructure

- Generous tree planting should be used to frame the street corridor, create a more human scale and provide shade and shelter for pedestrians
- SuDS in the form of rain gardens to drain away surface water to under drain systems
- Drainage channels at edge of carriageway.



Local Street

Local Streets in Old Oak should give priority to pedestrian and cycle movement with slow-moving vehicles predominantly accessing homes or local amenities. Local Streets provide a finer network of permeability.

Capacity and Character

- Local links within residential developments
- Traffic calming through change in surface treatment will improve the environment for pedestrians.
- Need to be carefully designed to control vehicle speeds and minimise rat-running
- Overall right of way generally 20-25m
- Buildings should front onto all streets and provide natural surveillance.

Microclimate and Urban Form

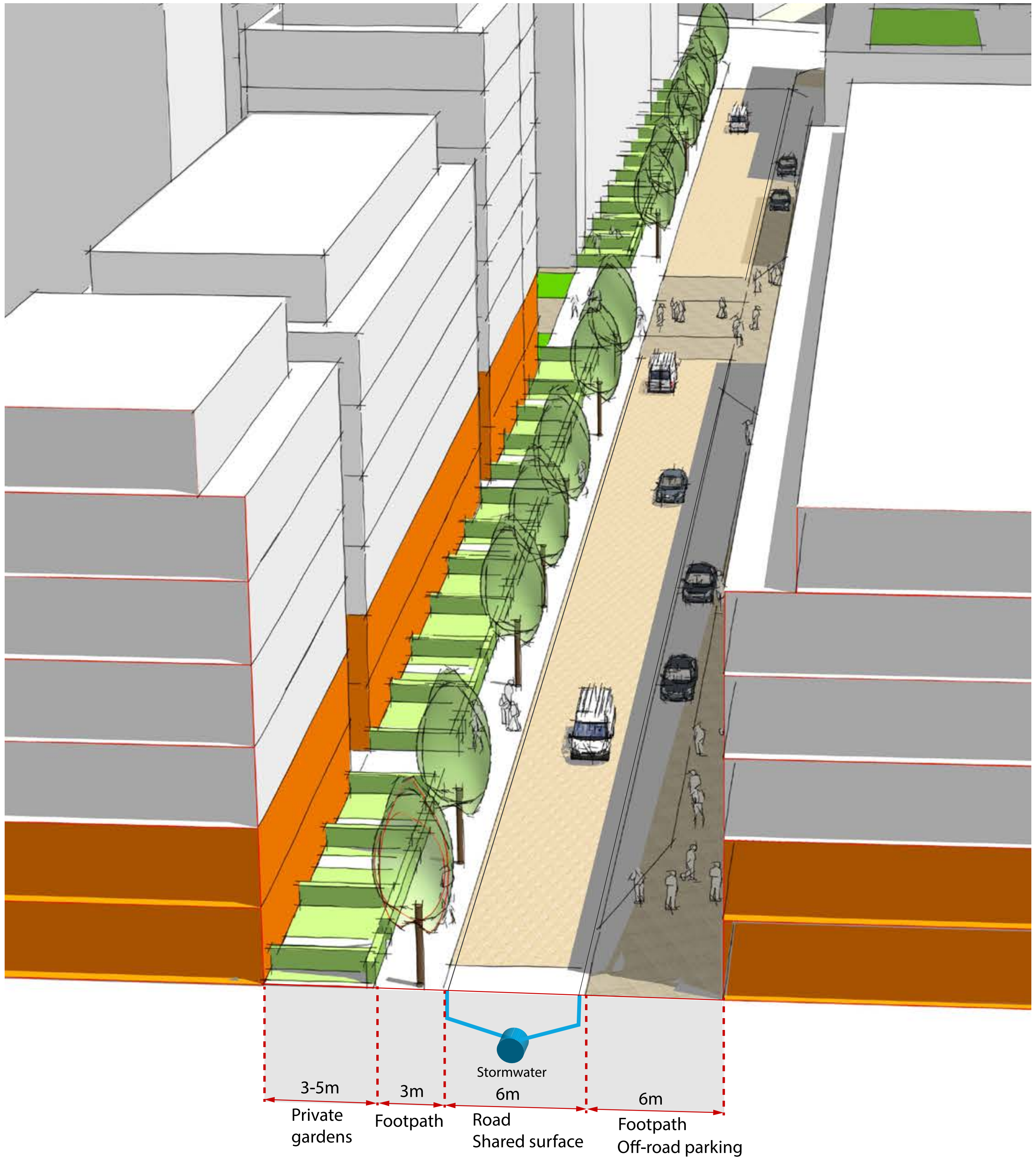
- Street section ratio generally not exceeding width/height ratio of 1:1.5
- Taller buildings to be placed on the northern side of the block to allow more daylight into the space

Sustainable Transport

- Designed for low vehicular and pedestrian flows
- Minimum 3m footpath on both sides of road
- Raised table crossings for pedestrians
- Traffic calming features, on-carriageway cycle lanes
- On-street parking for Blue Badge holders and Car Clubs
- 20mph speed limit

Green Infrastructure

- Smaller and/or fastigiate tree species
- SuDs provided by dished drainage channels at edge of carriageway.



North Acton

The London Borough of Ealing has led the regeneration of this area for the past ten years. Existing and planned developments include residential, significant amounts of student housing and retail uses which are expected to be joined by the development of employment uses and hotels either side of Portal Way. The UK headquarters of Carphone Warehouse, Park Royal's largest employer is close to the A40. A new public square is currently being delivered to the south of North Acton station. The existing and future population is likely to give rise to a need for approximately 5,000 sqm of gross A-class floorspace.

The following environmentally focussed development opportunities have been identified:

- **Rail Deck Park:** creation of a new local park by decking over the railway cutting. This will unite both sides of the new town centre and act as a catalyst for further regeneration. It will also play an important role in providing valuable publicly accessible greenspace
- **New Station:** the provision of a new station and public transport interchange combined with the rail deck park and partly funded by over-station development. North Acton station will be upgraded to increase its capacity and access arrangements
- **Perfume Factory:** regeneration of this important site and the sites to the east of Victoria Road either side of the railway would benefit from the extension of the proposed rail deck park to the east
- **Strategic Cycle Route:** the provision of an east-west route, partly following the rail corridors connecting the new HS2/ Crossrail station in Old Oak with North Acton Station and the enhanced Park Royal Centre
- **Enhancement of Existing Road Gyratory:** the design and layout of the existing road gyratory and public realm does not deliver a high quality walking and cycling movement network. The area is often blighted by heavy traffic due to its advantageous links to the A40. New and improved connections to Old Oak Common Station and the core development area will ensure that North Acton is integrated into the wider regeneration area. Major planting of large canopy street trees would significantly improve the environmental quality.

Rail Deck Park: creation of new local park by decking over the railway cutting

Grand Union Canal, Linear Park

The Grand Union Canal is one of the defining features of Old Oak and Park Royal and provides significant opportunities to shape the regeneration of Old Oak and Park Royal. Its role and function will change along its length, reflecting the diverse range of uses and activities from the mixed use character of Old Oak to the industrial character of Park Royal. The Canal forms part of London's Blue Ribbon Network (BRN) strategic network of waterspaces and is covered by the following policies in the London Plan:

- Policy 7.24 Blue Ribbon network
- Policy 7.25 Increasing the use of the Blue Ribbon network for passengers and tourism
- Policy 7.26 Increasing the use of the Blue Ribbon network for freight transport
- Policy 7.27 Blue Ribbon network: supporting infrastructure and recreational use
- Policy 7.28 Restoration of the Blue Ribbon network
- Policy 7.30 London's canals and other rivers and waterspaces

The Canal provides the only continual east - west walking and cycling route through the OPDC area and provides a direct connection to central London. It is designated as a cycle Quietway, a Site of Metropolitan Importance for Nature Conservation and a Conservation Area within Hammersmith and Fulham.

The opportunity exists to transform the canal corridor into a major linear park forming the main accessible greenspace for Old Oak North and the northern parts of Park Royal. This would involve providing an extended buffer of open space either side of the canal as it passes through Park Royal. This could be achieved by the rationalisation of underused areas of outdoor storage and parking and the purchase of low quality industrial units to provide accessible open space.

The Grand Union Canal will bisect Old Oak forming an important and integral part of the overall urban design. The proposals should aim to balance the existing enclosed and tranquil nature of the canal with the objective of improving its safety and accessibility.

- Proposals should meet biodiversity objectives and create access to nature opportunities. Habitat creation and management of spaces for the enjoyment of nature also creates opportunities for informal recreation, sustainable drainage and/or flood storage
- The towpath should be transformed as an access route for pedestrians and cyclists, and as place/destination in its own right
- Development sites will be required to improve existing walkways, and deliver new continuous walkways along the towpath, making it a safe and publicly accessible route together with an associated area of public green space to support recreation
- Development sites close to the canalside provide excellent opportunities for a range of canalside public open spaces. These spaces provide opportunities for social interaction, relaxation, event space and informal sports
- High quality, publicly accessible open space should be incorporated within new development adjoining the canal, integrating with the towpath and adjoining routes. Development adjacent to the canal should provide high quality active frontages
- Neighbouring development should carefully consider the approach to height, scale and massing to ensure tall buildings do not overshadow the canal corridor

Grand Union Canal as it passes through Old Oak

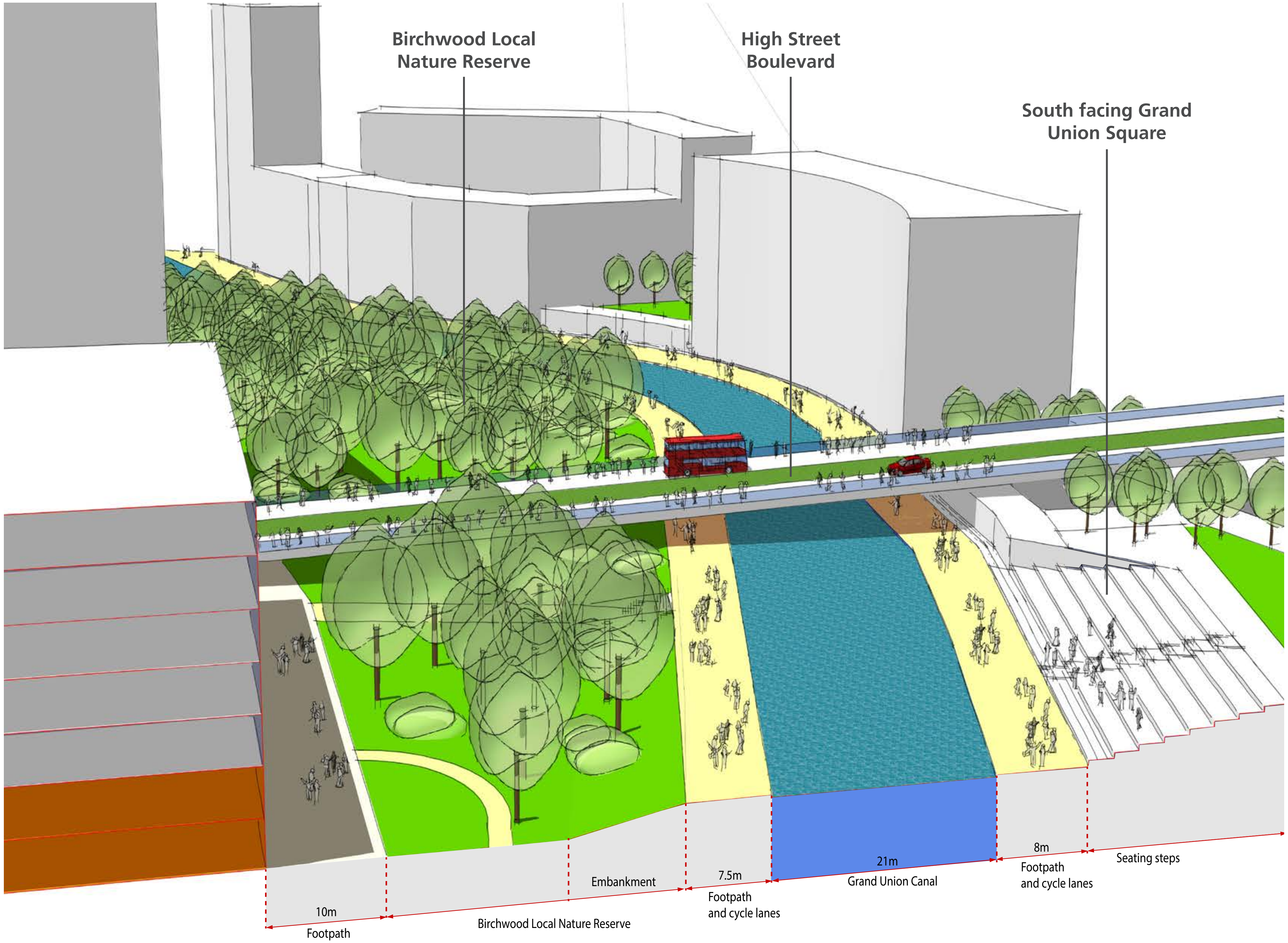
Granary Square, King's Cross

© John Sturrock

ATKINS

- To support access to the canal and north and south movement, development will need to coordinate the delivery of new routes and support the delivery of new bridge crossings. In delivering these elements engagement with stakeholders including the Canal and River Trust should be undertaken
- New development should be designed to incorporate Sustainable Drainage Systems following the SuDS hierarchy. They should not only seek to minimise the rate and volumes of surface water runoff, but also improve water quality, amenity benefits and improved biodiversity.

The High Street Boulevard would cross the canal by a new bridge. This will allow pedestrians, buses and taxis into the Grand Union Square and afford views out over the Grand Union Canal. Tiered seating and steps could cascade from Grand Union Square to the canal, enhancing the south facing aspect and reinforcing the historic relationship with the canal. This approach has been successfully adopted at Granary Square in King's Cross Central.



View of the Grand Union Canal corridor with the south facing Grand Union Square

Decking Over Railway Lines

The opportunity exists to resolve the key issue of a lack of publicly accessible open space by decking over the railway lines that separate Old Oak and Wormwood Scrubs and providing new public open space on top. This radical approach has already been adopted in four city centre projects in North America and Canada.

As well as providing much needed green infrastructure a rail deck park would resolve the issues of severance and connectivity between Old Oak Park and Wormwood Scrubs and mitigate the visual and acoustic impact of the major rail corridor.

Decking over the railway lines separating Old Oak Park and Wormwood Scrubs would create an additional 7.5 ha of accessible green space.

Millennium Park, Chicago: this 10ha park was constructed above a commuter railway station and the Illinois Central Railroad tracks. It is considered the world's largest rooftop garden. The park has proved a major visitor attraction and the communities surrounding the park have become some of the most fashionable residential addresses in Chicago.

Toronto Rail Deck Park: announced in August 2016, the proposed 8.5ha park will be built on a constructed deck over active railway lines owned by the Canadian National Railway, Toronto Terminals Railway and Metrolinx. Development of the park would require the City of Toronto to purchase the air rights.

Decking over the railway lines separating Old Oak Park and Wormwood Scrubs would create an additional 7.5 ha of accessible green space

Millennium Park, Chicago, the world's largest rooftop garden

Arundel Square:

The original Arundel Square was never completed. After three sides were finished the Victorian developer ran out of money and the North London Line was constructed in a cutting on the south side of the central gardens.

In a radical approach the railway has been decked over, creating an extra acre of land. Half of this land has been added to Arundel Square Gardens.

The North London line is a medium traffic line but noise and vibration had to be addressed through design and materials. A steel and concrete deck sits on concrete structures, rubber pads insulate the deck and successfully absorb the vibration. No further insulation was required to attenuate noise and vibration.

The integration of this new concrete deck extension over the railway line with the existing 19th century public square, has created an additional 43% of new public space. This new landscape is planted with a drought tolerant mix of trees shrubs and herbaceous perennials: sustained by a low tech light weight drainage system which retains and redistributes surface water into planted areas.

Limited parking is provided at basement level and each ground floor apartment has its own garden.

© Tim Crocker - Arundel Square by Pollard Thomas Edwards

Park Royal Environmental Quality Improvements

- **On Street Parking:** On-street parking currently dominates the streetscape of Park Royal. An overall parking strategy is required to reduce the impact of on-street cars on already narrow and congested streets
- **Greening of Distributor Roads:** Mature tree planting should be provided along primary routes. Where possible existing planting should be extended to create continuous green chains through the area. Planting will help to frame the street corridor and create a more pleasant pedestrian environment. This can be integrated with public realm, SuDS, walking and cycling improvements combined with rationalisation of on-street parking, servicing and deliveries. Roads include: Coronation Road, Park Royal Road, Chase Road, Acton Lane and Abbey Road.
- **Retrofit of SuDS:** The retrofit of SuDS within highways with a focus on their flood risk benefits; de-paving of large under-utilised outdoor storage areas; where feasible, installation of 'living' green roofs to increase attenuation storage capacity
- **Grand Union Canal:** Opening up views and public access to the canal, widening of green corridor with major tree planting programme using native species creating new wildlife habitats, interpretation of canal heritage, improved walking and cycling infrastructure. Encourage the use of the canal for transport and freight movement
- **Strategic walking/cycling routes:** Creation of a network of shared paths segregated from vehicular traffic set within greenways connecting to stations and major public facilities. Where cycling is accommodated on carriageway, on-street parking should be designed carefully and kept to a minimum to avoid potential safety issues of car doors opening into the cycleway
- **Open Spaces:** Provision of pocket parks to provide accessible greenspace within the dense urban fabric. Parks to be connected to strategic walking and cycling routes. Residential enclaves to be better connected by safe and inviting routes to allow existing and future residents in these areas to access the range of new services available in Old Oak
- **Biodiversity:** Enhance existing biodiversity assets along railway corridors, within the First Central Site, the Grand Union Canal, existing public open spaces and at the junction of Abbey Road and Premier Park Road
- **Access to Public Transport:** Provision of improved bus infrastructure including access to stops, passenger information and waiting facilities. Linked with public realm enhancements at stations
- **Centralised Delivery:** Centralised delivery points for goods which could be distributed by electric vehicle, on foot or by cycle should be provided to minimise servicing requirements in already congested streets
- **Solar Energy and White Roofs:** Major programme of installation of solar, thermal and photovoltaic panels on the large area of roofs, particularly warehousing. This could be combined with reflective paints to significantly reduce roof temperatures and the energy requirements of buildings.
- **Servicing:** Commercial units should be serviced from the rear where possible to reduce interactions between large vehicles, pedestrians and cyclists.
- **Mixed-Use Intensification:** A range of opportunities exist in selected locations outside of this Strategic Industrial Land for mixed-use intensification where there is good public transport accessibility. These selected locations include a series of 'gateway' sites identified in the Park Royal OAPF comprising the Eastern Gateway at Willesden Junction, the Southern Gateway around North Acton station, the Western gateway around the Diageo First Central site and the Northern Gateway centred around the Northfields industrial estate. The opportunity also exists to intensify the Park Royal Centre and introduce residential close to the existing retail and the Central Middlesex Hospital.

© greenroofers.co.uk

ATKINS

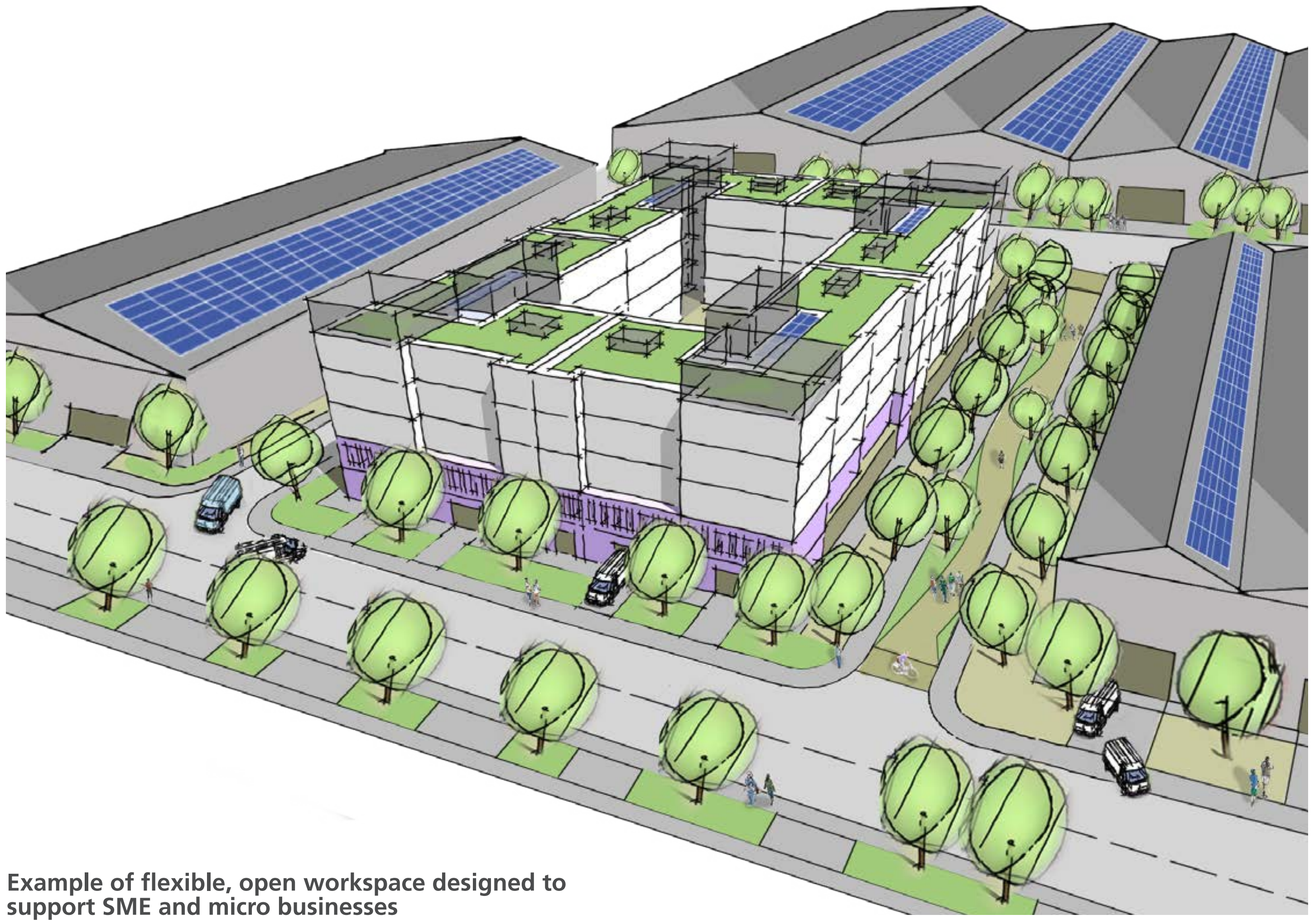
Park Royal Centre

Park Royal Centre sits at the heart of Park Royal and is surrounded by the Strategic Industrial Land designation. The southern portion is currently designated as a neighbourhood centre by the London Borough of Ealing. The area includes the ASDA 24-hour supermarket and the Central Middlesex Hospital.

Park Royal Centre will be enhanced to provide a range of local services and amenities to support the wider Park Royal area, including shops, hotels and other business services. There is likely to be a need for an additional gross 5,000 sqm of A-class floor space in Park Royal Centre. These proposals will require intensification and an increase in building heights.

The following opportunities for implementing an environmentally focussed development have been identified:

- **Mixed Use Centre:** Creation of mixed use high density street blocks combining convenience, retail, restaurants and cafés, providing an active frontage to Park Royal Road with micro, small and medium employment uses extending back along Minerva Road and Standard Road. Affordable housing in the form of co-living, car-free apartments set above retail and employment uses. This will require an increase in building heights fronting Park Royal Road
- **New Civic Square:** Through the realignment of the junction and/or the redevelopment of ASDA there is the potential to deliver a new publicly accessible open space which could include a variety of functions such as children's play area, events space and/or outdoor market
- **Public Transport and Public Realm Enhancement:** Improved passenger information and waiting facilities at bus stops provided as part of major public realm street enhancement with pedestrian priority measures. The public realm will be improved and benefit from new public open spaces alongside active street frontages
- **Cycling:** Improved cycle parking facilities and connections to nearby stations (North Acton, Harlesden) by segregated cycle routes set within green corridors
- **Solar Energy:** Installation of photovoltaic panels on the 0.65 ha roof of ASDA and other major buildings
- **Recycling:** New district recycling centre
- **Centralised Delivery:** Provision of centralised delivery point for goods which can be distributed by electric vehicle, on foot or cycle to minimise servicing requirements in the heavily congested narrow streets to the east of Park Royal Road. This area is the densest in Park Royal.
- **Open Workspaces:** There is a growing demand for flexible, affordable 'open workspaces' designed to support SME and micro businesses which will help to bring more people to the centre and drive the demand for additional business services. Alongside these non-traditional types of workspace, there will be an opportunity for the centre to deliver shared business support facilities such as meeting spaces, conference facilities and business orientated eating and drinking uses.



Example of flexible, open workspace designed to support SME and micro businesses

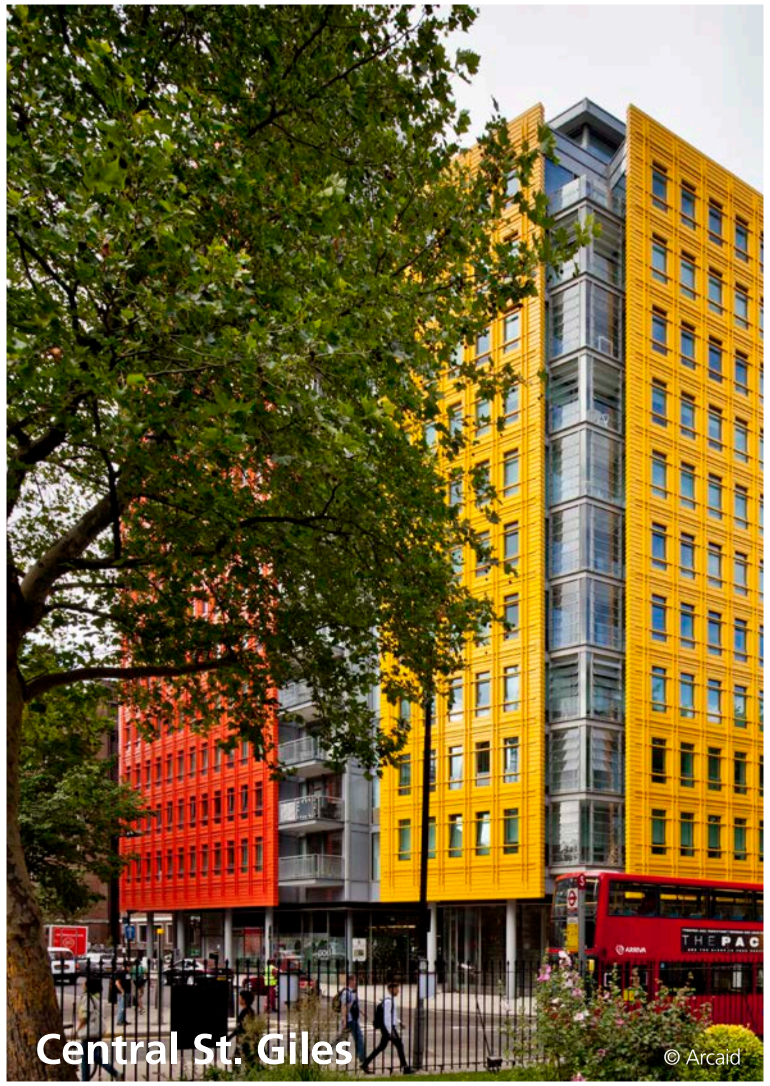
Woodberry Down

East Village

Wood Wharf

Bermondsey Spa

Regent's Place



Central St. Giles

7. Case Study Analysis

King's Cross Central

Successful high density mixed use development on 27ha site up to 19 storeys. Best connected part of London. Argent overall developer. Majority of land used for HS1 construction until 2007. Redevelopment of land between the two major stations. 10 new public spaces including Granary Square. Regeneration of Regent's Canal Corridor, Camley Street Natural Park. Includes BREEAM excellent buildings and site-wide district heating network.

7. Case Study Analysis

London Case Studies

A review of comparable high density residential and mixed use schemes in London has been carried out in order to identify examples of best practice and to see how ambitious environmental targets have been achieved and delivered in the capital. 24 projects were reviewed; from this long list 12 projects have been selected for more detailed analysis. The projects range in density from 230-600 dwellings per hectare. Appendix A contains the full case studies for the twelve selected London projects which are listed below:

Woodberry Down, Hackney

Elephant Park, Southwark

Hale Village, Tottenham

East Village
(Former London 2012 Athletes Village)

King's Cross Central, Camden

Bermondsey Spa, Southwark

St Andrew's, Phase 3, Bromley-by-Bow

The Library Building, Clapham High Street

Regent's Place, Euston Road, Camden

Arundel Square, Islington

Central St Giles, Camden

Wood Wharf, Tower Hamlets
(Canary Wharf's new phase)

Short UK Case Studies

Additional short UK case studies have been provided in the text earlier in the document to illustrate particular elements of best practice:

Green Bridge, Mile End Park, London

Future Proofing London

7 More London Riverside

King's Cross, Camley Street Natural Park

Greenwich Peninsula

Legible London Wayfinding

Kidbrooke Village, London

Royal Parks Management and Operational Plans

Vauxhall, Nine Elms, Battersea Opportunity Area

London 2012 Olympics: Queen Elizabeth Park

London 2012 Olympics Ground Remediation

London Borough of Camden Open Space Standards

One Angel Square, Manchester

Birmingham New Street Station, Green Wall

One Brighton

International Case Studies

Short international case studies, mainly from Northern Europe, have been provided in earlier sections to demonstrate best practice:

European Case Studies

Hammarby Sjöstad, Stockholm, Sweden

Stockholm Royal Seaport, Sweden

Bo01 Western Harbour, Malmö, Sweden

The Barcode, Oslo, Norway

Copenhagen Climate Adaptation Plan, Copenhagen, Denmark

Sonder Boulevard, Copenhagen, Denmark

HafenCity, Hamburg, Germany

Vauban, Freiburg, Germany

Rotterdam Climate Proof Strategy, Rotterdam, Netherlands

Bulksloterham, Netherlands

Flanders, Belgium

22@ Barcelona, Spain

The Stavros Niarchos Foundation Cultural Centre, Athens, Greece

North American and Canada Case Studies

A Stronger, More Resilient New York City

Hudson Yard, New York

South Waterfront, Eco District, Portland, USA

Dockside Green, Victoria, British Columbia, Canada

Australia and Asia

Barangaroo, Sydney, Australia

Singapore 'Biophilic City'

London Case Studies

Woodberry Down, London

Client: *Berkeley Homes*
Architect: *Masterplan: Fletcher Priest Architects with Townshend Landscape Architects; Architecture: Fletcher Priest Architects, Rolfe Judd, Hawkins Brown and others.*
Year: *Masterplan framework 2005, original masterplan 2009, revised masterplan 2014*
Site area (ha): *24*
Number of homes: *5,500*
Site density (dph): *229*
Best practice:

- *Electric car charging points, a car club, limited parking spaces and a high level of bicycle storage encourage sustainable transport.*
- *Occupants provided with 'Home Users' Guide' – encouraging them to use energy efficiently.*
- *Use of 'natural systems' maximised, including climatic systems, such as solar heat and air flow, and ecological systems, consisting of flora and fauna.*
- *Employs natural space heating/shading throughout – blocking summer sun but allowing winter sun to penetrate.*
- *Contribution towards the creation of a new, accessible wetland nature reserve in adjoining former reservoirs.*

© Shutterstock

Elephant Park, London

Client: *Lendlease*
Architect: *Duggan Morris Architects, Allford Hall Monaghan Morris, Panter Hudspith Architects, dRMM*
Year: *Began in 2012*
Site area (ha): *10.85*
Number of homes: *2,704*
Site density (dph): *249*
Typical block density (dph): *568*
Typical block density (hr/ha): *1,494*
Best practice:

- *Doubling density with zero growth in emissions*
- *Combined Heat and Power system (CHP) which will connect to 1000 neighbouring homes.*
- *Using grid-injected bio-methane as a carbon-offset.*
- *Using 100% controlled, responsibly-sourced FSC timber for all homes and VOC-free materials.*
- *Post-2016 will deliver zero-carbon homes and work towards Climate Positive development status*
- *Elephant Park: 0.9 ha new public park providing the green spine for the development.*

© Atkins

Hale Village, Tottenham

Client: *Bellway and Lee Valley Estates*
Architect: *BDP, KSS, RMA*
Year: *Works commenced 2008*
Site area (ha): *4.8*
Number of homes: *1,200*
Site density (dph): *252 (gross)*
Typical block density (dph): *330*
Typical block density (hr/ha): *910*
Best practice:

- *Heating and hot water demands will be met by the ESCo's district and heating and hot water system from the three sources of CHP, biomass and gas-fired boilers.*
- *Heat recovery from CHP – reduces carbon emissions by 20%*
- *Recycled aggregates used in construction of basement, retaining walls and concrete frame.*
- *Use of sustainable drainage systems (SuDS).*
- *Green roofing for rainwater attenuation for supplying WC's and site irrigation.*
- *New Perkyn Park won in July 2016 the prestigious Green Flag Award.*

© Atkins

East Village, London

Client: *ODA*
Architect: *16 different architects alongside Fletcher Priest Architects who produced the masterplan and VOGT landscape architects.*
Year: *Wider masterplan 2005; Zonal masterplans 2007 onwards*
Site area (ha): *21.56*
Number of homes: *2,818*
Site density (dph): *256 (based on 2012 devt)*
Typical block density (dph): *max allowed 866 (zone 3)*
Typical block density (hr/ha): *max allowed 2,684 (zone 3)*
Best practice:

- *District heating and cooling for all residential units.*
- *Water sensitive design and flood control measures, using a mosaic of habitats.*
- *Transformed highly contaminated brownfield site, cleaning and reusing 90% spoil.*
- *Good use of private open space provision through balconies and winter gardens.*

© Mike Odwyer & VOGT

ATKINS

King's Cross Central, London

Client: *King's Cross Central Limited Partnership*

Architects: *Masterplan by Allies & Morrison and Porphyrios Associates. Numerous designers involved; see full case study in Appendix A.*

Year: *Began 2007*

Site area (ha): *27*

Number of homes: *1,900*

Typical block density (dph): *290*

Typical block density (hr/ha): *649*

Best practice:

- *Ground source heat pumps and district level combined heating and power system (CHP).*
- *43% affordable housing, including the UK'S most urban student housing.*
- *Regent's Canal bisects and forms an integral part of the development. Enhanced public access balanced with protection of natural and cultural heritage.*
- *Camley Street Natural Park: retained and protected natural green space.*

© John Sturrock

Bermondsey Spa

Client: *Hyde Housing Association*

Architect: Levitt Bernstein

Year: *Ongoing*

Site area (ha): *2.03*

Number of homes: *644*

Site density (dph): *317*

Typical block density (dph): *297-407*

Typical block density (hr/ha): *900-1100*

Best practice:

- *Each block built around a central landscaped courtyard, perforated with openings to accommodate larger tree species.*
- *Winner of 2010 Housebuilder Awards – Best Regeneration Project, 2010 Evening Standard New Homes Award – Best Regeneration Project, and 2010 London Planning Awards – Best New Place To Live, among others.*
- *Car Club Membership for three years and secure bicycle parks encourage sustainable transport. 0.3 parking ratio.*
- *Maximises dual aspect residential units and natural ventilation.*

© Levitt Bernstein/Tim Crocker

St Andrew's, Bromley-by-Bow, London

Client: *Barratt Homes*

Architect: *Allies & Morrison (Masterplan, block A), MacCreanor Lavington (Block B) and Glenn Howells (Block C)*

Year: *Completed 2011*

Site area (ha): *3*

Number of homes: *964*

Site density (dph): *320 (990hr/ha) (gross)*

Typical block density (dph): *480*

Best practice:

- *Residential led redevelopment of former hospital site providing 50% affordable housing.*
- *2010 Building for Life Award and 2011 Housing Design Awards – Graham Pye Award.*
- *30% total site area is landscaped open space, each residence has own private open space.*
- *20% of energy is met by biomass generated onsite.*
- *Green roofs employed regularly throughout the development, with bat and swift boxes integrated into the brickwork.*
- *Extensive use made of brick because of it's long term durability and cost effectiveness.*

© Jimmy Wu Photography

The Library Building, Clapham High Street, London

Client: *Cathedral Group (U+I) and United House*

Architect: *Studio Egret West and DLA Architecture*

Year: *Completed January 2012*

Site area (ha): *0.4*

Number of homes: *136*

Typical block density (dph): *340*

Typical block density (hr/ha): *860*

Best practice:

- *Example of a mixed use ground floor project, with apartments situated above. Library, café and Primary Care Trust located below, becoming a hub of community.*
- *2010 Housing Design Award – Project Winner.*
- *Free branded hybrid bicycle for every apartment – encourages sustainable transport.*
- *Two year membership to City Car Club, promoting car sharing and limiting CO2 emissions.*
- *Served from an 'Energy Centre' which takes advantage of various uses' differing energy profiles to conserve energy.*

© Arcaid

London Case Studies

Regent's Place, London

Client: *British Land*

Architect: *Terry Farrell; Stephen Marshall Architects / Tate Hindle Architects, Wilkinson Eyre, Carmody Groarke.*

Year: *2009*

Site area (ha): *5.3*

Number of homes: *151*

Typical block density (dph): *427*

Typical block density (hr/ha): *1,137*

Best practice:

- *Vibrant mixed use campus.*
- *Up to 26% lower CO_2 emissions than current Building Regulations.*
- *Electronic energy monitoring.*
- *Largest 'insect hotel' (including beehives) in London on green roofs to promote biodiversity.*
- *Dedicated onsite team Regents Plaza hosts array of events and is enhanced by art installations.*
- *Successful management of intensively used square and spaces.*
- *150m² of rooftop photovoltaic cells.*

Arundel Square, Islington

Client: *United House Developments and London Newcastle*

Architect: *Pollard Thomas Edwards*

Year: *Completed 2010*

Site area (ha): *0.33*

Number of homes: *146*

Site density (dph): *442 (1,166 hr/ha approx).*

Best practice:

- *Decked over railway line to enable development, reduces noise pollution from trains for local residents and park users and created an additional 43% of new public space.*
- *Winner of 2011 Housing Design Award, BALI Principle Award for Restoration and Regeneration 2011, and 2004 Housing Design Project Award, among others.*
- *Levels and underground drainage put in place to hold, circulate, and redistribute rainfall. Runoff from deck redistributed around existing park site by series of subsurface swales.*
- *Membership to resident Car Club scheme encourages sustainable transport.*

Central St Giles, London

Client: *Legal & General with Mitsubishi Estate Corporation Stanhope PLC*

Architect: *Renzo Piano Building Workshop with Fletcher Priest Architects*

Year: *Completed 2010*

Site area (ha): *6.6*

Number of homes: *109*

Typical block density (dph): *537*

Typical block density (hr/ha): *1,450*

Best practice:

- *80% of heating in both residential and business blocks provided by a biomass boiler run on sustainably sourced wood pellets.*
- *Energy performance 20% better than Part L expects, accomplished through façade design, efficient plant design and collection/reuse of 60% of rainwater for offices.*
- *Air recycled for use in plant and basement areas to save energy and filtration.*
- *Green roofs lessen 'heat island' effect, decrease rainfall to reduce storm impact and increase biodiversity and insulation.*

Wood Wharf, London

Client: *CWG (Wood Wharf Two) Limited*

Architects: *Allies and Morrison, Darling Associates, KPF, Herzog & de Meuron, Stanton Williams Architects, Grid Architects, and Patel Taylor*

Year: *Began 2015, estimated completion 2026*

Site area (ha): *8.75*

Number of homes: *3,610*

Estimated site density (dph): *Approx. 600*

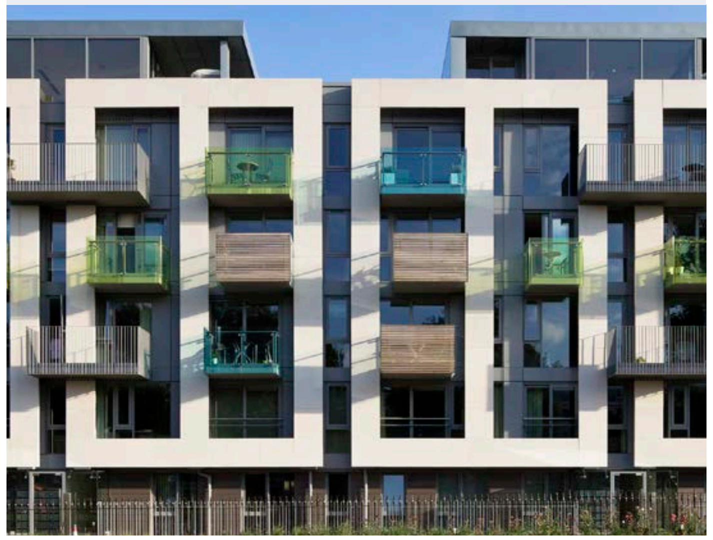
Typical block density (dph): *436*

Typical block density (hr/ha): *1,796*

Best practice:

- *Low toxicity materials, paints and finishes used for interiors.*
- *Re-use materials from existing buildings when demolished.*
- *Insulation will have a Global Warming Potential of less than 5.*
- *Natural and mixed mode ventilation.*
- *3.6 hectare of interconnected spaces covering 40% of the total site*

© Atkins



© Tim Crocker - Arundel Square by Pollard Thomas Edwards

© Legal & General Property

Photographs copyright © canarywharf

ATKINS

London Case Studies – Environmental Performance Summary

Environmental Topic	London Case Studies											
	Density (Dwellings per hectare)											
	229	249	252	256	290	317	320	340	427	442	537	600
	Woodberry Down	Elephant Park	Hale Village	East Village	King's Cross Central	Bermondsey Spa	St Andrews	The Library Building	Regent's Place	Arundel Square	Central St Giles	Wood Wharf
Energy		✳	✳	✳	✳		✳	✳	✳		✳	
Waste				✳	✳				✳			
Materials		✳	✳	✳	✳	✳				✳	✳	✳
Carbon emissions	✳	✳	✳	✳	✳			✳	✳			
Water	✳	✳	✳	✳			✳				✳	✳
Air quality	✳							✳		✳		
Green infrastructure	✳	✳	✳	✳	✳		✳		✳	✳	✳	

Lessons Learnt

Introduction

In choosing the case studies to showcase, we have taken into account both built and unbuilt exemplar schemes from London, Europe and North America which highlight key aspects of environmental performance and quality. The case studies encompass a broad range of building and development types and forms, and also a number of different land use typologies and mixes.

The process of compiling the list has revealed how complicated it is to build at density and achieve high environmental standards. Some schemes will manage to exceed certain criteria or targets, but often at the expense of other criteria. The following pages look at some of these challenges in detail, and set out the particular techniques and achievements of the case studies we have chosen to include in this report.

Calculating Density

Before looking at the challenges of environmental performance in high density schemes in more detail, it is first worth looking at the complexities around measuring density in the first place. Our case studies include schemes at a range of scales, from individual buildings such as the Library Building in Clapham, to large scale regeneration such as King's Cross Central which at 27ha is the largest scheme we have included. However, calculating the density of these developments has not been straightforward. Few publish details of their density, and while it is often possible to calculate by measuring the site area and using more readily published information on the number of units, this does not always give a comparable picture.

This is the case across the board, with those case studies which cover large areas, such as Woodberry Down or King's Cross, always producing a much lower figure than the individual buildings – as the figures are effectively gross vs net area calculations. However, sometimes this difference does not tell the full story. From reviewing the schemes it is clear that the relationship between the buildings and their immediate environment varies considerably – in terms of ownership, management and function. Striking a balance is key to maximising environmental performance, especially where spaces are needing to perform multiple functions.

For example, the Case Studies have also shown how generating energy on a building-by-building basis becomes more complicated once other competing uses for the limited roof space are considered. In the highest density schemes, roofs are a valuable open space asset, and using them for solar panels is a waste of space when a district heating / energy network may be a better solution.

Green Infrastructure

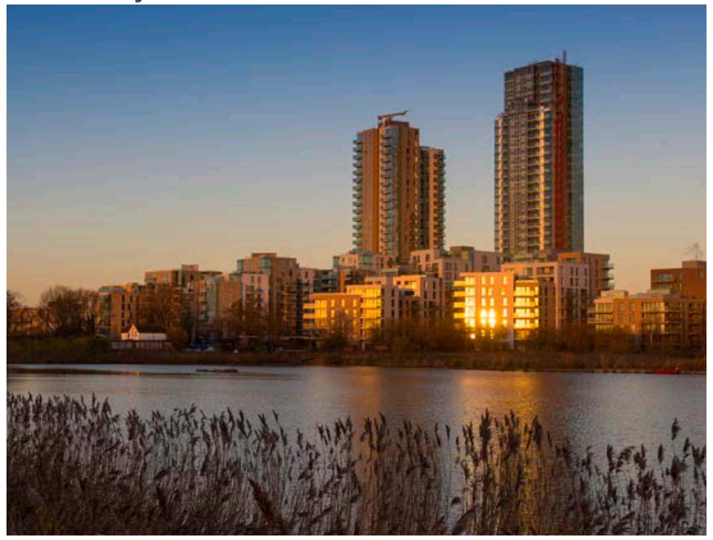
A number of the larger scheme case studies – such as East Village, Elephant Park and Woodberry Down – have shown that investment in Green Infrastructure and Habitat Creation can deliver multiple benefits. They provide a positive contribution to meeting national and local biodiversity objectives, they are an opportunity to manage water onsite and they are also useful in the publicity and marketability of the site. They promote a positive public image of the site and enhance the living and working environment for future occupiers. They can also have a long term benefit in reducing maintenance costs, which is an important consideration in schemes like King's Cross and East Village where the developer is retaining the long term maintenance and management responsibilities for the scheme.

At Woodberry Down they have provided an opportunity to partner with the London Wildlife Trust to develop the Woodberry Wetlands on the adjacent reservoir site, and

Wood Wharf

Photographs copyright © canarywharf

Woodberry Down



© Berkeley

Hale Village

© Atkins

King's Cross Central

© John Sturrock

the design of the housing facing the water has been developed to maximise the links to the water and encourage interaction between the wetland spaces and residents.

Much like at East Village, the ability to borrow adjacent wetlands as both a visual and physical enhancement has been fully exploited at Woodberry Down, and follows in the great British tradition of the 'borrowed landscape' exploited so well historically by the likes of Repton. The same occurs with Hale Village, which borrows near and distant views over the rivers and reservoirs of the Lea Valley, and even Arundel Square, which by decking over the railway and providing an extension to the existing public square, has made the greenspace more integral to the development.

On the smaller scale, many of the schemes have incorporated biodiverse roofs, and where possible terraces that can be publicly accessible. This not only applies to the residential schemes such as Hale Village, but also the mixed use ones like Regent's Place and Central St Giles, where rooftop terraces have been provided for the benefit of office occupiers as well as residents.

As part of the analysis of public open space requirement (Chapter 5), we assessed 6 of the London Case Studies, in terms of the amount of public open space (including civic spaces) as a percentage of the overall site area and the amount of public open space per person. It wasn't always easy to identify the quantum provided onsite for public open space (as defined by the London Plan Public Open Space categorisation) as it was often hidden within figures which included private or semi-private amenity space and active streets.

It was acknowledged that a high level of onsite provision was not always achievable where there is considerable policy impetus to deliver mixed use development. Increased private and communal open space and financial contributions towards enhancing the quality of adjacent open spaces were sought to compensate for lack of onsite provision. In addition all schemes included networks of green and active streets to supplement the provision of parks.

Carbon Emissions

Understanding the carbon emissions of the case study schemes has been the hardest of all the environmental criteria, as so few publish any information about it specifically. Many refer to reduction over 'standard' or specific targets, but none specifically quantify what that means in real terms. Most actually relate to energy (covered in more detail in the next section) in terms of both needing less energy and generating it from renewable sources. Some also refer to embodied carbon in construction materials, while Elephant Park actually start to look beyond the immediate development, citing the investment in the local public transport networks as a commitment to reducing carbon emissions.

Central St Giles

Regent's Place

St Andrew's, Bromley-by-Bow

King's Cross Energy Centre

What does come across from the case studies is that while a lot can be done in terms of carbon in materials, construction and through operational energy use, significant impacts can also be gained through the ability to reduce transport emissions – either by providing car share / electric car points, or by following the Clapham Library Building example of giving people bicycles!

More generally looking at the type and mix of jobs being delivered at Old Oak and Park Royal and seeing how that can be matched to the mix and tenure of housing will provide an opportunity to really impact on carbon emissions. Through the provision of enhanced cycling and walking links in and around the development areas, people can gain easy, carbon free access to employment, reducing the need for carbon intensive transport into Central London and long commutes.

Energy

The approach to energy across all case studies is to use the most efficient equipment and fixtures available, from the macro scale of cooling plant and equipment to the micro scale of LED lightbulbs. However, there are then clear differences in approach to energy. The smaller developments tend to focus on building-scale renewables, such as rooftop wind turbines or solar cells, while the larger schemes move toward district-level CHP from dedicated energy centres. These energy centres can either be 'celebrated' as buildings in their own right, such as at East Village, or they can be integrated and wrapped in development, such as at King's Cross Central.

The ability to step-up to a CHP system means that rooftop space is freed up to house other uses, such as semi-private open space. Some of the schemes also make use of the differing load profiles of the mixed uses to make the CHP even more efficient – for example at The Library Building in Clapham where the differing requirements of the library, health centre and residential elements increase the efficiency of the CHP further.

The international examples show how commercial buildings, which traditionally have high energy usage (and wastage) can achieve higher standards through the use of LED lighting, heat recovery coupled with geo-thermal heating and cooling and particularly with smart customisation of offices, allowing people to light and cool their own zones as they choose – The PWC building at Barcode in Oslo has over 600 different such 'zones'– and provides movement sensors for lighting.

The key lesson is that it is important to consider the location and mix of uses from an early stage in the design so that these efficiencies can be identified and captured.

Waste

All of the schemes we have looked at proudly boast of their waste reduction efforts during construction, covering all aspects from recycling demolition materials and re-use of soil through to high % recycled materials in construction, and minimisation of construction waste. It is clear that going forward an increased use of offsite construction can improve on this even further, and we would anticipate the development at Old Oak becoming an exemplar in this regard. However, it is far more complicated to ascertain what measures are in place for waste in operation. A couple of the schemes – such as Hale Village – talk about the provision of recycling and separation facilities in each unit, but ultimately most of the schemes transfer the management of waste onto the local authority, and ultimately residents.

Clapham Library

© Arcaid

King's Cross Central

© John Sturrock

Barcode, Oslo

© Shutterstock

Hammarby, Stockholm, Bio-gas Generation

© Atkins

ATKINS

What is clear is that much of the opportunity around operational waste is actually down to education and getting people to buy-in to waste sorting as much as providing them with the capability to do so with mixed recycling facilities in units. While King's Cross Central is starting to use waste monitoring data – part of the 'smart' city idea, none of the UK schemes offered opportunities for larger scale onsite waste recycling such as food waste to bio-gas generation, which is something that they have at Hammarby Sjöstad, and this is something which should be explored further as a way of making Old Oak stand out as being a level beyond what is happening elsewhere in London.

Materials

As anticipated, the focus on materials tended to be around themes such as recycled content, certification (eg FSC for Timber) and also the use of high specification / performance criteria, especially on glazing and cladding.

Setting specific standards for Old Oak will be based upon current standards and deciding how to secure those as a minimum, but also without impacting the ability for the scheme to provide a diverse and high quality environment – if the material performance specification is too inflexible then there will be a limited palette of material available and that could have negative impacts on design quality and variability, which are essential factors in delivering quality places.

From reviewing the available material it is clear that focus is placed on those aspects which help to sell the scheme – which tends to be focussed on 'green' issues – recycled content, energy efficiency – and health issues such as low VOCs and non-toxic materials.

Water

Similar to Energy, all the case studies demonstrate a basic level of water efficiency in terms of installing low-use fixtures and fittings, and most also have a basic level of SuDs as a minimum. Some of the schemes also start to move towards rainwater / greywater recycling and re-use, either in irrigation or in toilet flushing. This seems to be seen as a bigger investment, and anecdotally can place challenges on the occupiers who ultimately need to understand the dual-plumbing required, and find tradespeople that also understand when things go wrong. As a result of this limited education being in place, it is often the schemes where repairs are provided as part of service charges that have found it easier to adopt these systems that involve bringing the water back into the residential units.

Going forward, the re-use of greywater and dual plumbing should be seen as the norm, and Old Oak will need to address some of the challenges as it should be embedding these higher standards at the outset. The ability to then minimise run-off through the use of biodiverse roofs followed by swales, rain gardens and other green infrastructure, as demonstrated in East Village, should be easier and able to deal with the balance of the water requirements.

We know that climate change will make higher intensity rain events more frequent, and the ability to manage rain water will be vital to prevent flooding, but then harvesting it will enable us to manage the challenges around lack of freshwater and the high energy costs associated with moving water or desalination as a last resort.

Hammarby, Stockholm, Vacuum Waste Collection

© Envac

Bermondsey Spa

© Levitt Bernstein/Tim Crocker

East Village

© OPDC

Air Quality

As both an environmental and health issue, Air Quality is something which is seen as a hot topic, particularly in London. The schemes all state that they encourage non-motorised transport over motorised means as a way to improve air quality, and many also offer car club memberships / electric car charging as a further step towards this commitment.

None of the schemes talk specifically about internal air quality, although some do touch on ventilation requirements and issues, and this is something which can be a challenge when designing at higher densities.

The desire to maximise natural ventilation of units can be at odds with other targets to reduce energy use. There is also a challenge around the use of electric cars being good for reducing emissions and improving air quality at the point of use, but having negative impacts elsewhere when energy is generated by fossil fuel burning.

None of the schemes look at using onsite energy generation as a way of providing zero-carbon energy for electric vehicles. The role of green infrastructure in helping to improve local air quality was also highlighted in very few of the schemes. This is likely to be something which may need to be explored for Old Oak, but then the overall approach to personal transport based on existing modes and models may be challenged on the time horizons anticipated.

Conclusions

This review of case studies has shown that there are very distinctive ‘trends’ which can be seen operating at the different densities and scale of scheme. The largest schemes (by area) provide the best opportunities to improve environmental performance, as systems such as district energy and integrated sustainable transport become viable. However, they have also shown that at the highest densities, the relative environmental performance may begin to drop off, with the most dense buildings potentially requiring more energy to heat, cool and light them, and greater embodied carbon per unit of floor space, and that there is a level at which schemes can be seen as reaching ‘optimal sustainability’ both in terms of environmental and social factors.

Fortunately, this optimal density seems to correlate to the type of urban forms that also create the most socially sustainable places, with the greatest sense of place and an environment which encourages health and wellbeing. Density ultimately becomes the driver for the environmental approach taken – high density perimeter block models will achieve 300-450dph, then to increase that further taller elements are required – perhaps on the corners – to take that up towards the 600dph level.

At this point pressure on open space grows, and the roofs / podium spaces can become more valuable as open space than as surfaces for energy generation, heat rejection equipment or biodiversity mitigation, so developments then tend to move to a district level energy systems, with a dedicated energy centre, and it becomes more essential to have a varied mix of uses to help balance the load demands on the energy networks. In turn, this mix of uses promotes street life and helps to support small businesses by driving demand over a greater time horizon. It also helps promote co-location of housing and employment uses and associated active local travel.

Once densities start to go even higher, the building form changes to be more individual towers, potentially with some mixed use podium levels, but these typically require more mechanised systems – not just to operate high-rise lifts, but to deal with heating, cooling and ventilation. The pressures on space at ground level grow more intense, as greater levels of servicing are required to support the buildings, and more space is required for transport and leisure.

Typically all these cannot be catered for at ground level, so roof gardens and intermediate servicing floors have to be introduced. There is also less frequent entrances, and it is more difficult to activate ground floors. Some of the case studies have shown how this can be accomplished, but this is typically through mixing uses and building types.

Overall, the case studies direct the future development of Old Oak towards a certain type of higher density mixed use scheme which seeks to deliver at that optimum level, in order to balance all of the environmental criteria, support health and wellbeing, and create the quality of place that is aspired to.

8. Conclusions

Hammarby Sjöstad, Stockholm

Environmental sustainability has been built into the development on a district level through the installation of the innovative 'Hammarby Model', an efficient 'closed loop' system for water, energy and waste streams. The system was the product of rigorous masterplanning that has helped the area meet its stringent environmental targets of reducing water and energy usage by 50% of the typical 1990 level usage in Sweden. The district uses the ENVAC waste system, which collects separated waste centrally via an underground pipe network. Solid waste is then recycled and used for agriculture and forestry, biogas is produced for cooking, whilst heat produced from incineration is used to heat homes. The development has emphasised reduced car usage through improving sustainable transport links to the city and has restored natural ecosystems, such as the waterways in and around the development.

8. Conclusions

Scale and Ambition of the Project

It is OPDC's aspiration to deliver a new part of London that is an exemplar in environmental sustainability, and realise the wider investment potential from the HS2 and Crossrail transport infrastructure projects. Atkins was tasked with the development of a set of aspirational and deliverable environmental sustainability targets that will enable all future development across the Old Oak Common and Park Royal sites to be exemplar in construction and operation.

The OPDC area has a complex planning policy background being subject to the adopted and emerging planning policy of three constituent London Boroughs. OPDC is now developing a new Local Plan for the area. Old Oak Common is one of the most important Opportunity Areas in London and arguably is the biggest and most complex regeneration site in Europe. The purpose of the study was rooted in the need to develop robust, defendable planning policy for the ODPC area to take forward the ambitious development envisioned.

The study outcomes are being used to evidence OPDC's emerging Local Plan. They will guide future development, and will set the environmental sustainability performance context for the subsequent preparation of an OPDC area-wide strategy for the integrated delivery and management of utilities and other infrastructure that will follow.

London Plan targets provide examples of good practice but some are a challenge to achieve and a number are not up to date. There have also been recent advances in thinking in the area of social and natural capital. The project is being brought forward by a functional body of the GLA. As such it is expected to adopt and where possible exceed the London Plan policies and set a benchmark for best practice.

The integration of green infrastructure approaches with urban planning and design, and the role of rapidly emerging smart technologies, have also been critical areas of focus. Developing robust indicators that stand the test of time is challenging as regulations, technologies and trends change. Aspirational targets need to be dynamic so they can be responsive over time to key trends and, where possible, monetised so they can remain on balance sheets.

The scale and ambition of the project means that flexibility and adaptability have been key considerations in developing targets and supporting evidence. Longevity of targets has demanded a judicious blending of blue sky thinking with practical viability and 'buildability' analysis.

Project Challenges

The study has required integration and synthesis of inputs from of a wide range of specialists and experts across many disciplines. Efficiently and effectively extracting clarity from complexity has been a challenge. The study has attempted to avoid 'silo' thinking and foster collaborative, creative, 'outside the box' approaches to problem solving and analysis, whilst managing different opinions.

One of the key challenges throughout this project has been the need to take on board other related studies which are taking place in parallel. Where studies have been delayed or not yet started we have had to undertake some initial analyses to be able to progress and meet the timeframes for the Draft Local Plan. One example is the recommendation for the quantum of accessible open space, we have undertaken some robust but high level analysis which will need to be tested by a full open space strategy and the masterplanning exercise.

We have also undertaken extensive energy modelling. An energy model was generated for Old Oak and Park Royal developments based on a mixture of industry accepted energy benchmarks and measured data. This helped us to evaluate the overall energy demand and supply balance of the two developments under different energy performance scenarios, in addition to supporting the carbon analysis.

A separate water study to define the level of SuDS required onsite is on-going at the time of completing this report, this will update the Water section in Chapter 4 and the Flood Risk section in Chapter 5 of the main report.

Another challenge has been the breadth of topics which could be covered under an environmental target setting study. The study has grown from setting targets for environmental topics to developing targets and guidance on sustainability and design issues which are all interrelated and interdependent.

Future studies will take forward the high level, site-wide analyses to inform more detailed targets and guidance for the site and different areas within the site.

The Vision

We have proposed an environmental Vision which looks beyond the environmental impacts of developments and considers the need to address wellbeing:

> "To be a flagship zero carbon, resource efficient development which is resilient to climate change and promotes smart and healthy behaviours, environmental health and mental and physical wellbeing."

An approach which promotes wellbeing and healthy living closely balanced with environmental sustainability

The Opportunity

The Challenge of Super Density

Providing high quality and sustainable housing at the very high densities proposed presents a number of interrelated challenges, in particular, how to provide sufficient, high quality, well lit, green infrastructure to promote the health and wellbeing of the residents and workers and to mitigate flood risk and overheating, key risks to London from the effects of predicted climate change.

Another key issue with this level of density is how to reconcile the competing demands for space, particularly at basement/podium and rooftop level.

Wormwood Scrubs

Insufficient onsite provision of public open space is also likely to put unacceptable pressure on Wormwood Scrubs. The capacity of Wormwood Scrubs to absorb the increase in population and the proposed level of public open space required onsite will need to be tested through a future open space strategy.

Zero Carbon

Old Oak presents an opportunity for creating a new model of low/zero carbon development, with the potential to be a ground-breaking exemplar for London and the UK. Substantial reductions in transport related emissions are achievable with a fully integrated approach to urban form, movement, open space, green infrastructure and microclimate across the site.

To achieve an ambition of operational zero carbon for Old Oak in the short-medium term, there is likely to be a need to offset significant net carbon emissions, either through onsite or offsite sequestration, other designated offsite carbon reduction initiatives or carbon pricing. In the longer term, as the carbon intensity of grid electricity is expected to fall and energy efficiencies increase it may be possible for the new development to be carbon positive.

Zero Waste

There is a huge opportunity to promote a local economy based on ‘Circular Economy’ principles, which is waste free through maximising recycling and composting with minimal associated carbon emissions.

Park Royal

It is important that Park Royal functions efficiently as a reservoir of strategic industrial land. There is an opportunity to intensify this land to make it operate more efficiently, exploit the proposed high level of accessibility, new cycle and pedestrian connections and new amenities, and undertake modernisation and improvements to existing stock and sites.

Headline Recommendations

- Adopt the C40 Cities Climate Positive Framework (C40 CCPF) for all or part of the site.
- Develop an onsite 'virtual power plant' using modern smart grid technology capable of integrating electrical supply from a range of local sources, including CHP plant, energy from waste plant, solar PV arrays and energy storage.
- Develop onsite multi-source, lower temperature heat and higher temperature cooling networks.
- Fully incorporate waste facilities within new buildings to ensure 100% of user recyclable waste can be collected and stored within plot.
- Develop onsite integrated construction, demolition and excavation waste consolidation, storage and processing facilities.
- Develop onsite and/or offsite energy from waste/anaerobic digestion facilities capable of handling existing and potential waste streams from both Park Royal and Old Oak
- Develop onsite and/or offsite waste management facilities to recycle operational waste (organic and dry recyclable) generated from development at Old Oak and industrial activities at Park Royal.
- Support zero emission 'last mile' deliveries and implementation of Freight Consolidation Centres.
- Designate the entire OPDC area as a Low Emission Neighbourhood.
- Strong focus on transport related measures to reduce overall air emissions.
- Public spaces should benefit from good daylight, sunlight and microclimate, they should provide a good mix of facilities, including play and exercise equipment, be well located close to neighbourhoods and provide multiple functions (biodiversity, SuDS, play, connectivity, and shade).
- Provision of significantly more publicly accessible open space than identified within the illustrative masterplan in the draft Local Plan.
- Conservation and enhancement of Sites of Borough Importance for Nature Conservation, in particular Wormwood Scrubs and the Grand Union Canal.
- Major applications to be accompanied by an Ecological Statement.
- Establishment of the Grand Union Canal Linear Park forming the main east-west walking and cycling route and an important part of London's Blue Ribbon Network.
- Explore the feasibility of creating valuable public open space on the large roof of the HS2 station and by decking over the tracks either side of North Acton Station.
- Provide a green bridge directly connecting Old Oak Park to the north of the canal with Wormwood Scrubs in order to significantly improve accessibility and provide additional linear public open space.
- Wholescale and widespread installation of integrated sustainable drainage within streets and open spaces to ensure flood resilience is fully integrated across the development (required amount to be determined).
- Require all major development to undertake post-construction monitoring to demonstrate compliance with OPDC policies.

Headline Targets

- Old Oak: operationally zero carbon in the short term and overall operationally carbon positive in the long term (C40 CCPF definition). Park Royal: short term 10% and long term 25% carbon reduction (from 2016 levels).
- All new development: 35% reductions in carbon emissions beyond Building Regulations 2013 Part L in short term, Passivhaus standards for residential in long term. Park Royal: short term 15% overall demand reduction for industrial uses, long term 25% (from 2016 levels).
- Onsite zero / low carbon energy generation, 15% (short term) to 20% (long term) of onsite demand.
- Zero waste with a low and decreasing percentage of construction and operational waste sent to landfill over short to long term.
- Old Oak: percentage of organic waste processed by anaerobic digestion or composting: short term 50% and long term, 70% (targets for Park Royal less 10%). Percentage of dry recyclable waste recycled: short term 60% and long term 70% (Old Oak), short term 70% and long term, 75% (Park Royal).
- Percentage reduction in overall embodied carbon against site-specific benchmarks: 15% in short term, 20% (Old Oak) and 15% (Park Royal) in long term.
- 100% by value of wood from certified sustainable sources.
- 80% of materials by value from suppliers participating in responsible sourcing schemes such as BRE BES 6001.
- Targets to achieve water neutrality. Potable water consumption (l/person/day), residential: short term <=105lpd and long term 90-80lpd. Percentage of within-plot rainwater collected and used onsite: short term 50%, long term 60%. Percentage of greywater recycled onsite: short term 30%, long term 80%.
- Percentage of trips in to or out of Old Oak by combustion engine private vehicles: short term 15%, long term 10%.
- Percentage reduction in freight trips in to or out of Park Royal resulting from consolidated delivery: short term 60%, long term 75%.
- NO_x and PM_{10} average emissions (g/m^2/annum) 5% below air quality neutral benchmarks in Mayor's Sustainable Design and Construction Supplementary Planning guidance.
- Our initial work suggests that a minimum of 30% (29.3ha) of Old Oak's total area should be allocated to accessible open space including civic spaces and Green Streets. In addition, financial contributions should be directed to enhancing the facilities on Wormwood Scrubs (subject to the findings of a full open space strategy).

East Village, London E20

The former London 2012 Olympics Athletes Village overlooks the Queen Elizabeth Park. The scheme is close to Stratford International Station and HS1 and provides a good example of the use of green infrastructure

Appendix A:
London Case Studies

Woodberry Down, London

Client: Berkeley Homes

Architect: Masterplan: Fletcher Priest Architects with Townshend Landscape Architects; Architecture: Fletcher Priest Architects, Rolfe Judd, Hawkins Brown and others.

Year: Masterplan framework 2005, original masterplan 2009, revised masterplan 2014

Site Area (ha): 24

Number of units: 5,500

Site Density (dph): 229

Housing typologies: 1, 2 and 3 bedroom apartments and penthouses, 4 and 5 bedroom houses.

Housing mix: 58.5% private, 41.5% affordable (31.3% social rented and 10.2% intermediate), 10% wheelchair accessible once complete.

Range of storeys: 2-30

Car parking: Aim to limit residential and on-street parking. As such, parking provision varies from 0.47 spaces per dwelling towards Manor House Station and 0.49 per dwelling towards the site's eastern end. 10% disabled parking. Large proportion of this basement parking rather than on street. 4,881 bicycle spaces also provided.

Open space provision: High quality open space will cover 25% (6.1ha) of total land area of new neighbourhood, includes the area taken up by a new linear park along the riverside. Range of open spaces and play facilities provided, including a landscaped riverside walkway.

PTAL rating: 4-6a

Code for sustainable homes level: 4

Other uses: Primary school and academy – educational, public open space, community, retail/commercial opportunities and gym.

Awards: 2009 Housing Design Awards Nomination; 2011 Daily Telegraph Build Quality Awards Best Social Housing Development; 2011 Premier Guarantee Excellence Awards Social Housing Development of the Year; 2014 Premier Guarantee Excellence Awards Multi-Storey Development of the Year; and more.

Environmental Performance:

Carbon:

- Electric car charging points, a car club, limited parking spaces and a high level of bicycle storage encourage sustainable transport
- 51.8% CO_2 emission reduction against Part L of the Building Regulations.

Energy:

- Each apartment installed with energy efficient LED lighting, thermal insulation and efficient white goods specification. Occupants provided with 'Home Users' Guide' – encouraging them to use energy efficiently
- Code for Sustainable Homes Level 4 and Predicted Energy Assessment Rating B, as well as Lifetimes Homes compliant
- Combined heat/power plant generates hot water and electricity using photovoltaic panels. District heating also used.

Waste:

- Kitchen design allows for segregation of waste, plastic, glass, cardboard, cans and compostable waste – encouraging recycling
- Sustainable waste disposal during construction.

Materials:

- Sustainable procurement of materials
- One block made from Cross Laminated Timber.

Green Infrastructure:

- Improving ecology through further planting and provision for wildlife
- Offsite contribution to adjoining Woodberry Wetlands nature reserve. Managed by London Wildlife Trust
- Bird, bee and bat boxes incorporated into site to develop habitats for wildlife. Former reservoirs transformed into wetlands and made accessible with new footways.

Resilience:

- Vegetation and water systems act as 'heat sinks' – reducing "urban heat island" effect, whilst improving the development's appearance
- Employs natural space heating/shading throughout – blocking summer sun but allowing winter sun to penetrate
- Use of 'natural systems' maximised, including climatic systems, such as solar heat and air flow.

© Shutterstock

Further References:

Berkeley Group (2014) 'Woodberry Down Case Study', www.berkeleygroup.co.uk/media/pdf/t/e/FINAL_CASE_STUDY-v1.pdf

Hackney Council (2008), 'Woodberry Down Planning Application', http://idox.hackney.gov.uk/WAM/doc/Additional%20Information%20(Submitted%20By%20Applicant)-249983.pdf?extension=.pdf&id=249983&location=VOLUME1&contentType=&pageCount=1

Hackney Council (2016) 'Woodberry Down Regeneration', www.hackney.gov.uk/woodberry-down

Rolfe Judd (2016) 'Woodberry KSS1 Wins Multiple Design Awards', www.rolfe-judd.co.uk/news/awards/woodberry-downs-kss1/

Elephant Park, London

Client: Lendlease

Architect: Duggan Morris Architects, Allford Hall Monaghan Morris, Panter Hudspith Architects, dRMM, Maccreanor Lavington and Make Architects

Year: 2012 - ongoing. Construction began 2013

Site Area (ha): 10.85

Number of units: 2704

Site Density (dph): 249

Housing typologies: Studio, 2 & 3 bed, 3+ bed, townhouses, duplexes, flats

Housing mix: 25% affordable (50:50 rented/shared ownership)

Range of storeys: 3-31

Car parking spaces: 663 (all uses) (max. 62 on street parking); 10% to disabled standards; 10% electric charging points; 10% passive provision for electric vehicles. 3399 cycle parking spaces (all site).

Open space provision:
3-4ha of accessible open space with 2790 sq. m dedicated playspace.

PTAL rating: 5-6b

Code for Sustainable Homes: 4

Other uses: commercial, retail, public open space; community, temporary construction skills centre, temporary 'Grow Elephant' mobile gardening. Temporary low cost business space at Artworks Elephant made of recycled shipping containers.

Awards: Brick Awards 2015 Housing Design Award (Trafalgar Place); London Planning Awards 2016 Best New Place to Live (Trafalgar Place) and The Mayor's Award for Planning Excellence (Trafalgar Place). Trafalgar Place shortlisted for Stirling Prize.

Environmental Performance:

Carbon

- The development is committed to being operationally zero carbon as part of the C40 Climate Positive Development Programme.
- Doubling density with zero growth in emissions.
- Post-2016 will deliver zero-carbon homes and work towards Climate Positive development status.
- Masterplan encourages sustainable transport modes, particularly walking, cycling, and the use of public transport, with charge points for electric vehicles.
- Investing £30million in transport improvements.

Energy

- Buildings will meet Code for Sustainable Homes Level 4 and therefore will have 35% reduction in CO_2 emissions from Part L 2013 requirements.
- Combined Heat and Power system (CHP) with the potential to deliver to at least a further 1,000 neighbouring homes.
- Using grid-injected bio-methane as a carbon-offset.
- Large commercial units to achieve BREEAM 'Excellent'.

Materials

- Using 100% controlled, responsibly-sourced FSC timber for all homes.
- Use of VOC-free (non-toxic) materials.

Water

- 30% less water than the average London home through dual flush toilets and efficient-flow shower heads.

Green Infrastructure

- Elephant Park: 0.9 ha new public park providing the green spine for the development.
- Elephant Square: removal and transformation of the area's northern roundabout with the creation of a major new public space created by TfL.
- Investing into existing open spaces at Victory Park and St Mary's churchyard.
- Restoring nature onsite and helping to improve air quality through implementation of an extensive biodiversity strategy.
- Aspiration for 100% green roofing on available space.
- Retention of existing 120 mature trees from the former Heygate Estate.
- Over 1,000 new trees being planted both on and offsite forming part of an extensive greening programme.

© Lendlease

Further References:

Southwark Planning ref: 12/AP/1092

Trafalgar Place DRMM Architects

Lendlease Corporation (2014) Sustainability. Available at: www.elephantpark.co.uk/elephant-park/sustainability.

Lendlease (2014) Our plans - Elephant & Castle. Available at: www.elephantandcastle-lendlease.com/our-plans.

Southwark Council (2010) Documents for case. Available at: planbuild.southwark.gov.uk/documents/?casereference=12/AP/1092&system=DC.

Hale Village, London

Client: Bellway and Lee Valley Estates

Architect: BDP, KSS, RMA

Year: Works commenced 2008

Site Area (ha): 4.8

Number of units: 1200

Site Density (dph): 252

Typical Block Density (dph): 330

Typical Block Density (hr/ha): 910

Housing typologies: 1-4 bed flats

Housing mix: 542 affordable units totalling 45% of all units across the site (30% social rented 70% intermediate tenure).

Range of storeys: 1-18

Car parking spaces: 800 (0.66) (+1625 cycle spaces)

Open space provision: 1.8 ha public open space

PTAL rating: 4-6a

Code for Sustainable Homes level: 4

Other Uses: 1,244 rooms for student accommodation, offices, retail, health centre, education and 100 bed hotel. 750 jobs community centre, mainly funded by Church of England includes analysis unit, children nursery with apartments above.

Awards: Shortlisted in the Planning and Placemaking Awards.

Environmental Performance:

Carbon

- 20% reduction in baseline carbon emission.

Energy

- BREEAM EcoHomes 'Excellent'.
- Heating and hot water demands will be met by the ESCo's district and heating and hot water system from the three sources of CHP, biomass and gas-fired boilers.
- Utilises ESCo's clean energy and heating – primary heating is supplied from an ESCo including renewable heating, reducing CO_2 by more than 10% across the site.
- Heat recovery from CHP – reduces carbon emissions by 20%.
- Communal areas treated as external areas to prevent unnecessary heating.
- Low energy lighting in communal and external areas.
- Low energy lighting across 75% of each unit.

Waste

- Onsite recycling within each unit.

Materials

- Performance building fabric for energy efficient heat recovery for ventilation to reduce energy consumption.
- Recycled aggregates used in construction of basement, retaining walls and concrete frame.
- Fly ash is proposed as a waste product replacing cement content of concrete superstructure.
- Enhanced high spec U-values on glazing, walls and roof to reduce heat loss.

Water

- Use of sustainable drainage systems (SuDS).
- Green roofing for rainwater attenuation for supplying WC's and site irrigation. Designed for 1:100 year storm plus 20% allowance for climate change.
- Dual flush toilets.

Green Infrastructure

- 80% of the village roof space is green.
- A former culvert has been re-opened and planted to create an Eco Park connecting to the Lee Valley Regional Park.
- Wildlife corridors created and planted with native species.
- For the first time residents will have direct access to the Lee Valley from Hale Village.
- New Perkyn Park won in July 2016 the prestigious Green Flag Award. The name is derived from an old Chaucer's Tale set in Tottenham concerning an apprentice potter.
- Links with local community organisations supplying local fruit, vegetables and honey.
- Walthamstow Wetlands – large new urban wetland reserve close by.

Air Quality

- Cycle storage provided.
- CHP and Biomass to provide base heating with natural gas used for peak top-up.

© 2017 Hale Village London

Further References:

Reserved Matters Pavilions Planning No: HGY/2006/1177

BDP (2016) Hale village. Available at: http://www.bdp.com/en/projects/f-l/hale-village/

Haringey Special Planning Committee (2010) Notice of Meeting. Available at: http://www.minutes.haringey.gov.uk/Published/C00000106/M00004917/$$ADocPackPublic.pdf

Lee Valley Estates (2007) Hale village design statement. Available at: http://www.planningservices.haringey.gov.uk/portal/servlets/AttachmentShowServlet?ImageName=298815 .

East Village, London

Client: ODA

Architect: 16 different architects alongside Fletcher Priest Architects who produced the masterplan and VOGT as landscape architects

Year: Wider masterplan 2005; Zonal masterplans 2007 onwards

Site Area (ha): 21.56

Number of units: 2818 delivered by 2012; more to follow

Site Density (dph): 256 (based on 2012 development)

Typical Block Density (dph): Zone 4: 258 Zone 5: 198

Typical Block Density (hr/ha): Zone 4: 773 Zone 5: 599

Car parking spaces: 1242 (0.44)

Housing typologies: 1-4 bed flats and town houses

Housing mix: 70% private rented (from Get Living London); 15% social rent and 15% intermediate rents (from Triathlon Homes) (housing completed for 2012)

Range of storeys: 8-10

Other uses: Retail, commercial, medical centre, school Designed as a district of the wider Stratford City masterplan, and the mix of uses and relationship to public transport was designed in from the outset, in advance of the 2012 Olympic bid.

PTAL rating: 4-6a

Code for Sustainable Homes: 4

Open space provision: 5.3ha including 3 children's parks; 27 hectares open space and parkland in adjacent Olympic Park.

Awards: London's Awards for 'Planning Excellence' and 'Best New Place to Live' for "its simple and replicable design solution, its scale and its overall quality' & 2014 RESI awards for 'Development of the Year' for "outstanding landscaping and community facilities". National Civic Trust Award and RESI Development of the Decade and more.

General: East Village was designed as a district of the wider Stratford City masterplan, and the mix of uses and relationship to public transport was designed in from the outset, in advance of the 2012 Olympic bid.

Environmental Performance:

Carbon
- Zero carbon standard set for project achieved through offset defined through local Allowable Solutions agreement with local borough and improvements in emissions over Building regulations 2010.

Energy
- District heating and cooling for all residential units.
- BREEAM rating of "Very Good" for all buildings.
- 20% renewable energy used.

Waste
- Cleaned and reused 90% existing spoil.
- 99% reduction in construction and demolition waste at former Athletes village during construction
- Aim of zero municipal solid waste to landfill by 2025 and 60% home recycling and composting by 2020.

Materials
- Transformed highly contaminated brownfield site.
- All materials will conform to Green Guide to Specification (GGTS) rating B or better.
- 15% reduction in embodied carbon, 34% minimum recycled content of major materials(by value), recycling and reuse of 20% construction materials, 100% sustainably sourced timber, 86% responsibly sourced materials and 0% unhealthy materials.

Water
- Water sensitive design and flood control measures.
- Reduction of 60% in water across area averaging 105 litres/person/day.

Green Infrastructure
- Extensive use of green roofing.

Microclimate
- Buildings designed to accord with the BRE "Site Layout Planning for Sunlight and Daylight: A Guide to Good Practice".

Resilience
- Good use of private open space provision through balconies and winter gardens.
- Diversity housing typologies including maisonettes and town houses for families.
- Integration of podium approach including active frontages, car parking and maisonettes.
- Excellent transport solutions.

© Jimmy Wu Photography, VOGT as landscape architect

Further References:

Planning reference: 07/90208/AODODA London Legacy Development Corporation

London Legacy (2007a) Open Space Strategy. Available at: planningregister.londonlegacy.co.uk/swift/MediaTemp/4174-65149.pdf (Accessed: 4 August 2016)

London Legacy (2007b) Planning Statement. Available at: planningregister.londonlegacy.co.uk/swift/MediaTemp/2943-45445.pdf (Accessed: 4 August 2016)

London Legacy (2010) London and continental railways Stratford city application for extension in time sustainability statement. Available at: planningregister.londonlegacy.co.uk/swift/MediaTemp/2943-45416.pdf

Olympic Delivery Authority (2014) East village big winner at London planning awards. Available at: https://www.gov.uk/government/news/east-village-big-winner-at-london-planning-awards.

* Planning permission reference 07/90023/VARODA

Stratford City Housing Density Report (2007) submitted in relation to condition A1 (Zonal Masterplans for zones 3-6 of the Stratford City site) of planning consent 07/90023/VARODA

* Stratford City Open Space Strategy (2007) submitted in relation to condition A1 (Zonal Masterplans for zones 3-6 of the Stratford City site) of planning consent 07/90023/VARODA

* Stratford City Planning Statement (2007) submitted in relation to condition A1 (Zonal Masterplans for zones 3-6 of the Stratford City site) of planning consent 07/90023/VARODA

King's Cross Central, London

Client: King's Cross Central Limited Partnership

Architect: Masterplan by Allies & Morrison, Townshend Landscape Architects and Porphyrios Associates. Numerous designers involved; including Bennetts Associates, David Chipperfield Architects, Wilkinson Eyre, David Morley Architects, Heatherwick Studio, MacCreanor Lavington Architects, Duggan Morris, Eric Parry Architects, Glen Howells Architects, Squire & Partners, PRP Architects, Stanton Williams and Weedon Partnership.

Year: Began 2007

Site Area (ha): 27

Number of homes: 1900

Typical Block Density (dph): 290

Typical Block Density (hr/ha): 649

Housing typologies: 1-4 bed flats, student cluster flats.

Housing mix: 43% affordable housing – social rent, intermediate. Most urban student accommodation, up to 650 units of student housing.

Range of storeys: up to 27

Car parking: 1682 (overall site) 290 (residential= 0.3/ dwelling)

Open space provision: 7.45ha accessible open space

PTAL rating: 4-6

Code for sustainable homes level: - TBC

Other uses: student accommodation, retail, commercial, open space, community, education (University of Arts London and College of Central St Martin Art and Design) and health facilities, entertainment areas situated by the canal – cultural hub. Centre of transport with King's Cross Underground Station and St Pancras International nearby.

Awards: K2014 NLA Awards London Best of the Best Winner; 2014 RIBA London Regional and National Award Winner; 2013 Estates Gazette London Deal of the Year – Industry Impact; 2013 Property Week Awards London Regeneration Award Winner.

Environmental Performance:

Carbon

- Reduction of 39% carbon emissions in comparison to 'business as usual' benchmarks. Long term aim to reduce carbon emissions by 60% on 2000 levels by 2050.

Energy:

- All buildings rated at BREEAM rating 'Very Good' as minimum – 3 achieved 'Outstanding' in 2014.
- 14 roof level wind turbines and photovoltaics
- Ground source heat pumps
- District Heating/ Combined Heat and Power systems
- CHP plant provides 100% heat and hot water needs and 80% electricity needs.

Waste:

- Use of SMARTwaste and SMART(ER) to report waste performance.
- During development phase 92% waste diverted from landfill, currently 81% is diverted from landfill of which 58% is recycled and 42% converted into energy.

Green Infrastructure:

- Station Square: enhanced space between two stations.
- The Boulevard: primary route fronted by mixed use development connecting Station Square to Granary Square.
- Granary Square: the hub of King's Cross. Floor fountains, terraced steps down to Regent's Canal. Flexible space used for events.
- Long Park: tapering green spine with trees, gardens and lawns.
- Canal Corridor: Regent's Canal bisects and forms an integral part of the development. Enhanced public access balanced with protection of natural and cultural heritage.
- Camley Street Natural Park: retained and protected natural green space.
- Green roofs: 9000 sq m of green/brown roofs.

Further References:

Camden Gov (2015) 'King's Cross Central', http://www.camden.gov.uk/ccm/navigation/environment/planning-and-built-environment/major-developments/king-s-cross-central/;jsessionid=FBE4C8310F936E8D558542AF13541460

King's Cross Visitor Centre (2015) 'Who is Developing King's Cross?', https://www.kingscross.co.uk/whos-developing-kings-cross

Milne, R. (2015) 'King's Cross Development Forum', https://kxdf.wordpress.com/category/plans/camden-frameworks/

Urban Land Institute (2014) 'King's Cross | ULI Case Studies', http://casestudies.uli.org/kings-cross/

Bermondsey Spa, London

Client: Hyde Housing Association development partners of Southwark Council (Sites E-U)

Architect: Levitt Bernstein

Year: Original masterplan prepared by Southwark Council in 1999. Implemented in series of phases (A-T) completed 2013

Site area (ha): 2.03

Number of homes: 644

Site density (dph): 317

Typical block density (dph): 297-407

Typical block density (hr/ha): 900-1100

Housing typologies: The medium rise, high density approach has created a distinctive urban neighbourhood. Buildings are designed with tight footprints with central courtyard. Residential accommodation consist of deck accessed flats, duplexes, mansion flats and integrated older persons housing.

Housing mix: 41% Affordable. 32% Intermediate. 27% Outright Sale.

Range of storeys: 3-10 with the taller elements located near railway lines and Jamaica Road. Buildings near listed church lower.

Car parking: 0.3 spaces per dwelling, located in ground level undercrofts each below a landscaped courtyard. 110 secure bicycle parks.

Open space provision: 2.5 hectares of open space at adjacent Bermondsey Spa Gardens re-landscaped as part of regeneration process.

Each flat has large balcony, larger ground floor family dwellings have rear patios. Each block built around a central landscaped courtyard, perforated with openings to accommodate larger tree species.

PTAL rating: 3 - designated as PTAL which allows densities greater than those defined by the Southwark Plan.

Code for Sustainable Homes level: 4

Other uses: Medical centre, dental surgery, pharmacy, retail opportunities, youth centre – featuring one of London's largest and best equipped climbing walls.

Awards: RTPI Awards 2011: Commendation for sustainable communities; Building for Life 2010: Gold standard; Evening Standard New Homes Awards 2010: Best regeneration project, winner; Housebuilder Awards 2010: Best regeneration initiative, winner; London Planning Awards 2010: Best new place to live, winner; Housing Design Awards 2005: Project, winner; HomeBuilder Design Awards 2005: Best housing project, commendation.

Environmental Performance:

Carbon:

- H&H UK Limited, who provided building materials for the development, received the Carbon Trust Standard for the project, due to efforts to reduce their carbon footprint.

Energy:

- Minimum EcoHomes 'Very Good' standard.
- Larger windows with venetian blinds limit need for lighting, maximising daylight use.

Air quality:

- Car Club Membership for three years and secure bicycle parks encourage sustainable transport.
- Parking ratio 0.3.
- Maximises dual aspect residential units.

Green Infrastructure:

- The interventions have re-established the historic street network which had disintegrated.
- A new pedestrian route created linking Tower Bridge to St James' Church and the new tube station offering quiet traffic-free green space.
- Bermondsey Spa Gardens refurbished as part of the 1999 area masterplan and re-opened in 2006 with a new play area, multi-use games area and a 333m running track.
- Bermondsey Square created and used for a series of arts/cultural events. Also has cycle station.

© Levitt Bernstein/Tim Crocker

Further References:

H&H (2009) Case Study Bermondsey Spa Phase 2, https://www.hhcelcon.co.uk/files/download/26-Bermondsey-Spa-Homes.pdf

Hyde Housing (2012) Regeneration at Bermondsey Spa, https://www.hyde-housing.co.uk/corporate/building-homes/estate-regeneration/bermondsey-spa/

RIBA (2014) Bermondsey Spa, https://www.architecture.com/FindAnArchitect/ArchitectPractices/LevittBernstein/Projects/BermondseySpa-110680.aspx

Southwark Council (2010) Bermondsey Spa Masterplan, http://www.southwark.gov.uk/info/200180/bermondsey_spa/1144/bermondsey_spa_masterplan

Levitt Bernstein, Pollard Thomas Edwards, HTA and PRP (2015) Super Density: The Sequel

'Project Story': www.levittbernstein.co.uk/project-stories/bermondsey-spa/

* H + H UK Ltd. (2009) H+H case study Bermondsey spa phase 2, south East London build with ease. Available at: https://www.hhcelcon.co.uk/files/download/26-Bermondsey-Spa-Homes.pdf.

* Hyde Housing (2012) Regeneration at Bermondsey Spa: https://www.hyde-housing.co.uk/corporate/building-homes/estate-regeneration/bermondsey-spa/

St Andrew's, Bromley-by-Bow, London

Client: Barratt Homes for St Andrew's Hospital Site

Architect: Allies and Morrison (Masterplan, Block A, D & E), MacCreanor Lavington (Block B), Glenn Howells (Block C).

Year: All phases Blocks A-E have now been completed

Site Area (ha): 3

Number of units: 964

Site Density (dph): 320 (990hr/ha) (gross)

Typical Block Density (dph): 480

Housing typologies: High density scheme includes three linear urban blocks, each planned around a central courtyard and arranged to form streets. 30% family dwellings, 1-5 bed flats, townhouses, studio flats, wheelchair user dwellings, dual aspect dwellings, maisonettes.

Housing mix: 50% private, 50% affordable (69:31 social rented/shared ownership), *10% wheelchair accessible dwellings.

Range of storeys: 3-25. Two towers address major spaces.

Car parking: 151 (all uses), 0.16 car parking ratio per unit. Basement car parking. 860 bicycle parking spaces. 136 parking spaces in Block D.

Open space provision: 30% total site area is landscaped open space (approx. 1ha), each residence has a private open space – garden, patio, balcony or roof terrace.

PTAL rating: 4

Code for sustainable homes level: 3

Other uses: Community, leisure and cultural uses; Block A incorporates health centre for Tower Hamlets Primary Care Trust. Block D houses a community centre.

Awards: 2010 Building for Life Award; 2011 Housing Design Awards Graham Pye Award, 2012 Housing Design Awards; 2012 Building Awards Housing Project of the Year Highly Commended; 2014 Civic Trust Awards Commendation, amongst others.

Environmental Performance:

Energy:

- Site uses a district Combined Heat and Power (CHP) utilising Biomass - major part of scheme's sustainability credentials.
- 20% of energy is met by biomass onsite generation.

Water:

- Rainwater harvesting for garden irrigation.
- Greywater recycling in 5 bedroom flats.

Green Infrastructure:

- Residents have access to communal courtyards.
- Bat and Swift boxes integrated into the brickwork to protect wildlife.
- Green roofs employed regularly throughout the development.

Materials:

- Extensive use made of brick because of it's long term durability and cost effectiveness.
- Some of the London stock bricks from the former hospital recycled.

© Jimmy Wu Photography

Further References:

AKTII (2016) 'St Andrews Project', akt-uk.com/projects/st%20andrews

Allies & Morrison (2010) 'St Andrew's Block A', www.alliesandmorrison.com/project/st-andrews-phase-1/

Future of London (2012) 'Presentation on St Andrews, Bromley-By-Bow', issuu.com/futureoflondon/docs/120625_future_of_london_site_visit

Landezine (2015) 'St Andrews, Bromley-by-Bow by Townshend Landscape Architects', www.landezine.com/index.php/2016/06/st-andrews-bromley-by-bow-by-townshend-landscape-architects/

Allies and Morrison (2010) St Andrew's Masterplan. Available at: http://www.alliesandmorrison.com/project/st-andrews-masterplan/.html.

Barratt Homes at Future of London Site Visit (2012) Presentation on st Andrews, Bromley by bow. Available at: https://issuu.com/futureoflondon/docs/120625_future_of_london_site_visit.

Maccreanor Lavington Architects, Emily Greeves Architects and Graham Harrington Planning Advice (2012) Housing Density Study. Available at: http://wehearthart.co.uk/wp-content/uploads/2015/03/Housing-density-study-opt.pdf.

Macreanor Lavington Architects (2016) St Andrews block B. Available at: http://www.maccreanorlavington.com/website/en/project_2553.html.

© Atkins

Library Building, Clapham, London

Client: Cathedral Group and United House

Architect: Studio Egret West and DLA Architecture

Year: Completed January 2012

Site Area (ha): 0.4

Number of units: 136

Typical Block Density (dph): 340

Typical Block Density (hr/ha): 860

Housing typologies: 1 and 2 bed apartments. Variety of unit sizes

Housing mix: Mix established on local demand - combination of affordable and market for young professionals. 30% affordable housing, 10% wheelchair accessible.

Range of storeys: 1-12

Car parking: 46 (all uses) (43 located in basement). 7 of these disabled spaces. 25 spaces of these for residents. 243 cycle parking spaces, 213 of these for residents

Open space provision: Two large landscaped communal terraces on seventh and eighth floors with south-facing views and eco-deck decking

PTAL rating: 6a

Code for sustainable homes level: 4

Other uses: Library, café, Family Doctors Practice, and Primary Care Trust located on ground floor – health, community, leisure, retail, public and cultural uses.

Awards: 2010 Housing Design Award Project Winner; 2011 International Property Awards Best Mixed-Use Development; 2011 Daily Telegraph British Homes Awards Best Housing Project; 2012 New London Architecture Awards Culture & Community Winner; 2012 Sunday Times British Home Awards Best Apartment Building; 2013 Civic Trust Awards Winner, amongst others.

Environmental Performance:

Carbon:

- Carbon emissions reduced to 30% below normal standards and normal water usage reduced by 30%

Energy:

- Building achieves high environmental and energy efficiency standards, residential attaining Code for Sustainable Homes Level 4, Primary Care Trust to score NEAT 'Excellent' and Library to score BREEAM bespoke 'Very Good'
- Each apartment designed to achieve energy performance grade between B and C - reducing running costs. All lighting is low-energy and low voltage
- Served from an 'Energy Centre' that takes advantage of the various uses' differing energy profiles (library, health centre etc.) to conserve energy
- Bay windows and glass fronted façade encourage the use of natural light, limiting energy wastage
- Energy-efficient heating and hot water system with under-floor heating throughout operated by zoned thermostats

Materials:

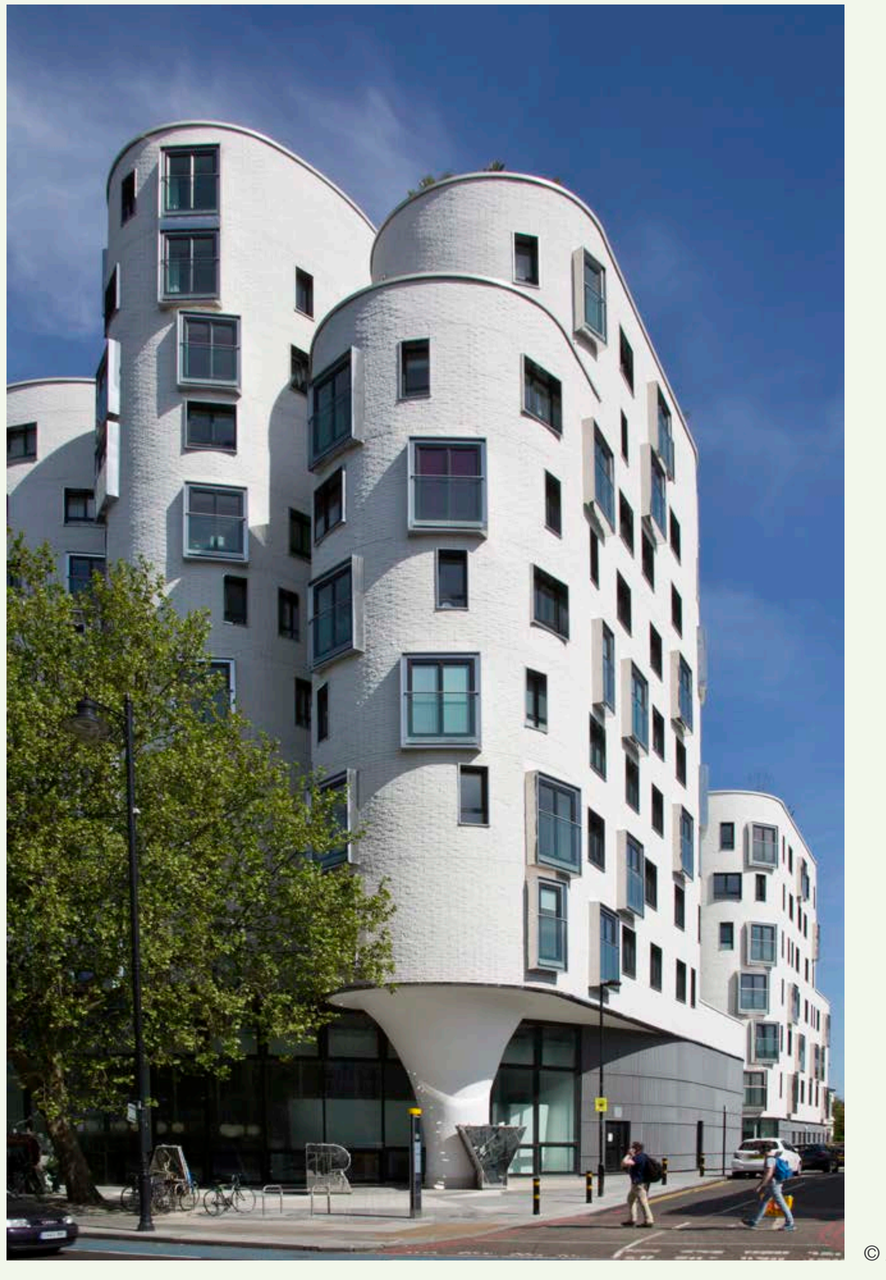
- Designed with curved ends to each of cores to reduce noise pollution produced by building

Green Infrastructure:

- Uses sustainable technology, including water saving systems and solar panels

Air Quality:

- Free branded hybrid bicycle for every apartment, plus a bespoke basement bike park – encourages sustainable transport
- Free two year membership to City Car Club Scheme – aiming to encourage car sharing and limiting CO2 emissions



© Arcaid

Further References:

DLA Design (2016) 'DLA Design Projects - Clapham One', www.dla-design.co.uk/residential/clapham-one.

Lambeth Council (2009) 'Clapham One Planning Application', http://planning.lambeth.gov.uk/online-applications/applicationDetails.do?

The New Clapham (2013) 'About the Library Building', http://www.thenewclapham.com/pages/the-library-building-about.php

United House Developments (2012) 'Clapham One', http://www.unitedhousedevelopments.net/developments/view/clapham-one

Greater London Authority (2009) Strategic planning application stage II referral (new powers) the proposal. Available at: https://www.london.gov.uk/sites/default/files/PAWS/media_id_147805/mary_seacole_house_report.pdf.

Regent's Place, London

Client: British Land

Architect: Terry Farrell Masterplan and Architect; Stephen Marshall Architects / Tate Hindle Architects, Wilkinson Eyre, Carmody Groarke.

Year: 2009

Site area (ha): 5.3

Number of homes: 151

Typical block density (dph): 427

Typical block density (hr/ha): 1,137

Housing typologies: 1-3 bed flats (23%= 1 bed; 60%= 2 bed; 17%= 3 bed)

Housing mix: 40% Social; 20% Intermediate; 40% Private

Range of storeys: 8-36 (residential= 8-26)

Car parking: 182

Open space provision: 180m² roof space on one residential block; 530m² in public square

PTAL rating: 6b

Code for Sustainable Homes level: 4

Other uses: 186,000m² office space, catering units, public space, cultural and residential.

Awards: Best Built Project at the 2014 London Planning Awards; Better Buildings Partnership and Green500 Platinum Award 2009 for 350 Euston Road; Lord Mayor's Dragon Award 2009 for long-term community engagement in West Euston. Green Heroes 2009 Award.

Environmental Performance:

Carbon

- Up to 26% lower CO_2 emissions than current Building Regulations.

Energy

- Combined Heat and Power system
- 1,6000sqft PV panels.

Heat recovery.

- Motion and daylight sensors.
- Electronic energy monitoring.
- BREEAM 'Excellent' for offices.
- EcoHomes Excellent and Very Good ratings for residential.

Waste

- 80% waste was diverted from landfill during construction.
- 24.6% construction materials were from recycled sources.

Materials

- Increase air tightness, high performance glazing.

Water

- Rainwater is recycled a surface water run off is attenuated (reducing discharge to sewer by 70%).

Green Infrastructure

- 0.56ha green roofs (see Green Infrastructure case study).
- Largest insect hotel (including beehives) in London.
- Pedestrian routes opened up to improve permeability through site.

© Atkins

Further References:

Broadgate Estates (2016) British land. Available at: http://www.regentsplace.com/british-land.

Ijeh, I. (2010) Terry Farrell's Regent's place: Regent's spark. Available at: http://www.building.co.uk/terry-farrells-regents-place-regent%E2%80%99s-spark/5003788.article.

New London Architecture (2014) London's Growing Up: Project Showcase. Available at: http://www.newlondonarchitecture.org/docs/tb_b2.pdf.

Wills, J. (2013) British land - creating a masterplan for one of London's most deprived areas. Available at: https://www.theguardian.com/sustainable-business/british-land-masterplan-london-deprived-area.

Planning application no.: 2007/0823/P London Borough of Camden.

British Land (2009) Carbon reduction = Cost Reduction. Available at: http://www.britishland.com/~/media/Files/B/British-Land-V4/reports-and-presentations/download-archive/pdf_130.pdf.

British Land (2014) Regent's Place at 30. Available at: http://www.britishland.com/~/media/Files/B/British-Land-V4/reports-and-presentations/reports-archive/BL-Regents-Place-at-30.pdf.

British Land (2017) Regent's Place. Available at: http://www.britishland.com/our-places/find-a-place#/detail/GRTPRT.

Arundel Square, London

Client: United House Developments and London Newcastle

Architect: Pollard Thomas Edwards

Year: Completed 2010

Site area (ha): 0.33

Number of homes: 146

Site density (dph): 442 (1,166 hr/ha approx).

Housing typologies: 1 and 2 bed flats, studio flats, 1 to 5 bed maisonettes, 5 bed houses.

Housing mix: 43% 1 bedroom, 52% 2 bedroom, 5% family dwellings (3-5 bedroom), high proportion of dual aspect dwellings. 115 private sale dwellings, 31 affordable homes.

Range of storeys: 5-6 (including roof gardens).

Car parking: 0.45 spaces per dwelling. 65 spaces overall, situated in a basement car park.

Open space provision: Reinforced concrete deck bridges over adjacent railway cutting, connecting development to Arundel Square, 0.5 ha green public park. New flexible, multipurpose and playful areas include large grass central space and ball court.

PTAL rating: 4

Code for sustainable homes level: 4

Awards: 2012 New London Award Winner; 2011 Building Award; 2011 Housing Design Award; 2011 What House Awards Best Landscape Design and Best Exterior Design Winner; BALI Awards 2011 Principle Award for Restoration and Regeneration Winner; 2010 Daily Telegraph British Homes Award; 2004 Housing Design Project Award; among others.

Environmental Performance:

Materials:

- Imported topsoil, turf and plant materials sourced from sustainable suppliers. Timber FSC, locally sourced – e.g. European Oak.
- Play area equipment comprises mix of recycled existing equipment and new equipment.

Water:

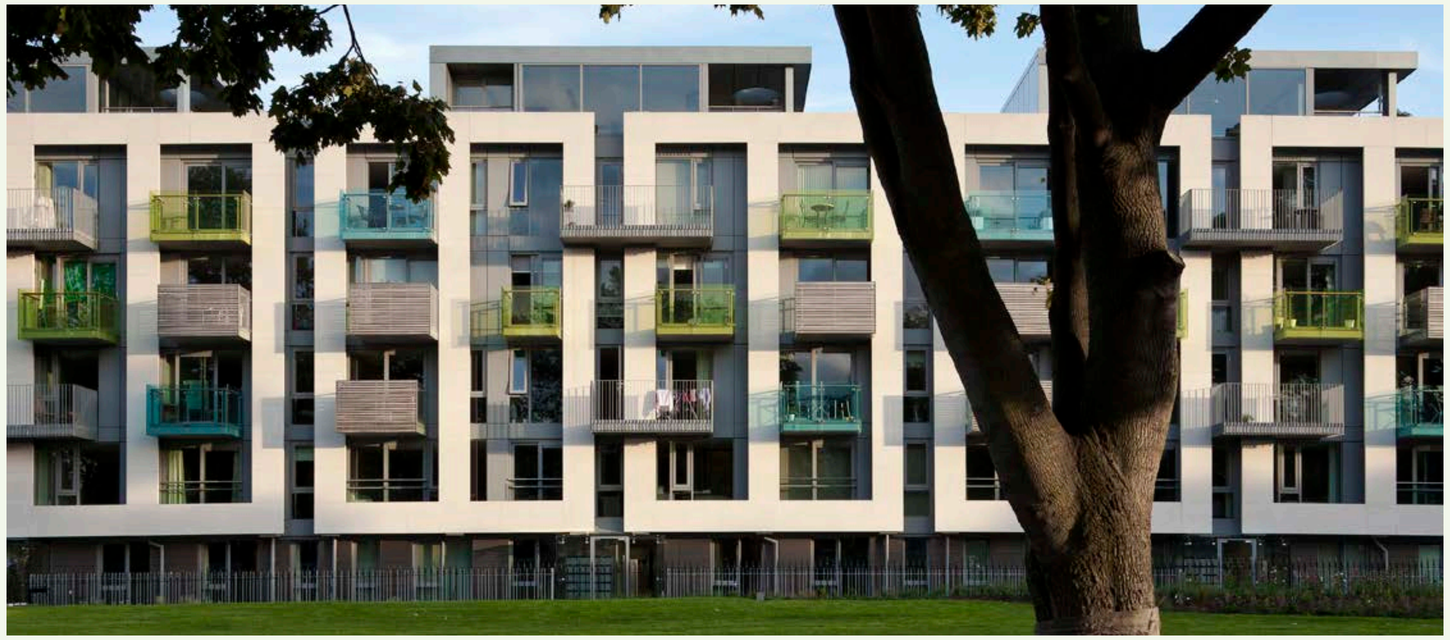
- Sustainable drainage strategy in place. Levels and underground drainage put in place to hold, circulate, and redistribute rainfall. Runoff from deck redistributed around existing park site by series of subsurface swales.

Green Infrastructure:

- Decked over railway line to enable development, reduces noise pollution from trains for local residents and park users and created an additional 43% of new public spaces.
- Pavement design, ground modelling and surface water drainage employed in hard standing areas, with land drainage design implemented in soft landscaped areas, in order to store water on site as long as possible – lowering discharge off site. This is to ensure deck does not increase impermeable areas, thus limiting site's run-off rate.
- Planting has created variety of habitats, in varied microclimates, particularly for birds and insects – enhancing wildlife, linking with existing ecological habitats, such as railway verges.

Air Quality:

- Membership to resident Car Club scheme encourages sustainable transport.



© Tim Crocker - Arundel Square by Pollard Thomas Edwards

© Tim Crocker - Arundel Square by Pollard Thomas Edwards

Further References:

Cassels, A. and Badrock, J. (2016) 'Landscape Institute - Arundel Square Case Study', http://www.landscapeinstitute.org/casestudies/casestudy.php?id=231

Pollard Thomas Edwards (2012) 'Arundel Square', http://pollardthomasedwards.co.uk/project/arundel-square/

United House Developments (2012) 'Arundel Square, Islington', http://www.unitedhousedevelopments.net/developments/view/arundel-square

Pollard Thomas Edwards (2010) Islington square: Shaping up nicely. Available at: http://www.building.co.uk/pollard-thomas-edwards-islington-square-shaping-up-nicely/5010053.article.

Planning Application reference: P022833(MA02)

Central St. Giles, London

Client: Legal & General with Mitsubishi Estate Corporation Stanhope PLC

Architect: Renzo Piano Building Workshop with Fletcher Priest Architects

Year: Completed 2010

Site area (ha): 6.6

Number of homes: 109

Typical block density (dph): 537

Typical block density (hr/ha): 1,450

Housing typologies: 1 to 3 bedroom apartments.

Housing mix: 56 private apartments and 53 affordable housing units.

Range of storeys: 10-14

Car parking: Only 10 spaces available, at cost of £100,000 each, due to Camden Council's stipulation that development should be largely car-free.

Open space provision: 1500sqm of green roof terraces utilised throughout development for use by residents and businesses, development constructed around public retail courtyard.

PTAL rating: 6b

Code for Sustainable Homes level: 4

Awards: 2012 British Home Awards nominated for Best Apartment Building; 2011 British Council for Offices Awards Best of the Best and Best Commercial Workspace Winner.

Other uses: 38,000 m^2 of office space divided over ten floors. Successful public courtyard at base with shops and restaurants.

Environmental Performance:

Energy:

- Scored an 'Excellent' BREEAM rating for sustainability.
- 80% of heating in both residential and business blocks provided by a Biomass boiler run on sustainably sourced wood pellets.
- Energy performance 20% better than Part L expects, accomplished through façade design, efficient plant design and collection/reuse of 60% of rainwater for offices.
- Daylight controlled lighting installed adjacent to building perimeter.

Waste:

- During construction 90% of demolition materials recycled.

Materials:

- High efficiency façade reduces heat loss and solar gain, improves tenant comfort and helps limit energy use.

Water:

- Rainwater collected and stored on roof terraces, and reused for irrigation throughout site. 60% of rainwater reused for offices.
- All water discharged from cooling tower stored for re-use in irrigation systems and toilets.
- High efficiency Climaveneta water source chillers provide over 1,800kW cooling capacity.

Green Infrastructure:

- Planted roof terraces add to local biodiversity, providing previously unavailable habitats.
- Green roofs lessen 'heat island' effect, decrease rainfall to reduce storm impact and increase biodiversity and insulation.

Air Quality:

- Air recycled for use in plant and basement areas to save energy and filtration.
- Only 10 car parking spaces available.

Further References:

ArchDaily (2011) Central St. Giles Court/Renzo Piano & Fletcher Priest, http://www.archdaily.com/104147/central-st-giles-court-renzo-piano-fletcher-priest-architects/

Planning Application reference: 2005/0259/P

London Borough of Camden (2007) Officer Committee Report for planning application 2005/0259/P

Renzo Piano Building Workshop (2012) Central St. Giles Court Mixed-Use Development, http://rpbw.com/project/60/central-st-giles-court-mixed-use-development/

United House Developments (2012) Central St Giles, http://www.unitedhousedevelopments.net/developments/view/central-st-giles

Canary Wharf Group: Wood Wharf, London

Client: Canary Wharf Group

Architects: Allies and Morrison, Herzog & de Meuron, Darling Associates, KPF, Stanton Williams Architects, Grid Architects, and Patel Taylor

Year: Began 2015, estimated completion 2026

Mix of uses: Up to 3610 residential units, 350,000 sqm office foorspace, 35,000 sqm retail floorspace, a hotel, a primary school, a health facility and community facilities. Up to 728,880 sqm total floorspace.

Site area (ha): 8.75

Site density (dph): 265 (gross)*

Typical block density (dph): 436

Typical block density (hr/ha): 1,796

Housing typologies: 1-4 bed units; studios, maisonettes, duplex apartments.

Housing mix: 25% of habitable rooms will be affordable. This will be 80:20 affordable rent/ intermediate tenure. 45% of affordable rented home to be 3-4 bed family homes.

Range of storeys: residential towers 5-56 storeys

Car parking: Min 3000 Cycle parking spaces
Max 1300 car parking spaces

Open space provision: Min 2.5ha

PTAL rating: 3-4

Mobility

PTAL (2021 forecast): 5-6

- Highly efficient public transport network due to its proximity to the Jubilee line and future CrossRail station.
- Sustainable transportation also promoted by cyclist facilities in the public realm, new bus stops and electric car charging points.

Code for Sustainable Homes level: 4

Environmental Performance:

Energy

- Enhanced energy performance achieved with optimum facades design that maximise day lighting levels while minimising solar gain, and high air tightness levels.
- Site wide enhanced energy performance with onsite Energy Centre.

Environment

- Residential: Code for Sustainable Homes Level 4.
- Commercial buildings: BREEAM Excellent/Outstanding.
- Retail: BREEAM Excellent and BREEAM Very Good.

Water

- The project will optimise water consumption through the use of high efficiency sanitary ware fittings and highly efficient irrigation systems for the public realm.

Materials

- Embodied carbon analysis and materials efficiency strategies, including design out of waste strategies.
- Use of FSC certified timber throughout and a stringent supply chain monitoring and control in place.
- The project aims to achieve a final Considerate Constructors Scheme score of more than 40 points (exemplary level).

Green Infrastructure

- 3.6 hectare of interconnected spaces covering 40% of the total site (8.9 ha).**
- Integrated and holistic approach to Biodiversity, which promotes health and wellbeing.
- Creation of new and connected green spaces with a varied and rich planting palette of native shrubs, different sized trees and perennials, which will provide shelter and nesting to small local fauna.
- +4000m^2 of green and brown roofs supporting the ground level green infrastructure.
- Creation of aquatic habitats and ecology sanctuaries (fish nurseries, Ecology Islands).

Photographs copyright © canarywharf

Further References:

Planning Ref No: PA/13/02966 and PA/13/02967

London Borough of Tower Hamlets (2014b) Wood wharf planning sub-committee report. Available at: http://moderngov.towerhamlets.gov.uk/documents/s59188/PA-13-02966%2002967%20Wood%20Wharf%2004-07-2014%20agenda.pdf.

Levitt Bernstein and Pollard Thomas Architects (2015) SUPERDENSITY: The Sequel

Tower Hamlets (2016) Tall Buildings Evidence Base Stage 1 Report

*Based on Outline Planning Permission maximum parameters
**Based on Outline Planning Permission indicative scheme

Appendix B: Environmental Performance Scenarios Analysis

Appendix B.1 - Site Energy Scenarios Analysis

Introduction

Energy demand and supply scenarios were developed for Old Oak and Park Royal based on a mixture of industry accepted energy benchmarks and measured data. The aim of developing these scenarios was to evaluate the overall energy demand and supply balance of the proposed development under different energy performance scenarios. The energy demand and supply scenarios were used to:

a) test the prerequisites for meeting current Mayoral policy / guidance requirements;

b) test the potential for exceeding current policy / guidance requirements, under different scenario assumptions; and

c) provide additional evidence for the policy recommendations and supporting strategy set out in Table 1 above.

The energy demand and supply scenarios were also used to supporting the carbon analysis (see Carbon topic below).

Energy Demand Scenarios

To explore the potential regulated energy reductions achievable within both Old and Park Royal, a set of energy demand scenarios was developed based on improvements to current 'standard practice' energy efficiency performance of different building types. Preliminary high-level estimates of operational energy demand were then calculated for each scenario based on masterplan data on land uses supplied by OPDC for Old Oak and publicly available data for Park Royal.

The energy demand scenarios for Old Oak and Park Royal have been generated by referencing a combination of industry-accepted energy benchmarks. Different benchmarks have been assigned for different building uses, and then proportioned to the building areas for each use. The sections below provide a summary together with details of the assumptions and references used for each scenario.

Old Oak

The energy demand scenarios for Old Oak considered residential, office and retail building types. Three different demand scenarios were generated relating to three different building specifications as follows: Standard Practice, Best Practice and Pioneering Practice. Table B.1.1 provides a summary of the three scenarios. The different benchmark sources used for each scenario are shown in Table B.1.2 below.

Table B.1.1 – Summary of Old Oak Energy Demand Scenarios

Energy Demand Scenario	Summary
Standard Practice	Represents current UK average sector-wide performance: • Residential: building fabric specification to meet minimum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes. Lighting, small power and hot water as per SAP 2012 calculation methodology. • Non-residential: current sector benchmarked performance.
Best Practice	Represents current UK best practice, improving on the Standard Practice scenario via: • Residential: building fabric specification to meet maximum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes: enhanced fabric insulation, reduced air leakage, optimised solar shading. Improved lighting. Small power and hot water as per SAP 2012 calculation methodology. • Office: higher thermal performance building shell, higher air tightness, energy efficient ventilation, daylighting combined with solar shading. • Retail: Average better performing facilities, based on measured data.

Pioneering Practice	Represents current international pioneering practice, improving on the Best Practice scenario via: • <u>Residential:</u> Stringent building envelope thermal transfer, air tightness, shading specifications, mechanical ventilation with heat recovery to ensure very low energy overall energy demand. • <u>Office:</u> automatic adjustable shading, greater focus on daylighting and solar control (low g-value glazing), LED lighting, continuous monitoring and fine-tuning performance, interactive user feedback; GSHP cooling. • <u>Retail</u>: Per Best Practice, with higher efficiency lighting.

Note: all scenarios relate to regulated and unregulated energy.

Source: Atkins analysis.

Table B.1.2 – Old Oak Energy Demand Scenarios References

Demand Scenario	Building Type	Electricity	Fossil Thermal
Standard Practice	Residential	Code for Sustainable Homes - Fabric Energy Efficiency. SAP 2012[1].	Code for Sustainable Homes - Fabric Energy Efficiency. SAP 2012.
	General office	Max Fordham Sustainability Matrix for Offices[2].	Max Fordham Sustainability Matrix for Offices.
	Retail - supermarket	CIBSE Guide F[3].	CIBSE Guide F.
	Retail - restaurant	CIBSE Guide F.	CIBSE Guide F.
	Retail - large non-food shop	CIBSE Guide F.	CIBSE Guide F.
Best Practice	Residential	Code for Sustainable Homes - Fabric Energy Efficiency. SAP 2012.	Code for Sustainable Homes - Fabric Energy Efficiency. SAP 2012.
	General office	Max Fordham Sustainability Matrix for Offices.	Max Fordham Sustainability Matrix for Offices.
	Retail - supermarket	CIBSE Guide F.	CIBSE Guide F.
	Retail - restaurant	CIBSE Guide F.	CIBSE Guide F.
	Retail - large non-food shop	CIBSE Guide F.	CIBSE Guide F.
Pioneering Practice	Residential	Passivhaus[4].	Passivhaus.
	General office	Max Fordham Sustainability Matrix for Offices.	Max Fordham Sustainability Matrix for Offices.
	Retail - supermarket	CIBSE Guide F.	CIBSE Guide F.
	Retail - restaurant	CIBSE Guide F.	CIBSE Guide F.
	Retail - large non-food shop	CIBSE Guide F.	CIBSE Guide F.

Source: As indicated in table. Atkins analysis.

The residential energy demand scenarios have been calculated by considering 1, 2 and 3 bedroom apartments (see Table B.1.3)[5]. The heating demand was referenced from the Fabric Energy Efficiency (FEE) scale from Code for Sustainable Homes (2014). Minimum and maximum standards within FEE scale were referenced for Standard Practice and Best Practice scenarios respectively. Lighting, Domestic Hot Water and Small Power loads were referenced from the SAP (2012) calculation methodology for both for Standard Practice and Best Practice scenarios. The Best Practice scenario incorporated improved lighting efficiency. The Pioneering Practice scenario was referenced from the Passivhaus standard.

Table B.1.3 – Residential Building Assumptions

Building Property	1 bed	2 bed	3 bed
Gross Internal Area (GIA) (m^2)	54	74	90
Occupancy (N)	2	3	4
Proportion	0.3	0.45	0.25
Dwelling Numbers	7,721	11,582	6,434
Total GIA (m^2)	**416,939**	**857,042**	**579,083**

Source: OPDC draft masterplan data. Atkins analysis.

[1] The Government's Standard Assessment Procedure for Energy Rating of Dwellings, Building Research Establishment / Department for Energy and Climate Change. 2012. (http://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf)
[2] Green Offices Sustainability Matrix. Max Fordham, 2010. (http://www.maxfordham.com/assets/media/images/publications/Sustainability%20-%20Refurbished%20offices/ OFFICES_matrix_website_download.pdf).
[3] CIBSE Guide F: Energy efficiency in buildings. Chartered Institute of Building Services Engineers, Cheshire D., Butcher K., 2012.
[4] Passivhaus Research Project, Passivhaus Trust, January 2015.
[5] Due to uncertainty regarding building typologies and totals for existing homes, scenarios include new homes only.

Office demand scenarios have been referenced from Max Fordhams' Sustainability Matrix for Offices (see Table B.1.2 above for reference sources). Standard Practice, Best Practice and Pioneering practice demand scenarios have been generated with 'minimum standard', 'best practice' and 'pioneering' standards from Max Fordham respectively.

Retail demand scenarios have been referenced from CIBSE Guide F benchmarks. Standard Practice and Best Practice scenarios for retail have been estimated by referencing 'typical' and 'good practice' benchmarks from CIBSE Guide F respectively. The Best Practice retail scenario has been generated by referencing the 'good practice' benchmark from CIBSE Guide F, with improved lighting efficiency.

The above benchmarks formed the basis for estimated fossil thermal and electrical figures for total delivered energy. Using these figures, building-specific energy demand estimates were derived. To calculate the building specific loads by use, the thermal and electrical loads were divided according to DBEIS UK energy consumption data[6], as shown in Table B.1.4. Following this, in order to convert the delivered energy in energy demand, a set of services efficiencies was assumed.

Table B.1.4: Assumed Building-Specific Delivered Load Breakdown with Efficiencies

Building Type	Specific Building Type	Fossil-Thermal	Electrical				
		Heating	DHW	Cooling	Aux	Light	Equipment
Office	General office	89%	11%	13%	8%	17%	62%
Retail	Large food shops	98%	2%	1%	7%	15%	78%
	Large non-food shops	95%	5%	5%	6%	70%	19%
	Retail warehouse	99%	1%	9%	5%	70%	16%
Efficiency assumed for services		90%	90%	COP = 5	100%	100%	100%

Source: Department of Business, Energy and Industrial Strategy. Atkins analysis.

Park Royal

Park Royal energy demand scenarios include industrial, retail and office building types[7], and have been defined as Standard Practice and Best Practice. Table B.1.5 provides a summary of the two scenarios. The different benchmark sources used for each scenario are shown in Table B.1.6 below.

Table B.1.5 – Summary of Park Royal Energy Demand Scenarios

Energy Demand Scenario	Summary
Standard Practice	For non-industrial, represents current UK average sector-wide performance: • Residential: building fabric specification to meet minimum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes. Lighting, small power and hot water as per SAP 2012 calculation methodology. • Office and retail: represents current sector benchmarked performance. For industrial, represents assumed current performance in Park Royal based on national average benchmarks.
Best Practice	For non-industrial, represents current UK best practice, improving on the Standard Practice scenario via: • Residential: building fabric specification to meet maximum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes: enhanced fabric insulation, reduced air leakage, optimised solar shading. Improved lighting. Small power and hot water as per SAP 2012 calculation methodology. • Office: higher thermal performance building shell, higher air tightness, energy efficient ventilation, daylighting combined with solar shading. • Retail: Average better performing facilities, based on measured data. For industrial, incorporates improvements on Standard Practice scenario with retrofitting of industrial buildings.

Note: all scenarios relate to regulated and unregulated energy.
Source: Atkins analysis.

[6] Energy Consumption in the UK. Department for Business, Energy & Industrial Strategy, 2016. (https://www.gov.uk/government/collections/energy-consumption-in-the-uk).

[7] Due to uncertainties regarding building typologies, scenarios do not include new homes in Park Royal.

Table B.1.6 – Old Oak Energy Demand Scenarios References

Demand Scenario	Building Type	Electricity	Fossil Thermal
Standard Practice	General office	Max Fordham Sustainability Matrix for Offices[8].	Max Fordham Sustainability Matrix for Offices.
	Retail - supermarket	CIBSE Guide F[9].	CIBSE Guide F.
	Retail - restaurant	CIBSE Guide F.	CIBSE Guide F.
	Retail - large non-food shop	CIBSE Guide F.	CIBSE Guide F.
	Industrial	Energy Consumption Guide 18[10]. Park Royal Atlas[11].	Energy Consumption Guide 18. CIBSE Guide F. Park Royal Atlas.
Best Practice	General office	Max Fordham Sustainability Matrix for Offices.	Max Fordham Sustainability Matrix for Offices.
	Retail - supermarket	CIBSE Guide F.	CIBSE Guide F.
	Retail - restaurant	CIBSE Guide F.	CIBSE Guide F.
	Retail - large non-food shop	CIBSE Guide F.	CIBSE Guide F.
	Industrial	Energy Consumption Guide 18; Park Royal Atlas.	Energy Consumption Guide 18; CIBSE Guide F. Park Royal Atlas.

Source: As indicated in table. Atkins analysis.

Energy demand estimates for office and retail uses have been calculated as per Old Oak approach above.

The Standard Practice energy demand scenario for industrial uses was estimated by generating a load scenario proportional to Table 4.04 of *Energy Consumption in the UK* spreadsheet produced by DBEIS. This spreadsheet covers several different types of manufacturing and other industrial activities. The DBEIS derived energy demand figures for the Standard Practice scenario were then proportioned to Park Royal areas in line with the Park Royal Atlas reference. For this purpose, the CIBSE Guide F fossil fuel benchmark for industrial buildings was also used. The Best Practice scenario for industrial uses was estimated proportional to the Standard Practice using proportions from the Energy Consumption Guide 18 (BRE).

Table B.17: Park Royal Energy Standard Practice Energy Demand Scenario: Assumed Industrial Demand by Use Type and Energy Type

Industrial Use Type	Natural Gas (kWh/yr/m^2)	Electricity (kWh/yr/m^2)
High temperature process	26.98	8.29
Low Temperature Process	198.34	76.53
Drying / Separation	64.23	27.99
Motors	-	136.66
Compressed Air	-	42.96
Lighting	-	13.00
Refrigeration	-	25.81
Space Heating	96	-
Other	48.52	17.31
TOTAL	**144.5**	**56.10**

Source: Department of Business, Energy and Industrial Strategy. Atkins analysis.

Low Carbon Energy Supply Scenarios

To explore the potential onsite low carbon energy supply achievable, and test the degree to which onsite demand could be met by low carbon energy supply, a set of low carbon energy supply scenarios was developed, based on proven, well-established technologies. Low carbon technology scenarios explored included three types of renewables, summarised in Table B.18. The set of scenarios explored was intended to be indicative rather than exhaustive. Due to time and resource constraints it was not possible to analyse the full range of potential sources of onsite or near offsite energy supply. Some of these offer considerable potential for deployment at the OPDC site; in particular, extraction of low grade heat from water bodies, including the Grand Union Canal, and sewerage mains, as well recovery of waste heat from industrial processes, transport and electrical grid infrastructure, large retail facilities, offices and data centres. Further study is

[8] Green Offices Sustainability Matrix. Max Fordham, 2010. (http://www.maxfordham.com/assets/media/images/publications/Sustainability%20-%20Refurbished%20offices/ OFFICES_matrix_website_download.pdf).
[9] CIBSE Guide F: Energy efficiency in buildings. Chartered Institute of Building Services Engineers, Cheshire D., Butcher K., 2012.

[10] Energy Consumption Guide 18 - Energy Efficiency in Industrial Buildings and Sites, Department of the Environment/Action Agency, 1998.
[11] The Park Royal Atlas, Greater London Authority, Williams F. et al, 2014. (https://www.london.gov.uk/sites/default/files/Park%20Royal%20Atlas%20Screen%20Version%201.1_0.pdf

recommended to explore the potential of these energy source options in Old Oak and Park Royal.

Table B.1.8 – Onsite Renewable Energy Technologies

Renewable Energy Technology	Summary
Solar photovoltaic (PV)	A solar PV deployment scenario has been developed for both Old Oak and Park Royal. In both cases it is assumed that 35% of the total roof area is excluded for access and maintenance, and a further 15% of the remaining roof space would be occupied by roof equipment. In the case of Old Oak, a further 25% of the remaining roof space has been assumed to be over-shaded by higher buildings, thus limiting the effectiveness of solar PV deployment. Of the remaining roof space, assumed to be available for solar energy generation, 70% has been assumed for deployment of solar PV panels. The assumed conversion efficiency of solar PV panels is based on an average value for units readily available in the UK market.
Solar thermal	From the available roof space for solar PV estimated above, the remaining roof space not occupied by solar PV (30%) has been assumed for deployment of solar thermal panels. The assumed conversion efficiency of solar thermal panels is based on an average value for units readily available in the UK market.
Ground source heat pumps (GSHP)	The GSHP scenario assumes deployment of borehole fields in six of the main public open spaces in Old Oak, equating to a total area of 26,500 m2. This scenario assumes coefficients of performance of 3 for heating and 3.5 for cooling, with GSHP units providing year round heating / cooling output.

Source: Atkins analysis.

Table B.1.9 below sets out indicative estimates of potential energy generation for each renewable energy technology considered, together with further details on assumptions used for each.

Table B.1.9 - Potential Onsite Renewable Energy Generation

Low Carbon Energy Technology	Area and Unit	Energy Generation (MWh/yr)		Indicative Total Capacity (MWp)	Assumptions
		Thermal	Electrical		
Solar Photovoltaic	Old Oak: 131,470; m^2 panels. Park Royal 501,163; m^2 panels	0	81,700	85	• Available roof area = roof area, cumulatively less: 35% (access/ maintenance); 25% (shading – Old Oak only); 15% (roof equipment). • Park Royal: roofs <60m^2 excluded. • PV panel deployment area = 70% available roof area. • Solar radiation: 950kWh/m^2/yr. • Polycrystalline panels • South orientation, 30º pitch roof mounted • 15% system conversion efficiency • Inverter loss: 10%
Solar Thermal	Old Oak: 56,344; m^2 collectors. Park Royal: 216,070m^2 collectors	103,500	0	110	• Available roof area = per photovoltaic • Solar thermal collector deployment area = 30% available roof area. • Solar radiation: 950kWh/m^2/yr. • Evacuated tube panels. • South orientation, 30º pitch roof mounted. • Collection efficiency: 40%.
Ground Source Heat Pumps	Old Oak: 26,586m^2; borehole fields	3,700	-1,400	20	• Borehole depth: 130m; borehole separation: 5m • 3,462kWh / yr / borehole. • COP: 3 (heating); 3.5 (cooling) • Dual function heat pumps: heating and cooling • Cooling load offsets electrical cooling. Less electrical consumption.

Note: All figures are indicative estimates only. MWh: Megawatt hour. MWp: Megawatt peak.
Sources: Atkins analysis.

In addition to onsite renewables, a set of scenarios was developed to explore potential energy from waste and AD from onsite arisings. These scenarios were based on the waste stream scenarios developed under the Waste topic below, identifying waste types and quantities (in tonnes) for Old Oak and Park Royal (see Table B.1.10 below). Using gross calorific values applied to each waste stream, an incineration energy from waste production scenario was developed, and referenced from World Bank Technical Guidance[12] to have 20% energy recovery efficiency for electrical and 65% for thermal generation. Electrical energy generation from anaerobic digestion was estimated based on analysis of Atkins projects and assuming gas turbine technology with electrical efficiency of 35%.

Table B.1.10 – Waste Stream Scenarios

Waste Stream Scenario		Summary
Business as Usual	Old Oak	Based on current practice in London, a high percentage of waste combustion is assumed and below average recycling rates, compared to other England regions. A significant landfill disposal rate is also assumed.
	Park Royal	Based on current practice in London, assumes around a third of waste is recycled with similar proportion to Old Oak sent to landfill and the remainder combusted.
Zero Waste	Old Oak	Based on London Plan requirements, a very low landfill disposal rate is assumed, together with high recycling rates and minimal waste combustion.
	Park Royal	N/A
Low Waste	Old Oak	N/A
	Park Royal	Based on London Plan requirements, assumes a higher rate of recycling, and lower rates of landfill and combustion compared to business as usual scenario.

Note: Information in this table is reproduced from the Waste topic in this report below.
Source: Atkins analysis.

A heat led CHP scenario has been assumed to cover 40% of the total annual heat demand of Old Oak and Park Royal developments. The assumed conversion efficiency is 90% with heat to power ratio of two (60% efficiency for thermal and 30% for electrical). In order to estimate the annual savings, the CHP scenario was compared against a notional 100% boilers scenario (90% efficiency assumed).

Table B.1.11 below sets out the indicative estimates of potential energy generation for each waste stream scenario considered, together with associated waste input volumes and further details on assumptions used for each.

Table B.1.11 – Potential Energy from Waste Generation

Low Carbon Energy Technology – Waste Scenario	Total Waste Input (KTPA)	Energy Generation (MWh/yr)				Indicative Total Power Capacity (MWp)	Assumptions
		Old Oak		Park Royal			
		Thermal	Elec-trical	Thermal	Elec-trical		
Energy from Waste							
Business-as-Usual	Old Oak: 39.0 Park Royal: 12.4	66,000	20,300	18,800	5,800	3	CHP – 20% electrical efficiency; 65% thermal efficiency
Zero Waste / Low Waste	Old Oak: 15.8 Park Royal: 5.5	28,600	8,800	8,600	2,700	1.25	CHP – 20% electrical efficiency; 65% thermal efficiency
Anaerobic Digestion							
Business-as-Usual	Old Oak: 3.4 Park Royal: 0.7		1,100		200	0.2	Gas turbine – 35% electrical efficiency
Zero Waste / Low Waste	Old Oak: 12.9 Park Royal: 2.6		4,200		500	1	Gas turbine – 35% electrical efficiency

Note: All figures are indicative estimates only. KTPA: Kilotonnes per annum. MWp: Megawatt peak.
Sources: Atkins analysis.

Due to the density and compactness of the development at Old Oak, and the lack of open space at Park Royal, deployment of wind turbine technology was considered problematic and unlikely to meet more than a very small proportion of electrical demand. It was not possible to cover water source and sewerage

[12] Municipal Solid Waste Incineration: Requirements for a Successful Project, Technical Paper No. 462, World Bank, June 2000.

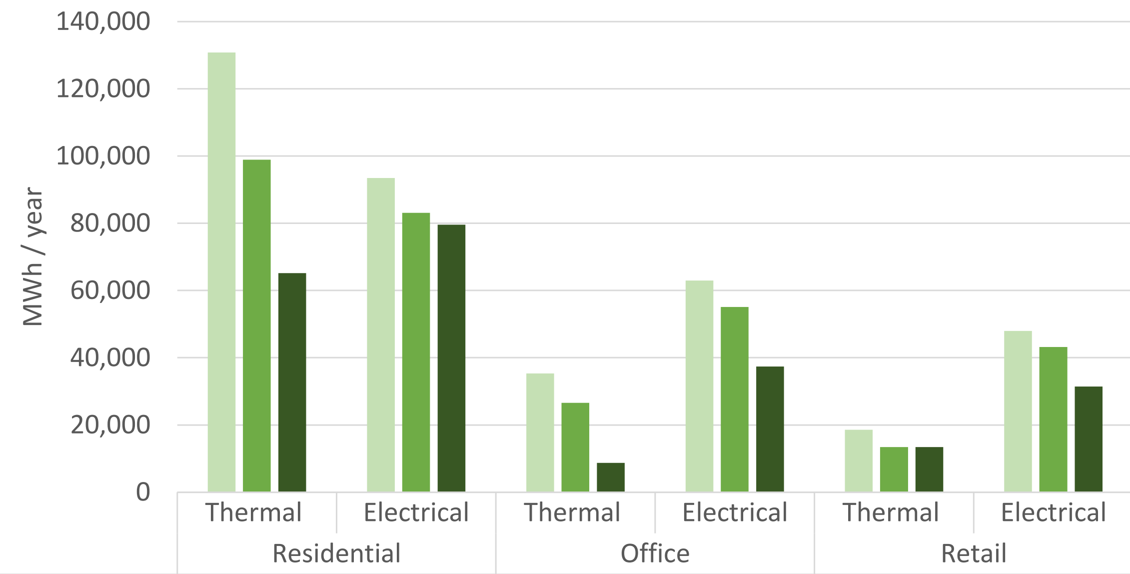
source heat pump technology in the energy analysis, both of which offer considerable potential for the OPDC site. Sewerage source heat pumps represent particular potential, given the density of the development and the dominance of residential uses. The requirement to achieve ‘water neutrality’ for the development (see the Water section below) means that wastewater flows to the sewer system may be lower than with a more conventional development, thereby reducing the potential available energy for sewerage source heat exchangers. However, flows in the wider sewer system should also be considered. Other heat sources with potential for heat pump technology application include warm air from underground rail ventilation systems, power sub-stations and building exhaust air. It is recommended that the energy generation potential from all feasible heat sources should be explored with further analysis.

Results of Analysis

Old Oak

Operational energy estimates for the three energy demand scenarios are summarised in Figure B.1.1. The figures show very substantial reduction in demand from the Standard Practice scenario to the Pioneering Practice scenario: around 53% for thermal demand and around 27% for electrical demand; approximately 39% overall, across all land use types. While the largest percentage reduction is for office thermal demand (75%), the largest absolute reduction is for residential thermal (around 66GWh / year).

Figure B.1.1 – Old Oak - Estimated Energy Demand by Land Use Type



	Residential		Office		Retail	
	Thermal	Electrical	Thermal	Electrical	Thermal	Electrical
Standard practice	130,800	93,500	35,300	63,000	18,600	48,000
Best Practice	98,900	83,100	26,600	55,100	13,400	43,200
Pioneering Practice	65,200	79,600	8,700	37,400	13,400	31,400

Note: All figures are indicative estimates only.
Source: Atkins analysis.

Figures B.1.2 – B.1.5 provide a breakdown of estimated energy demand percentages by land use type and energy type for the Standard Practice scenario. The results show the clear dominance of residential thermal in the overall load, with residential electrical and office electrical the next largest loads. Clearly, a focus on reducing these loads is likely to have the greatest impacts on overall load reduction. The residential thermal load is reduced by around 50% from the Standard Practice to the Pioneering Practice scenario (see Figure B.1.1 above), second only to reduction in office thermal load (75%). However, residential electrical load is reduced by only around 15% between the Standard and Pioneering Practice scenarios.

ATKINS

Figure B.1.2 – Old Oak - Estimated Total Electrical Energy Demand by Land Use Type – Standard Practice

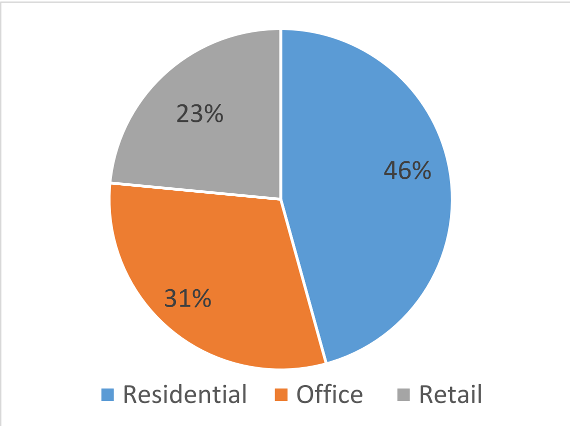


Figure B.1.3 – Old Oak - Estimated Total Thermal Energy Demand by Land Use Type – Standard Practice

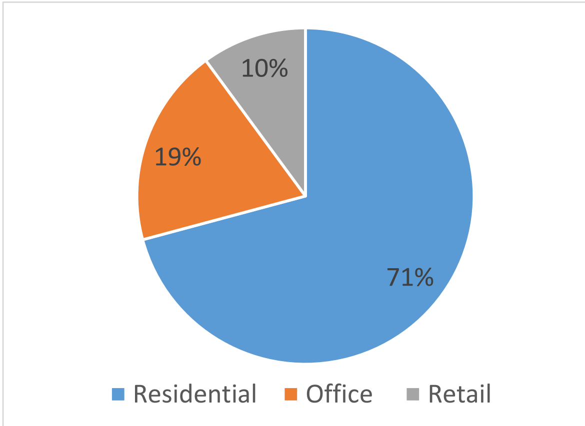


Figure B.1.4 – Old Oak - Estimated Total Energy Demand by Land Use Type – Standard Practice

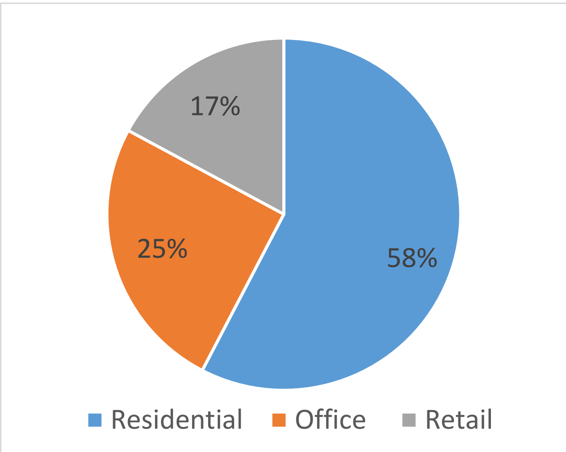
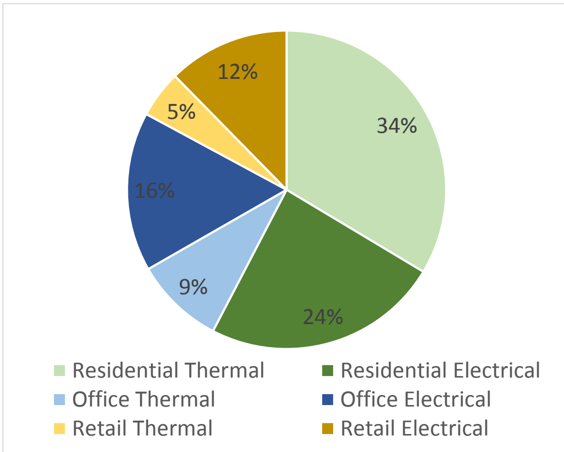


Figure B.1.5 – Old Oak - Estimated Total Electrical and Thermal Demand Energy Demand by Land Use Type – Standard Practice



Source (all figures): Atkins analysis.

Figure B.1.6 and Table B.1.12 provide a summary of the balance between energy demand and onsite low carbon supply, split between thermal and electrical components. Onsite supply is further split between renewable energy and energy from waste / AD. Two estimates for the latter are given, based on the two scenarios developed for the waste analysis: Business as Usual (BAU) and Zero Waste. The Waste section below provides further details on the waste estimates calculated for these scenarios. The energy balance analysis shows that renewable energy alone could offset around 12% of demand under the Standard Practice scenario and around 19% of demand under the Pioneering Practice scenario. Adding potential supply from energy from waste / AD under the BAU and Zero Waste scenarios, respectively to the Standard Practice and Pioneering Practice energy demand scenarios, indicates that onsite low carbon energy could potentially offset approximately 22% (Standard Practice energy demand and Zero Waste scenarios) and 37% (Pioneering Practice energy demand and Zero Waste waste scenarios) of total energy demand.

Table B.1.12 – Old Oak Energy Demand Scenarios and Low Carbon Energy Supply

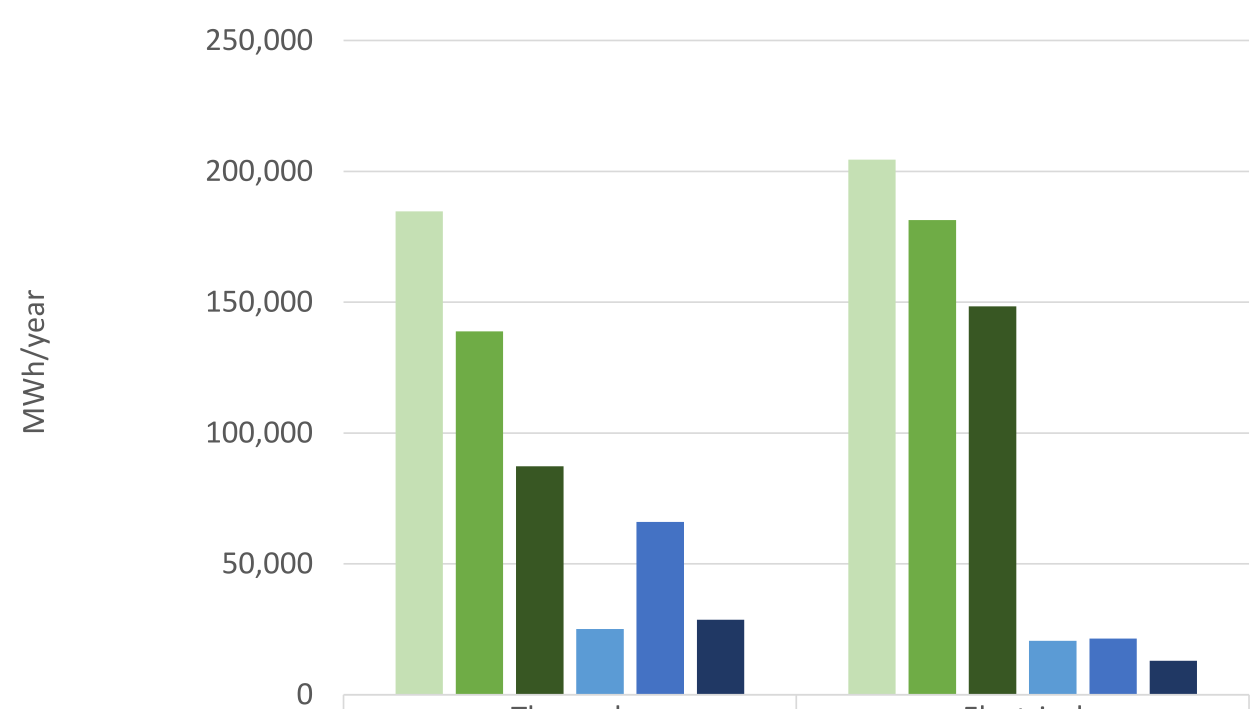
Energy Demand		Low Carbon Supply (MWh/yr)		Percentage of Demand		
Scenario	MWh/yr	1 - Onsite Renewables	2 - EfW / AD (Zero Waste)	1	2	1 + 2
Standard Practice	389,200	45,700	41,600	12	11	22
Best Practice	320,300			14	13	27
Pioneering Practice	235,700			19	18	37

Note: All figures are indicative estimates only. EfW: Energy from waste. AD: Anaerobic digestion.
Source: Atkins analysis.

The analysis indicates that meeting the current Mayoral requirement for 25% of energy demand from localised distributed energy systems is potentially achievable based on deployment of a mix of renewable energy generation and energy from waste / AD facilities. Meeting the current Mayoral requirement with renewable energy alone would be more challenging and would entail a very substantial reduction in building energy consumption, compared to the Standard Practice energy demand scenario. However, the requirement from October 2016 for all new major development to be zero carbon (residential uses) or 35% below Building Regulations Part L 2013 (non-residential uses) is likely to provide strong incentives to optimally reduce energy demand across all building types as well as optimise deployment of renewable energy, thus making achievement of the 25% localised distributed energy requirement based on non-fossil based generation more feasible. Deploying distributed generation plant utilising local secondary heat sources as part of a multiple-source local heating network would be likely to considerably increase the feasibility of meeting the current Mayoral target.

While onsite gas-fired CHP led distributed energy systems could meet a substantial proportion of both thermal and electrical demand (anticipated at around 40% of thermal and 21% of electrical demand given the scenario assumptions outlined above) the limited short term carbon savings would mean such a system would likely need to be rapidly switched to alternative combustion fuel, i.e. biofuel or waste, to avoid negative carbon savings given projected grid decarbonisation. Designing a CHP led system to be fired from locally available waste streams would appear to offer a more feasible low carbon solution in the medium to long term.

Figure B.1.6 – Old Oak - Estimated Energy Balance for Whole Development



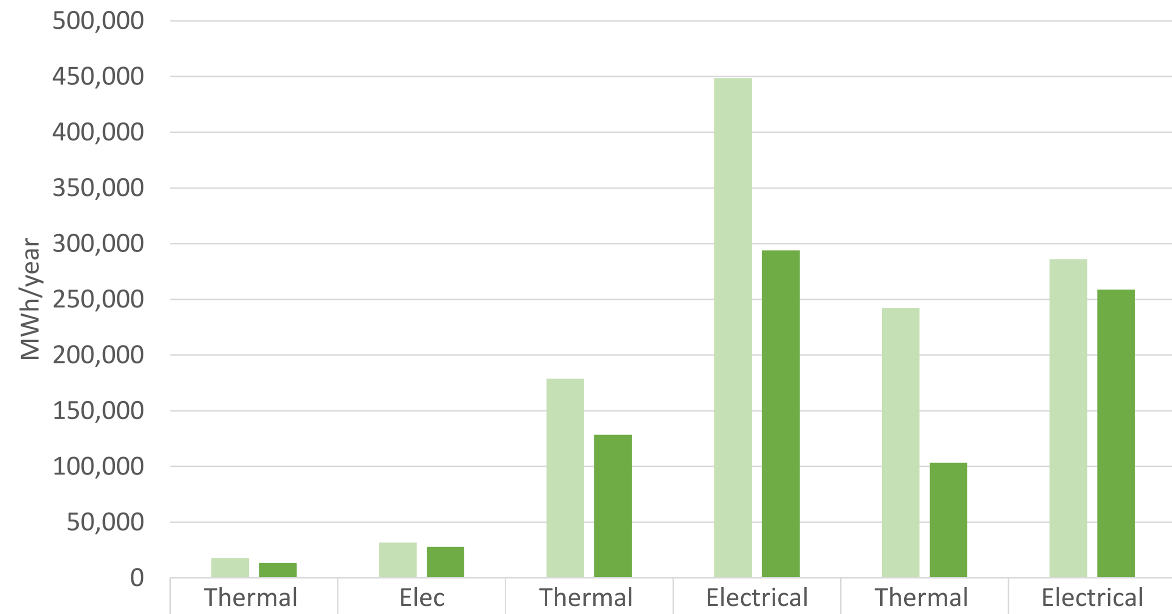
	Thermal	Electrical
Standard Practice	184,700	204,500
Best Practice	138,900	181,400
Pioneering Practice	87,300	148,400
Onsite RE	25,100	20,600
EfW / AD - BAU	66,000	21,400
EfW / AD - Zero Waste	28,600	13,000

Note: All figures are indicative estimates only. EfW: Energy from waste. AD: Anaerobic digestion. BAU: Business as Usual
Source: Atkins analysis.

Park Royal

Figure B.1.7 summarises operational energy estimates for the two energy demand scenarios for Park Royal. The figures show significant reduction in demand from the Standard Practice scenario to the Best Practice scenario: around 44% for thermal demand and around 24% for electrical demand; approximately 31% overall, across all land use types. While the largest percentage reduction is for industrial thermal demand (57%), the largest absolute reduction is for retail electrical (around 155GWh / year). The lowest percentage reduction is for industrial electrical (10%).

Figure B.1.7 – Park Royal - Estimated Energy Demand by Land Use Type



	Office		Retail		Industrial	
	Thermal	Elec	Thermal	Electrical	Thermal	Electrical
Standard Practice	17,800	31,700	178,700	448,600	242,200	286,000
Best Practice	13,400	27,800	128,500	293,900	103,200	258,800

Note: All figures are indicative estimates only.
Source: Atkins analysis.

Figures B.1.8 – B.1.11 provide a summary of energy demand percentages estimated by land use type and energy type for the Standard Practice scenario for Park Royal. The results suggest that retail electrical and industrial electrical loads are the highest in the overall load scenario. Therefore, a focus on reducing these loads is likely to have the greatest impacts on overall load reduction.

Figure B.1.8 – Park Royal - Estimated Total Electrical Energy Demand by Land Use Type – Standard Practice

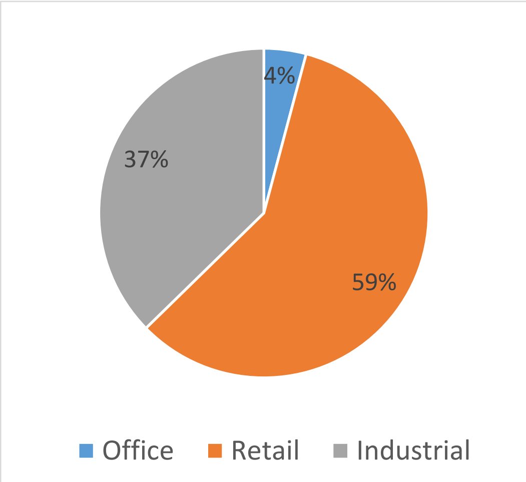


Figure B.1.9 – Park Royal - Estimated Total Thermal Energy Demand by Land Use Type – Standard Practice

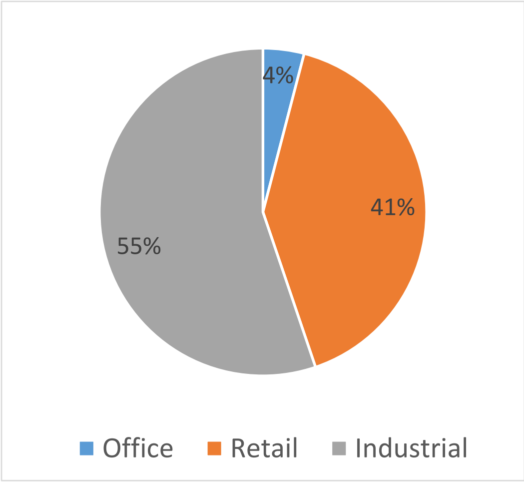


Figure B.1.10 – Park Royal - Estimated Total Energy Demand by Land Use Type – Standard Practice

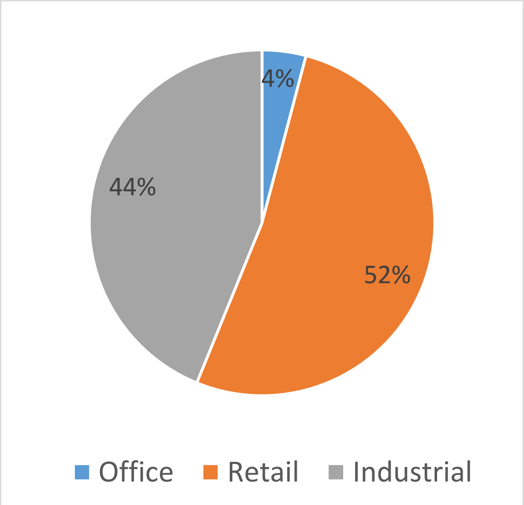
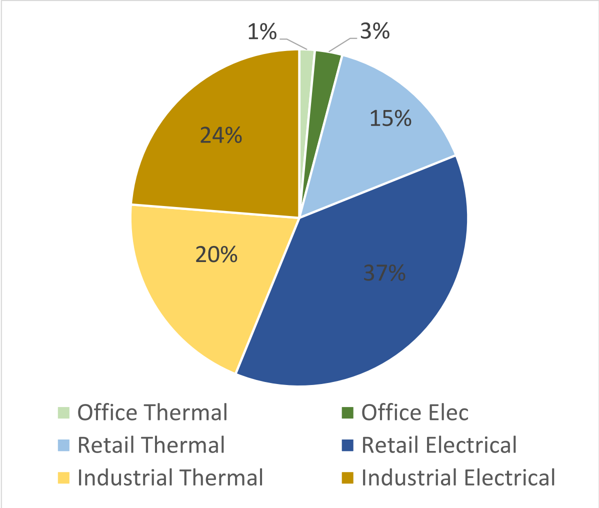


Figure B.1.11 – Park Royal - Estimated Total Electrical and Thermal Demand Energy Demand by Land Use Type – Standard Practice



Source (all figures): Atkins analysis.

Figure B.1.12 and Table B.1.13 provide a summary of the balance between energy demand and onsite low carbon supply, split between thermal and electrical components. Onsite supply is further split between renewable energy and energy from waste. A similar approach to Old Oak to estimating the energy from waste has been implemented. Table B.1.13 indicates that around 14% of the demand under the Standard Practice scenario could potentially be offset by renewables only. If combined with potential supply of energy from waste, analysis results indicate that onsite low carbon energy could potentially offset approximately 16% (Standard Practice energy demand and Low Waste waste scenarios) and 23% (Best Practice energy demand and Low Waste waste scenarios).

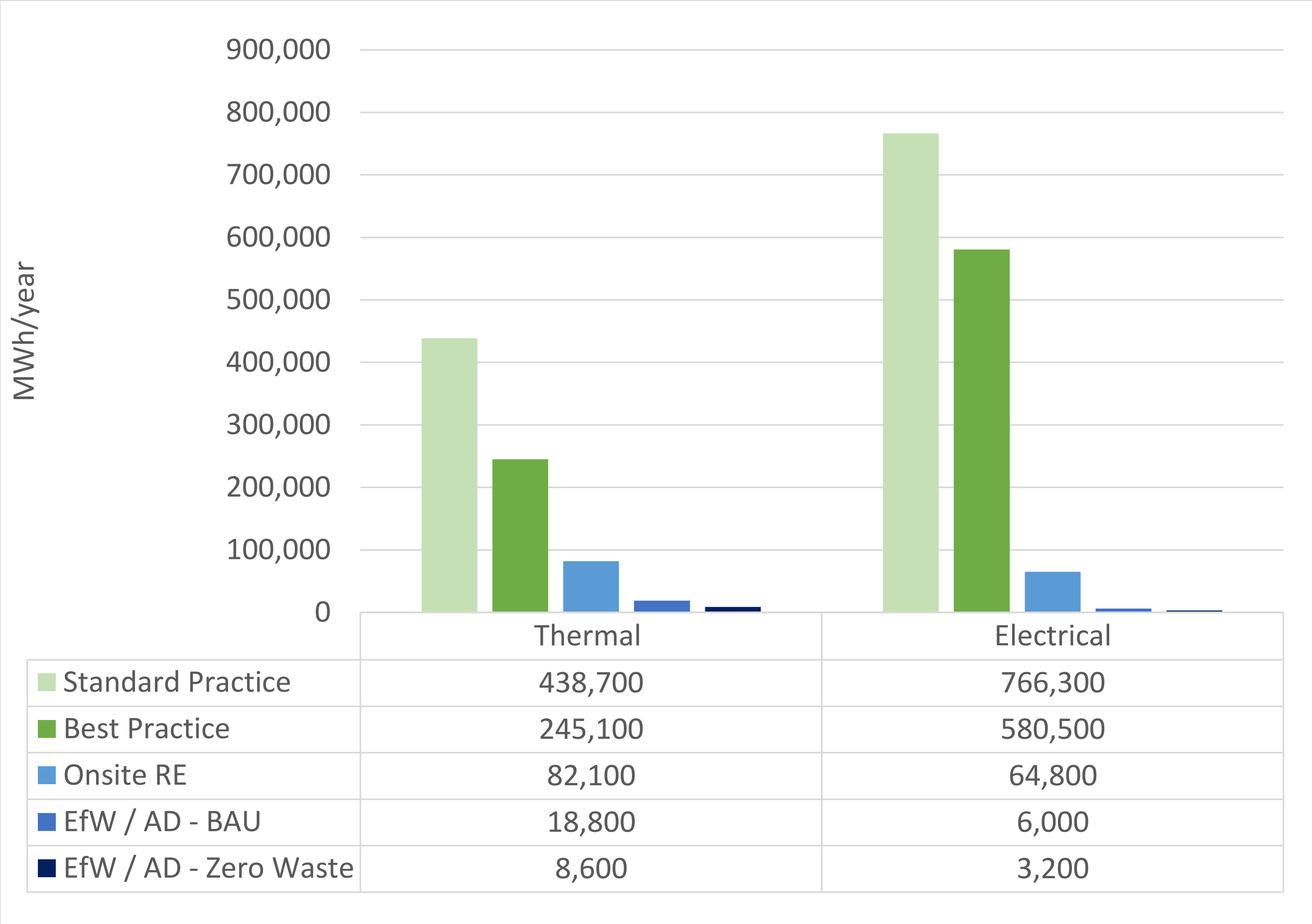
Table B.1.13 – Park Royal Energy Demand Scenarios and Low Carbon Energy Supply

Energy Demand		Low Carbon Supply (MWh/yr)		Percentage of Demand		
Scenario	MWh/yr	1 - Onsite Renewables	2 – EfW / AD (Low Waste)	1	2	1 + 2
Standard Practice	1,205,000	146,900	11,800	12	1	13
Best Practice	825,600			18	1	19

Note: All figures are indicative estimates only. EfW: Energy from waste. AD: Anaerobic digestion.
Source: Atkins analysis.

The analysis indicates that meeting the current Mayoral requirement for 25% of energy demand from localised distributed energy systems from renewables only would be challenging and would require implementation of energy reduction measures going beyond the Best Practice scenario. The combined renewables and energy from waste / AD scenario would still require improvement beyond the Best Practice scenario.

Figure B.1.12 – Park Royal - Estimated Energy Balance for Whole Development



Note: All figures are indicative estimates only.
Source: Atkins analysis.

Indicative Costs

Table B.1.14 below sets out estimated indicative capital cost uplifts[13], relative to the Standard Practice scenario, for the Best Practice and Pioneering Practice energy demand scenarios developed for Old Oak. It should be emphasised that these estimates are based on desktop research, and thus should be treated as purely indicative only, with a considerable degree of uncertainty, and subject to further verification and analysis. It should also be noted that indicative cost uplifts are based on a several building types, including residential and non-residential, none of which included high rise buildings.

Table B.1.14 – Old Oak Energy Demand Scenario Indicative Cost Uplifts Relative to Standard Practice Scenario

Demand Scenario	Cost Uplift	Sources
Best Practice	3 – 20%; Average: 12.5%	Max Fordham[14]; Atkins[15]; SHINE Network[16]
Pioneering Practice	9 – 30%; Average: 19%	Passivhaus Trust[17]; Passive House Plus[18]

Note: All figures are indicative estimates only.
Sources: As indicated in table.

Indicative estimated capital costs[19] for the low carbon energy generation technologies included in the Old Oak and Park Royal energy analysis described above are set out in Table B.1.15 below.

Table B.1.15 – Low Carbon Energy Technology Indicative Costs

Low Carbon Energy Technology	Cost (£ / kWp capacity)			Sources	Assumptions
	Low	High	Average		
Solar Photovoltaic	800	2,100	1,300	DECC[20]; Atkins analysis	Polycrystalline panels, roof mounted, 30o pitch.
Solar Hot Water	1,000	2,100	1,700	DECC[21]; Atkins analysis	Evacuated tube panels, roof mounted, 30o pitch
Ground Source Heat Pumps	600	2,400	1,500	DECC[22]; Atkins analysis	Coupled ground heat exchanger with up to 130m deep borehole. High cost variability. Cost per kW highly dependent on size of installation.
Energy from Waste	5,500	9,100	6,700	Defra[23]; Atkins analysis	Electricity generation only.
Anaerobic Digestion	2,800	8,100	5,500	DECC[24]; Atkins analysis	Electricity generation only.

Note: All figures are indicative estimates only. kWp: Kilowatt peak.
Sources: As indicated in table.

13 Indicative demand scenario cost uplifts are based on total construction costs.
14 High Level Feasibility Study for a University College, Confidential Client, UK, July 2016.
15 High Level Feasibility Study for a University College, Confidential Client, UK, August 2016.
16 Sustainability Budgeting: A guide to using whole life costing in sustainable procurement, SHINE Network, 2009.
17 Passivhaus Research Project, Passivhaus Trust, January 2015.
18 Passive House Plus, Issue 3, June 2013: The Cost of Building Passive.
19 Costs are based on references issued between 2013 and 2015. Thus, there is some variation in certainty of cost estimation.
20 Small-Scale Generation Cost - Update, Department of Energy and Climate Change, August 2015.
21 Research on the costs and performance of heating and cooling technologies, Department of Energy and Climate Change, February 2013.
22 Research on the costs and performance of heating and cooling technologies, Department of Energy and Climate Change, February 2013.
23 Incineration of Municipal Solid Waste, Department of Environment, Food and Rural Affairs, February 2013.
24 Small-Scale Generation Cost - Update, Department of Energy and Climate Change, August 2015.

The figures in Table B.1.15 indicate energy from waste generation is considerably more expensive, on a kW peak basis, than the three renewable energy technologies analysed. However, when taking into account typical capacity factors[25] the capital cost per capacity factored kilowatt peak for the highest cost energy from waste technology is potentially similar to that of the lowest cost renewable energy technology (solar photovoltaic).

Table B.1.16 shows indicative costs for each low carbon technology scenario together with indicative unit costs.

Table B.1.16 – Low Carbon Energy Technology Indicative Scenario and Unit Costs

Low Carbon Energy Technology	Cost (£)		Total Cost (£)	Indicative Unit Cost (£ / New Home)*
	Old Oak	Park Royal		
Solar Photovoltaic	23,400,000	87,100,000	110,500,000	900
Solar Hot Water	39,100,000	147,900,000	187,000,000	1,500
Ground Source Heat Pumps	30,000,000	-	30,000,000	1,200
Energy from Waste – Business As Usual	16,750,000	3,350,000	20,100,000	700
Anaerobic Digestion – Business as Usual	825,000	275,000	1,100,000	30
Energy from Waste – Zero Waste	6,700,000	1,675,000	8,375,000	300
Anaerobic Digestion – Zero Waste	2,750,000	2,750,000	5,500,000	100

Note: All figures are indicative estimates only. * Figures are for Old Oak only.

Sources: Per Table B.1.15. Atkins analysis.

[25] The capacity factor of energy generation equipment is the ratio of its actual output over a period of time to its potential output if it were possible for it to operate at full peak capacity continuously over the same period of time.

Appendix B.2 - Site Waste Scenarios Analysis

Introduction

Waste treatment / disposal scenarios were developed for Old Oak and Park Royal based on publicly available London and national data regarding waste arisings rates and composition for mixed use development and industrial parks, and treatment / disposal types defined by the UK Government in relation to estimation of carbon emissions.

The aim of developing these scenarios was to evaluate the overall resource and carbon efficiency of the two developments under different operational waste treatment / disposal environmental performance assumptions. The waste treatment / disposal scenarios were used to:

a) test the prerequisites for meeting current Mayoral policy / guidance requirements;

b) test the potential for exceeding current policy / guidance requirements, under different scenario assumptions; and

c) provide additional evidence for the policy recommendations and supporting strategy set out in Table 1 above.

The waste treatment / disposal scenarios were also used to support the carbon analysis (see Carbon topic below).

Waste Treatment / Disposal Scenarios

To explore the potential for deployment of resource and carbon efficient waste treatment technologies to process predicted waste streams associated with proposed development at Old Oak and Park Royal, a set of waste treatment / disposal scenarios was developed based on improvements to current Business as Usual practice.

Preliminary high-level estimates of predicted waste arisings were calculated for Old Oak and Park Royal (see next section). Waste treatment / disposal scenarios were then used to estimate the total quantities of waste associated with each treatment / disposal type, based on treatment / disposal types defined by the UK Government in relation to estimation of carbon emissions[26].

The waste treatment / disposal scenarios developed, and the assumptions underlying them, are described in Table B.2.1 below.

Table B.2.1 – Waste Treatment / Disposal Scenarios

Waste Treatment / Disposal Scenario		Summary
Business as Usual	Old Oak	Based on current practice in London, a high percentage of waste combustion is assumed and below average recycling rates, compared to other England regions. A significant landfill disposal rate is also assumed.
	Park Royal	Based on current practice in London, assumes around a third of waste is recycled with similar proportion to Old Oak sent to landfill and the remainder combusted.
Zero Waste	Old Oak	Based on London Plan requirements, a very low landfill disposal rate is assumed, together with high recycling rates and minimal waste combustion.
	Park Royal	N/A
Low Waste	Old Oak	N/A
	Park Royal	Based on London Plan requirements, assumes a higher rate of recycling, and lower rates of landfill and combustion compared to business as usual scenario.

Source: Atkins analysis.

Tables B.2.2 – B.2.5 set out the assumed waste stream apportionment to treatment / disposal technology for each scenario.

[26] 2012 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting, Department of Energy and Climate Change (DECC) and the Department for Environment, Food and Rural Affairs (Defra), May 2012.

ATKINS

Table B.2.2 – Old Oak Business as Usual Scenario: Waste Stream Apportionment Assumptions

Waste stream	Recycling	Incineration	Anaerobic Digestion	Composting	Landfill
Organics	0%	60%	20%	5%	15%
Paper and Cardboard	40%	40%	0%	0%	20%
Glass	40%	40%	0%	0%	20%
Plastics	40%	40%	0%	0%	20%
Metals	40%	40%	0%	0%	20%
Textiles	40%	40%	0%	0%	20%
Other	0%	70%	0%	0%	30%

Note: All figures are indicative estimates only.
Source: Atkins analysis.

Table B.2.3 – Old Oak Zero Waste Scenario: Waste Stream Apportionment Assumptions

Waste stream	Recycling	Incineration	Anaerobic Digestion	Composting	Landfill
Organics	0%	10%	80%	5%	5%
Paper and Cardboard	80%	15%	0%	0%	5%
Glass	80%	15%	0%	0%	5%
Plastics	80%	15%	0%	0%	5%
Metals	80%	15%	0%	0%	5%
Textiles	80%	15%	0%	0%	5%
Other	15%	80%	0%	0%	5%

Note: All figures are indicative estimates only.
Source: Atkins analysis.

Table B.2.4 – Park Royal Business as Usual Scenario: Waste Stream Apportionment Assumptions

Waste stream	Recycling	Incineration	Anaerobic Digestion	Composting	Landfill
Organics	0%	60%	20%	0%	20%
Paper and Cardboard	50%	40%	0%	0%	10%
Glass	50%	40%	0%	0%	10%
Plastics	50%	40%	0%	0%	10%
Metals	50%	40%	0%	0%	10%
Wood	50%	40%	0%	0%	10%
Textiles	50%	40%	0%	0%	10%
Rubber	50%	40%	0%	0%	10%
Inert	0%	0%	0%	0%	100%
WEEE	50%	40%	0%	0%	10%
Sludges	0%	0%	0%	0%	100%
Oil, Solvents, Chemical Wastes	0%	75%	0%	0%	25%
Mixed Household Waste	50%	40%	0%	0%	10%
Other	0%	75%	0%	0%	25%

Note: All figures are indicative estimates only.
Source: Atkins analysis.

Table B.2.5 – Park Royal Low Waste Scenario: Waste Stream Apportionment Assumptions

Waste stream	Recycling	Incineration	Anaerobic Digestion	Composting	Landfill
Organics	0%	15%	80%	0%	5%
Paper and Cardboard	80%	15%	0%	0%	5%
Glass	80%	15%	0%	0%	5%
Plastics	80%	15%	0%	0%	5%
Metals	80%	15%	0%	0%	5%
Wood	80%	15%	0%	0%	5%
Textiles	80%	15%	0%	0%	5%
Rubber	80%	15%	0%	0%	5%
Inert	0%	0%	0%	0%	100%
WEEE	80%	15%	0%	0%	5%
Sludges	0%	0%	0%	0%	100%
Oil, Solvents, Chemical Wastes	15%	80%	0%	0%	5%
Mixed Household Waste	80%	15%	0%	0%	5%
Other	15%	80%	0%	0%	5%

Note: All figures are indicative estimates only.
Source: Atkins analysis.

Waste Arisings Estimates

Preliminary high-level estimates of predicted waste arisings, identifying waste types and quantities (in tonnes), were calculated based on masterplan data on land uses supplied by OPDC for Old Oak and publicly available data together with data supplied by OPDC for Park Royal. Data on use characteristics, waste generation rates and composition from a variety of publicly available sources were also used to develop the waste arisings estimates. The sections below provide an overview of the methodologies used for the estimates for Old Oak and Park Royal.

Projected Population and Employment

In order to provide an estimate of future waste generation it is necessary to obtain details regarding the expected population and occupancy (i.e. permanent residents and transient workers) as well as the proposed land uses. Waste generation will be fundamentally linked to the quantity of people who occupy, work in, and visit Old Oak and Park Royal, as well as the type of buildings developed. Different land uses will result in varied rates of waste generation.

To provide a basis for calculating the waste arisings, information contained in the latest masterplan area schedule for Old Oak from OPDC, the Old Oak and Park Royal Industrial Land Review (2015) and Development Capacity Study (2016) have been used. These include assumed quantities of both existing and projected occupancy and employment. This information was augmented by updated estimates of dwellings, residential population and employment from OPDC received in January 2017.

Based on the above referenced information it has been assumed that development at Old Oak may result in an additional population of 63,525, occupying 25,737 new homes. A further allowance of 7,000 people associated with existing 2,800 homes has also been included as per the Draft Local Plan[27], amounting to an indicative total residential population for the development of some 70,500 and circa 28,500 homes.

For compositional purposes, it was also necessary to estimate the proportion of waste attributed to retail food establishments such as restaurants, including cafes and fast food outlets, as well as retail non-food outlets as this will affect the estimated proportion of food and packaging waste available (and which may influence treatment processes). It is assumed that as a mixed residential and commercial area, a proportion of the development will include suitable facilities for restaurants, fast food outlets, etc. Due to the lack of information within the area schedule this has been based on the ‘Employment by Sector’ averages published by the Office of National Statistics[29], and which assumes a split of ~56% retail (non-food) employment to ~44% retail (food) employment. The results of this for Old Oak are shown in Table B.2.6.

[27] Local Plan, Draft for Regulation 18 Consultation, OPDC, 2016.

Table B.2.6 - Old Oak Commercial / Retail Employment Estimates

Land Use Type	Employees
Office	60,780
Retail (Non-Food)[28]	2,370
Retail (Food)[28]	1,850
Total	**65,000**

Source: Office of National Statistics (ONS)[29]. OPDC[30].

As figures for existing employment expected to be retained on the Old Oak site are currently uncertain, it has been assumed that no existing employment will be retained. A residential population of 3,036 has been assumed for Park Royal, based on information received from OPDC. A summary of the estimated projected population and employment for both Old Oak and Park Royal is shown in the following tables.

Table B.2.7 - Old Oak Occupancy and Employment Estimates

Land Use Type	Projected Occupancy / Employment
Residential	70,525
Office	60,780
Retail (Non-Food)	2,370
Retail (Food)	1,850
Total	**135,525**

Source: ONS[29].. OPDC Old Oak Draft Masterplan.

Table B.2.8 – Park Royal Occupancy and Employment Estimates

Land Use Type	Existing Occupancy / Employment	Projected Occupancy/ Employment	Total Occupancy / Employment
Industrial	26,707	4,675	31,382
Office	1,113	-	1,113
Retail (Non-Food)	590	119	709
Residential	-	3,036	3,036
Total	**28,410**	**7,830**	**36,240**

Source: ONS[29]. OPDC Old Oak Draft Masterplan.

Waste Arisings Indices

To quantify the waste arisings, estimated kilograms of waste per capita per day indices, based on London municipal and commercial and industrial waste generation, have been applied to the estimated number of residents and employees proposed as part of the project, as defined in the previous tables. The indices and sources considered are shown in Table B.2.9. Note that the waste generation for commercial/ industrial establishments is likely to vary and therefore more detailed calculations should be undertaken for each individual element by the designer during the design stages to ensure suitable allocation to each building is provided.

Table B.2.9 – Summary of Indices Used

Land Use Type	Indices	Basis
Residential (Household Waste)	1.20 kg waste/ resident/ day 1,098 kg waste/ household	West London Waste Authority (2008/09) waste generation of 619,000 tonnes per annum, with total households of 564,000 and a population of 1,441,000[31].
Commercial (Commercial and Industrial Waste)	2.30 kg waste/ employee/ day	London commercial and industrial waste (2016) estimated to be 4,654,000[32] with employment[33] (2016) at 5,538,000.

Source: As indicated in table.

[28] Retail and restaurant assumptions based on Old Oak Draft Masterplan schedule retail/leisure land use (69,222 m^2) and proportioned according to Office for National Statistics, 'Employment by Sector', 2015 percentage averages of retail and restaurant equating to 56.25% retail space to 43.75% restaurant.
[29] 'Employment by Sector', Office for National Statistics, 2015.
[30] Industrial Land Review, Local Plan Supporting Study, 2016.
[31] Addendum to West London's Joint Municipal Waste Strategy, West London Waste Authority, 2009.
[32] London Plan, Greater London Authority, 2015.
[33] London Labour Market Projections, Greater London Authority, 2016, https://www.london.gov.uk/sites/default/files/llmp-2016.pdf.

Based on the indices it is estimated that 1.20 kg of household waste will be generated per person per day by residents, and 2.30 kg of commercial and industrial waste per employee. As a comparison, nationwide statistics published be Defra show that 1.10 kg waste per person per day may be generated by residents from households across England.

Results of Analysis

Old Oak

Operational waste estimates for Old Oak, projected baseline, are summarised in Table B.2.10 and Figures B.2.1 – B.2.3. The results of the analysis show the strong dominance of office arisings, accounting for around 60%, with residential arisings making up 36%. The results also show paper and cardboard accounting for more than half of total arising, at 56%, with organics and plastics accounting for around 19% and 9% respectively. Paper, cardboard and plastics are readily recyclable and present fewer issues in terms of collection. Organic food waste also offers strong potential for recycling. However, the specific issues of separation and collection of food waste in the dense, compact urban environment of Old Oak require close attention to facilities for food waste storage and movement, both within buildings and the wider built environment, in particular managing the impacts of odour. More generally, achieving high recycling rates will require strong consideration of how waste is managed across the development, including its collection, storage and handling as well as continuous and significant regulation and enforcement amongst residents and tenants.

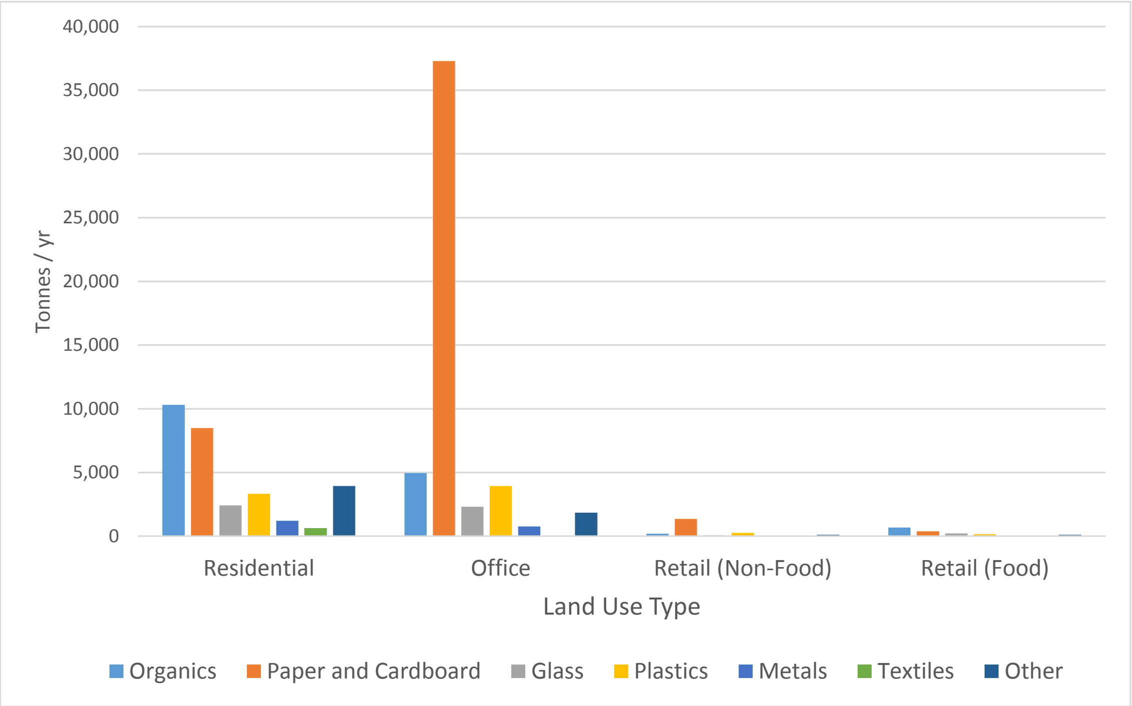
Table B.2.10 – Old Oak Total Waste Arisings by Land Use Type and Waste Type – Projected Baseline

Waste Type	Residential	Office	Retail (Non-Food)	Retail (Food)	Total
Organics	10,300	4,955	183	684	16,122
Paper and Cardboard	8,483	37,287	1,349	373	47,491
Glass	2,424	2,299	62	218	5,001
Plastics	3,332	3,933	257	140	7,662
Metals	1,212	766	24	40	2,042
Textiles	606				606
Other	3,938	1,839	118	99	5,994
Total	**30,295**	**51,078**	**1,992**	**1,554**	**84,919**

Note: All figures are in Tonnes per Annum and are indicative estimates only.

Source: OPDC, ONS[29]. West London Waste Authority[31]. GLA[32, 33, 34]. WRAP[35]. Atkins analysis.

Figure B.2.1 – Old Oak Total Waste Arisings by Land Use Type and Waste Type – Projected Baseline



Source: Per Table B.2.6.

[34] Waste Composition Scoping Study, Greater London Authority, 2004.

[35] The Composition of Waste Disposed of by the UK Hospitality Industry, Waste and Resources Action Programme, 2011.

Figure B.2.2 – Old Oak Total Waste Arisings by Land Use Type – Projected Baseline

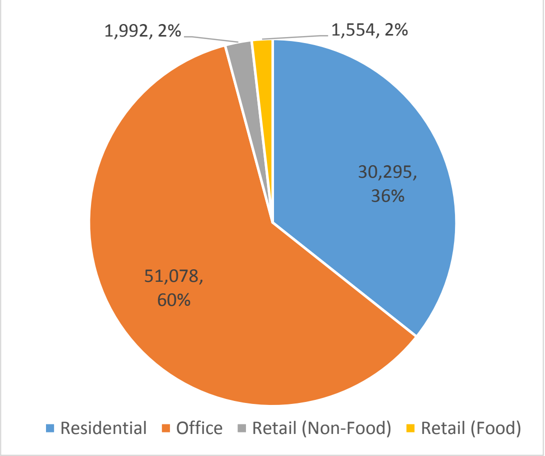
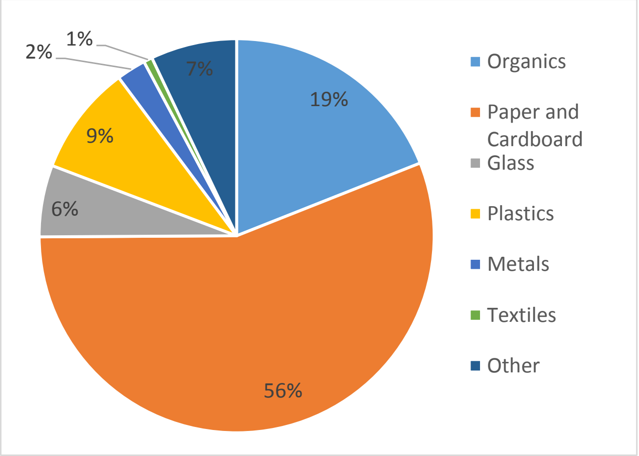


Figure B.2.3 – Old Oak Total Waste Arisings by Waste Type – Projected Baseline



Source (all figures): Per Table B.2.6.

Figures B.2.4 and B.2.5 show the breakdown of waste treatment / disposal tonnages for the Business as Usual and Zero Waste scenarios, given the estimated waste streams indicated above. Both scenarios use the same waste composition breakdown.

Figure B.2.4 – Old Oak Waste Treatment / Disposal – Business as Usual

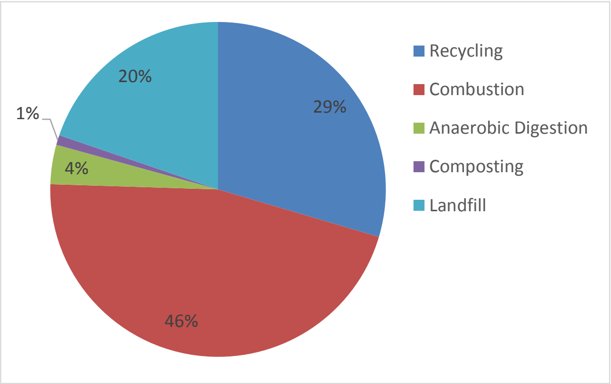
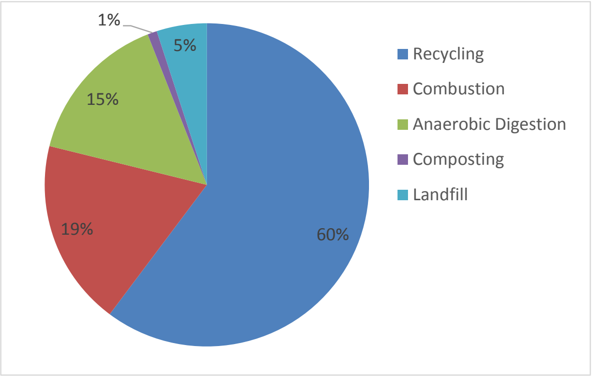


Figure B.2.5 – Old Oak Waste Treatment / Disposal - Zero Waste



Source (all figures): Per Table B.2.6.

The dominance of combustion and landfill under the Business as Usual scenario is apparent from Figure B.2.4, representing poor performance in terms of resource and carbon efficiency. Under the Zero Waste scenario total recycling (including dry recycling, anaerobic digestion and composting) accounts for around three quarters of waste treatment / disposal, well in excess of the Mayor's 2031 target of 60% for LACW, with the majority of the remainder accounted for by combustion. For some forms of waste, it is assumed that combustion comprises the more resource and carbon efficient option, and not all wastes will be recyclable or compostable. Landfill disposal will be confined to residual wastes from other treatment.

From the case study examples it is clear that targets similar to the zero waste scenario have been pursued in a number of developments. For Old Oak one of the key challenges will be the feasibility of source separation and capture. The segregation and storage of specific materials by the waste generator is defined as the capture rate. To demonstrate a diversion or recycling rate it is necessary to estimate the capture rates for the recyclable materials considered within the composition. Materials regarded as recyclable and likely to be captured include organic (food), paper, cardboard, plastic, glass, and metal wastes.

It should also be considered, regardless of the desired rate, that to achieve any form of recycling / composting will require an end destination for materials, such as a materials recovery facility, and suitable markets for resale.

To provide some context, the current London Borough of Hammersmith and Fulham combined recycling, reuse and composting rate is 20.7% as of 2014/15 whereas the rate for the highest performing English local authority, South Oxfordshire District Council, was 67.3%[36]. To achieve the highest performing rate based on the estimated waste compositions would require capture rates in excess of 80% as well as separate food waste collections. This is significantly ambitious in an urban high density area with a wide range of different socio-economic backgrounds such as is likely for Old Oak. Nevertheless, it is useful to consider what may be possible, and it should be considered that capture rates can improve over time.

Although it is difficult to predict the likely change in waste from the present day up to the period of full build out at Old Oak some assumptions can be made. Given the heightened awareness around environmental issues which has been steadily growing over the last few decades as well as the push by local authorities for ever increasing recycling rates it could be considered that the most likely change is for the participation and capture rates of recyclable wastes to steadily increase over time. This assumes that a drive for recycling continues and sustained awareness raising regarding the management of waste is utilised. Typically, the recycling rates in local authorities have increased over the past decade[37]. However, in recent years rates have not grown as fast and there may be

[36] Let's Recycle Local Authority League Tables 2014/15.

[37] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/251567/pb13883-forecasting-2020-waste-arisings-131017.pdf.

evidence of rates flat-lining in some cases. This possibly reflects reductions in resourcing of communications campaigns.

By way of example, in the London Borough of Hammersmith and Fulham, where the project resides, recycling rates have increased from 8.46% in 2002/03 to 20.7% in 2014/15, an increase of circa 0.9% a year. The highest recycling rate achieved in the country (South Oxfordshire) increased from 44.37 % in 2002/03 to 67.3% in 2014/15, an annual increase of circa 1.8%. If this trend continues then it could be expected that higher recycling rates may be achieved for the lowest performers in later years, remembering that there is a maximum achievable and which will be limited according to the waste composition and management measures put in place.

The quantity of waste generated per capita within the development is more difficult to predict as this will be heavily linked to the socio-economic background of residents which is likely to change as well as the type of commercial properties developed. If all aspects remained constant it could be considered that there may be a marginal decrease in waste generation per capita for the same reasons as noted above. Greater awareness of environmental issues and waste has resulted in the population being more considerate about their consumption and disposal habits as well as associated legislation, for example reduced packaging within products.

The Digest of Waste and Resource Statistics[38] has some limited data around waste per capita for households and indicates it decreased by an average of 1.8% between the years of 2010 to 2013. The total amount of waste managed by local authorities was also found to show a decrease. A total of 25.6 million tonnes was collected in 2013/14 which was 9.1% lower than 2000/01 when the total waste managed was 28.0 million tonnes. However, between 2012/13 and 2013/14 there was a 2.3% increase, demonstrating that there is still some fluctuation.

The composition of waste arisings may also undergo some changes over the development period. Similar to the other aspects discussed above, the composition will be highly dependent on features such as changing legislation, demographics, housing density, land uses, etc. However, as waste is inherently variable in nature it should be considered that there may always be some fluctuation in its composition. If all aspects remained constant the quantity of food waste and recyclables is likely to undergo some minor fluctuations (<5%) from year to year. However, this is unlikely to have a significant effect on any processing measures.

Park Royal

Operational waste estimates for Park Royal, projected baseline, are summarised in Table B.2.11 and Figures B.2.6 – B.2.8. The composition of waste is based on statistics published by Defra in 2015 with material categories defined[38]. The results of the analysis show the strong dominance of arisings from warehouse and general industrial uses, together accounting for around two thirds of the total, with light industry accounting for another 23%. Readily recyclable waste types (organic, paper and cardboard, glass, plastics, metals, wood, textiles, rubber) comprise over half the total estimated waste arisings. These sectors and waste streams should form the focus of efforts to encourage development of circular economy activities and linkages within Park Royal. Further study would be required to provide the detailed information necessary to underpin development of a circular economy strategy for the area.

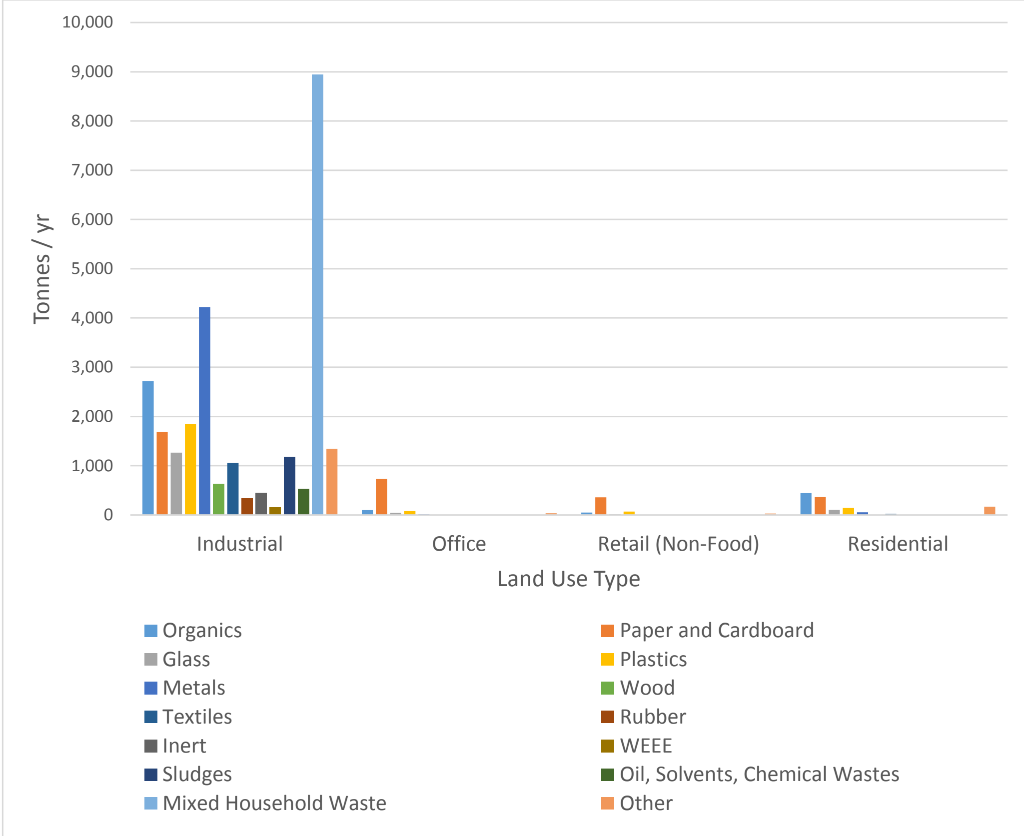
[38] Digest of Waste and Resource Statistics, Department for Environment, Food and Rural Affairs (Defra), 2015.

Table B.2.11 – Park Royal Total Waste Arisings by Land Use Type and Waste Type – Projected Baseline

Waste Type	Industrial	Office	Retail (Non-Food)	Residential	Total
Organics	2,716	97	49	443	3,306
Paper and Cardboard	1,688	730	359	365	3,143
Glass	1,266	45	16	104	1,432
Plastics	1,846	77	68	143	2,135
Metals	4,220	15	6	52	4,293
Wood	633				633
Textiles	1,055			26	1,081
Rubber	343				343
Inert	448				448
WEEE	158				158
Sludges	1,187				1,187
Oil, Solvents, Chemical Wastes	527				527
Mixed Household Waste	8,940				8,940
Other	1,345	36	31	170	1,582
Total	**26,373**	**1,001**	**530**	**1,304**	**29,208**

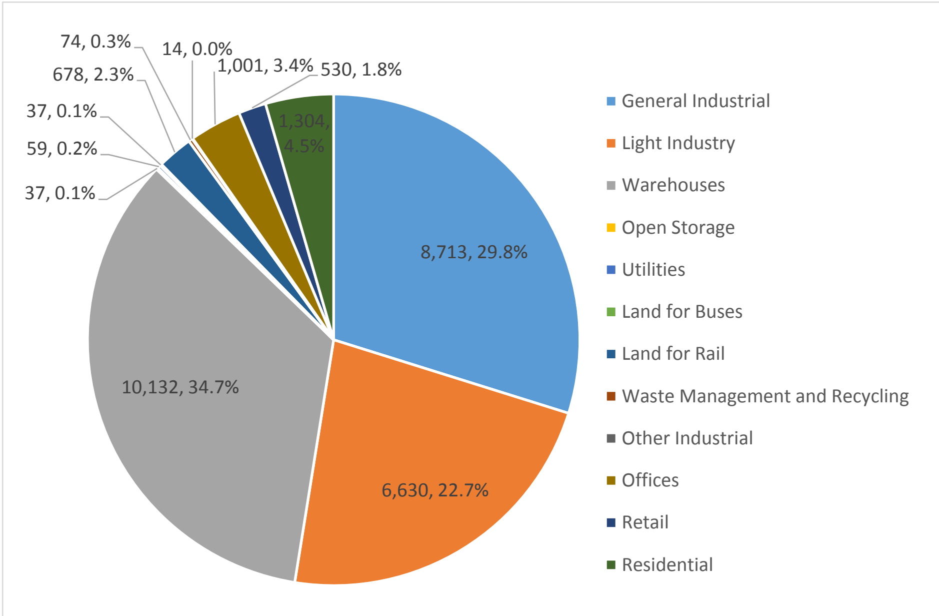
Note: All figures are in Tonnes per Annum and are indicative estimates only. WEEE: Waste Electrical and Electronic Equipment.
Source: OPDC. West London Waste Authority[31]. GLA[32, 33]. WRAP[35]. Defra[38]. Atkins analysis.

Figure B.2.6 – Park Royal Total Waste Arisings by Land Use Type and Waste Type – Projected Baseline



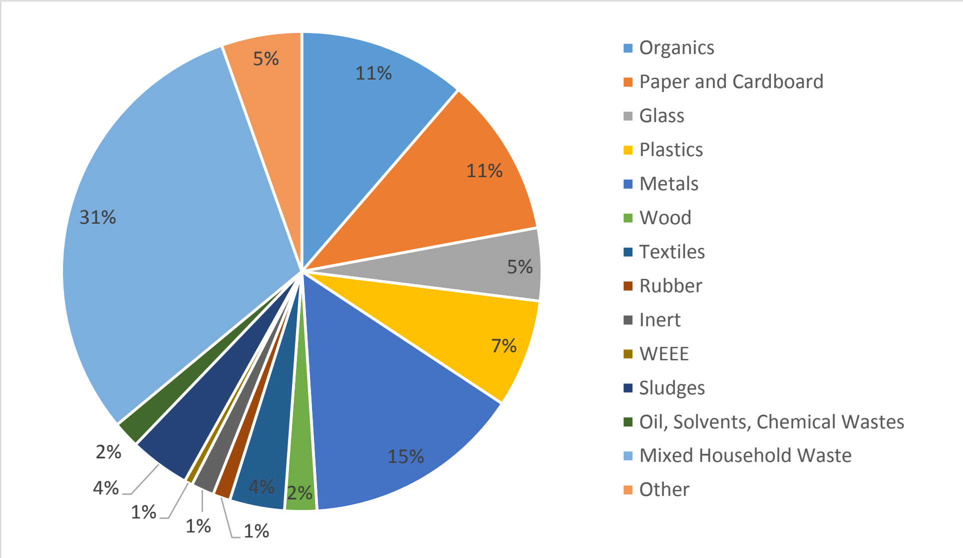
Source: Per Table B.2.7

Figure B.2.7 – Park Royal Total Waste Arisings by Land Use Type – Projected Baseline



Source: Per Table B.2.7

Figure B.2.8 – Park Royal Total Waste Arisings by Waste Type – Projected Baseline



Source: Per Table B.2.7.

Figures B.2.9 and B.2.10 show the breakdown of waste treatment / disposal tonnages for the Business as Usual and Low Waste scenarios, given the estimated waste streams indicated above. Both scenarios use the same waste composition breakdown.

Figure B.2.9 – Park Royal Waste Treatment / Disposal – Business as Usual

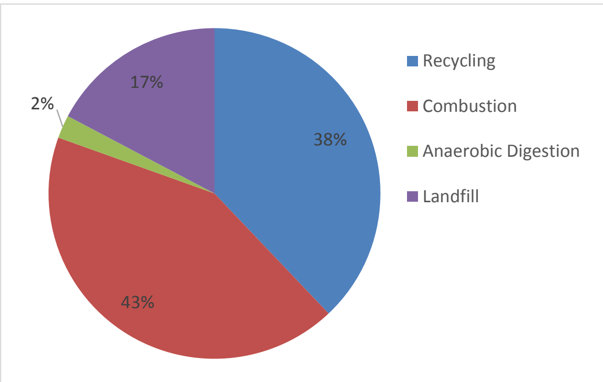
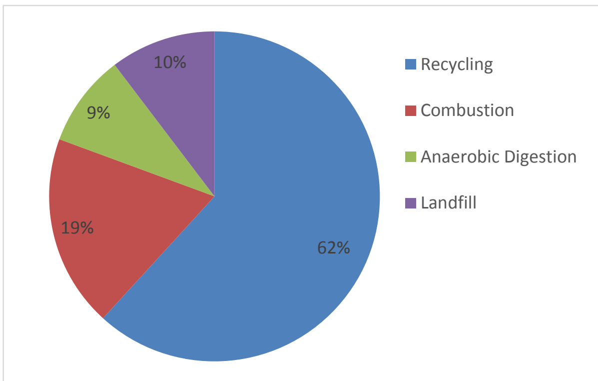


Figure B.2.10 – Park Royal Waste Treatment / Disposal - Low Waste



Source (all figures): Per Table B.2.7.

Figure B.2.9 shows the dominance of combustion and landfill under the Business as Usual scenario. The proportion (40%) of waste recycled (including dry recycling and anaerobic digestion) under the Low Waste scenario falls considerably short of the Mayor's target (70%) for commercial and industrial waste by 2020. This is a reflection of the proportion of mixed household and 'other' waste streams in the arisings. The lower organic waste streams within Park Royal constrain opportunities for anaerobic digestion within Park Royal alone, and these waste streams would be more effectively combined with those of Old Oak to improve the efficiency of localised facilities should these be developed, which would be preferred in order to generate and use biogas (e.g. within a Combined Cooling and Heating Plant led anaerobic digestion plant) within the OPDC site.

Indicative Costs

Table B.2.12 below provides indicative estimated capital costs[39] for key waste treatment technologies, in terms of cost per tonne of waste input. Of the technologies which do not enable energy recovery from waste[40], windrow composting represents the lowest cost option, followed by in-vessel composting. Recycling of dry recyclable materials also represents a relatively low cost technology.

Capital costs for anaerobic digestion are approximately half those of energy from waste. Mechanical biological treatment capital costs are slightly lower than those for anaerobic digestion. However, this technology typically has lower overall resource and carbon efficiency due to the reduced separation of organic and dry recyclable waste. Advanced thermal treatment, which typically includes pyrolysis, gasification and plasma gasification, represents the highest cost technology.

Table B.2.12 – Waste Treatment Technology Indicative Capital Costs

Waste Treatment Technology	Capital Cost (£ / tonne)		
	Low	High	Average
Energy from Waste	221	736	403
Anaerobic Digestion	100	342	189
Materials Recycling Facility	68	249	128
Mechanical Biological Treatment	29	426	172
Advanced Thermal Treatment	170	914	462
Composting - Windrow	24	155	79
Composting - In-Vessel	68	246	157

Note: All figures are indicative estimates only.
Source: See reference list below.

[39] Costs are based on references issued between 2011 and 2016. Thus, there is some variation in certainty of cost estimation.

[40] Technologies which enable energy recovery from waste include energy from waste, anaerobic digestion and some advanced thermal treatment technologies.

Table B.2.13 below provides indicative estimated capital costs for key waste collection technologies. The figures in Table B.2.13 indicate that the types of technologies required for high density, high-rise buildings, such as refuse chutes and underground storage systems, would be expected to entail significant additional costs per dwelling when compared to established collection technologies for low density, low rise development.

Table B.2.13 – Waste Collection Technology Capital Costs

Technology	Categorised Capital Cost					Cost Per Unit (£)	Unit
	Very Low	Low	Medium	High	Very High		
Refuse Sacks	✓					0.08	1 Bag
Dustbin		✓				12	1 Bin
Eurobin (1)		✓				250	1 Bin
Eurobin (2)		✓				2,550,000	1,700 bins for 10,000 flats2
Eurobin Compactor			✓			9,600	1 Compactor (will compact at a ratio of ~ 3:1)
Portable Skip			✓			850	1 * 12 cubic yard Standard Skip
Static Compactor Skip			✓			2,000	1 * 12 cubic yard Standard Skip (will compact at a ratio of ~ 5:1)
Refuse Chutes				✓		4,346	Chute system for a 3 story building that has two intake doors
Underground Storage System					✓	11,000,000	For 10,000 flats

Note: All figures are indicative estimates only.

Source: ISWA (2013). Underground Solutions for Urban Waste Management; http://www.sharpchuter.net/chute-systems. Atkins analysis.

This section provides high-level indicative costs for various waste treatment and collection technologies. Further detailed work is recommended to explore these aspects further. In particular, further analysis of waste collection approaches in terms of the effect that the density of the development may have on technical issues such as collection vehicle movements (down to turning circles and access heights) and potential use of chutes in high rise buildings is recommended to help with guidance at the detailed design stage.

Indicative Land Take

Table B.2.14 below provides indicative estimates of tonnages and land take for the main types of waste treatment facility. Average tonnages for EfW, mechanical biological treatment (MBT) and advanced thermal treatment (ATT) facilities are substantially higher than those for other types of facilities. Not surprisingly, land take, in terms of average facility total footprint (ha), is also considerably higher for EfW, MBT and ATT facilities than that of other types of facility. However, land take in terms of m^2 / tonne input, is markedly lower for EfW, MBT and ATT facilities. Although average facility footprints for Materials Recycling Facilities (MRF) are lower compared to EfW, MBT and ATT facilities, m^2 per tonne of input is close to that for MBT facilities. Windrow compositing facilities have very significantly lower average tonnages than other facility types, as well as markedly higher land take in terms of m^2 per tonne of input. Anaerobic digestion and in-vessel composting have very similar average tonnages and land takes, with markedly lower overall land take efficiency in terms of m^2 per tonne input, compared to the larger tonnage facilities. Clearly, across all facility types, land take efficiency increases with greater scale of facility.

Although some of the facility types, in particular energy from waste, would typically be too large to be based on waste from the OPDC site alone, other types can be developed at smaller sizes. Indeed, smaller scale localised facilities could be something to be promoted at the OPDC site and would be well aligned with circular economy aims.

Table B.2.14 – Waste Treatment Facility Capacities and Land Take

Waste Treatment Facility	Tonnage (KTPA)			Land take (ha)			Land Take (m^2 / tonne)		
	Low	High	Av.	Low	High	Av.	Low	High	Av.
Energy from Waste	149	183	166	2.87	3.20	3.03	0.23	0.17	0.18
Anaerobic Digestion	20	50	35	1.00	1.50	1.25	0.50	0.30	0.36
Materials Recycling Facility	14	135	75	0.75	3.00	1.88	1.03	0.24	0.27
Mechanical Biological Treatment	85	124	104	1.75	3.13	2.44	0.25	0.26	0.25
Advanced Thermal Treatment	85	110	98	1.79	2.47	2.13	0.19	0.24	0.22
Composting - Windrow	5	10	8	1.00	1.00	1.00	2.00	1.00	1.33
Composting - In-Vessel	20	50	35	1.00	1.50	1.25	0.50	0.30	0.36

Note: All figures are indicative estimates only. KTPA: Kilotonnes per Annum.

Source: See reference list below.

References – Waste Technology Costs, Facility Capacities and Land Take

Energy from Waste

http://legacy.london.gov.uk/mayor/environment/waste/docs/efwtechnologiesreport.pdf
http://www.epem.gr/waste-c-control/database/html/costdata-00.htm#AD
http://www.sita.co.uk/services-and-products/local-authority-customers/public-private-partnerships/kirklees
http://www.wrap.org.uk/content/list-energy-waste-sites
http://www.facilitiesshow.com/files/richard_skehens.pdf
http://www.theguardian.com/business/2013/aug/16/tilbury-power-station-mothballed

Anaerobic Digestion

http://www.epem.gr/waste-c-control/database/html/costdata-00.htm#AD

Materials Recycling Facility

http://www.wrap.org.uk/sites/files/wrap/MRFCostModelUserGuide.pdf
http://www.epem.gr/waste-c-control/database/html/costdata-00.htm#AD

Mechanical Biological Treatment

Defra
http://www.epem.gr/waste-c-control/database/html/costdata-00.htm#AD
'Solid Waste Technology Options: Mechanical Biological Treatment (MBT), Juniper Consulting, 2008

Advanced Thermal Treatment

http://legacy.london.gov.uk/mayor/environment/waste/docs/efwtechnologiesreport.pdf
http://expertpc.org/gasifier/idea2.pdf
http://www.theneweconomy.com/technology/pioneering-sustainability-in-the-uae-beeah-advises
http://resource.co/article/air-products-shuts-down-tees-valley-development-10987

Composting - Windrow

http://www.epem.gr/waste-c-control/database/html/costdata-00.htm#AD

Composting - In-Vessel

http://www.epem.gr/waste-c-control/database/html/costdata-00.htm#AD

Appendix B.3 - Site Carbon Emissions Analysis

Introduction

A set of carbon emissions scenarios was developed for Old Oak and Park Royal. The analysis used to develop the carbon emissions scenarios was based on a) estimates of operational energy and waste from the energy and waste scenarios developed under the site energy and waste analyses for the current study; b) estimates of transport related carbon emissions from the development proposed for Old Oak. The purpose of developing these scenarios was to evaluate the overall operational carbon emissions of the two developments under different energy, waste and transport performance scenarios. The carbon emissions scenarios were used to:

a) test the prerequisites for meeting current policy / guidance requirements; and

b) test the potential for exceeding current policy / guidance requirements, under different scenario assumptions.

The results of these analyses and the methodology used are summarised in the sections below.

Carbon Assessment Methodology

The carbon assessment methodology used to develop emissions estimates and evaluate the carbon emission scenarios references the following key standards:

- Greenhouse Gas Protocol - Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).[41]
- PAS 2070:2013+A1:2014 - Specification for the Assessment of Greenhouse Gas Emissions of a City (PAS 2070).[42]
- London Energy and Greenhouse Gas Inventory (LEGGI), 2014.[43]

The following also comprised key references:

- Application of PAS 2070 - London, United Kingdom.[44]
- London 2012 Carbon Footprint Methodology and Reference Footprint – London 2012 Learning Legacy.[45]

The carbon assessment approach adopted for the present study is broadly based on the BASIC level of the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), which is designed to allow city/area based carbon footprint estimation with limited data availability. The GPC BASIC level framework covers scope 1 and scope 2 emissions from stationary energy and transportation, as well as scope 1 and scope 3 emissions from waste (see below for description of scopes). The main exclusions under the GPC BASIC level framework relate to emissions from industrial processes and product use (IPPU), and agriculture, forestry and other land use (AFOLU). Product use related emissions are relevant for Park Royal. However, there is currently insufficient data available to enable appropriate estimation of emissions from this source. AFOLU related emissions are not relevant to the Old Oak and Park Royal site.

GPC groups emissions into three categories based on where they occur. Definitions are based on an adapted application of the scopes framework used in the GHG Protocol Corporate Standard (see www.ghgprotocol.org/standards/corporate-standard). The GPC scope definitions are:

- **Scope 1** - GHG emissions from sources located within the city/area boundary.
- **Scope 2** - GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city/area boundary.
- **Scope 3** - All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city/area boundary.

The methodology used in the present study is not intended to provide comprehensive or definitive carbon footprinting outputs for Old Oak and Park Royal. Rather, the aim is to provide indicative estimates of the key carbon emissions to enable comparison between different development scenarios and evaluation of these in relation to Mayoral objectives and guidance. Using the GPC BASIC level scoping framework also affords a degree of comparability with

[41] Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, World Resource Institute, C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability, 2014. http://www.ghgprotocol.org/city-accounting.
[42] PAS 2070:2013 - Specification for the Assessment of Greenhouse Gas Emissions of a City, British Standards Institute, 2013. http://shop.bsigroup.com/Browse-By-Subject/Environmental-Management-and-Sustainability/PAS-2070-2013/.
[43] London Energy and Greenhouse Gas Inventory (LEGGI), GLA, 2014. https://data.london.gov.uk/dataset/interim-london-energy-and-greenhouse-gas-inventory--leggi--2014.
[44] Application of PAS 2070 - London, United Kingdom, British Standards Institute, 2014. https://data.london.gov.uk/dataset/application-pas-2070-london-case-study.
[45] London 2012 Carbon Footprint Methodology and Reference Footprint – London 2012 Learning Legacy, London Organising Committee of the Olympic Games, 2012.

LEGGI emissions estimates, which cover energy and transportation but exclude waste. However, LEGGI does cover industrial related emissions.

The scope boundary defined for carbon assessment in the present study is broadly per that of the GPC BASIC level framework. However, there are some differences. These are set out in Table B.3.1 below. The geographic boundary is the Old Oak and Park Royal site boundary. The temporal boundary is one year.

The GPC covers operational emissions only. Emissions embodied in materials and products are not currently included. The GPC BASIC level boundary framework is comparable to that used for LEGGI. The PAS 2070 standard, development of which was supported by the GLA, builds on the GPC and provides two separate methodologies for calculating emissions, each of which deals with embodied emissions in different ways. The application of the first of these, the direct supply chain methodology, in a London-wide carbon footprinting case study[44], was used as a reference in the current study in developing calculation approaches and checking data sources. For broad consistency with LEGGI outputs, and due to the lack of an established methodology or set of emissions factors for estimating embodied carbon from broad planning and design data covering land use and/or building types, the assessment approach adopted in the present study excludes embodied carbon. However, the importance of embodied carbon in the overall footprint, and the need to ensure robust data collection and monitoring of embodied carbon during design and construction, is emphasised in the policy recommendations.

Table B.3.1 – Carbon Assessment Scope Boundary and Emissions Factor Sources

Sector	Scope Boundary		Emissions Factor Sources
	Included	Excluded	
Stationary Energy	• Indirect and direct emissions from grid-supplied electricity consumption and gas consumption from residential, commercial and industrial buildings. • Indirect emissions associated with energy generation from solar photovoltaic solar thermal and ground source heat pump equipment. • Direct emissions (fossil carbon fraction) from waste combustion in waste from energy facilities. • Direct emissions (biogenic carbon fraction)[46] from waste combustion in waste from energy facilities. • Direct fugitive emissions from anaerobic digestion.	• Indirect emissions from energy generation equipment, buildings and facilities, other than solar energy. • Indirect emissions from energy consuming industrial equipment, buildings and facilities.	• Department of Energy and Climate Change / Department of Environment, Food and Rural Affairs, 2016. • UK Treasury, 2012. • UK Committee on Climate Change, 2013. • US National Renewable Energy Laboratory, 2012. • GCP, 2014.
Transportation	• Emissions from on-road transportation: fuel and electrical consumption. Included private road vehicles and buses. • Emissions from fuel combustion and grid-supplied electricity for railway transportation.	• Indirect and direct and emissions from off-road transportation. Indirect, and direct emissions from transportation fixed infrastructure, related buildings and facilities. • Indirect emissions of vehicle fleets and transportation fixed infrastructure, related buildings and facilities. • Indirect and direct emissions related to water transportation.	• Department of Energy and Climate Change / Department of Environment, Food and Rural Affairs, 2016. • US Department of Energy / Environmental Protection Agency
Solid Waste	• Emissions from collection, transport and storage of waste. • Direct emissions from waste decomposition in landfill.	• Indirect and direct emissions from waste management fixed infrastructure, related buildings and facilities, including recycling.	• Department of Energy and Climate Change / Department of Environment, Food and Rural Affairs, 2016.

Source: Atkins analysis

[46] Assumed to be zero due to combustion of short-cycle carbon sequestered in biomass.

Carbon Emissions Scenarios

To explore the potential operational carbon emissions reduction achievable within both Old and Park Royal a set of three environmental performance scenarios was developed: a standard Business as Usual (BAU) scenario and two enhanced performance scenarios: Best Practice, which improves on the BAU scenario, and Pioneering Practice, which improves on the Best Practice scenario. The carbon emissions scenarios were developed based on combining energy and waste scenarios described in the Energy and Waste sections of this report, together with additional transport scenarios (see below) developed specifically for the carbon emissions analysis. Preliminary high-level estimates of operational carbon emissions were then calculated for each scenario.

Table B.3.2 below summarises the various components comprising each of the carbon emissions scenarios. This should be read in conjunction with Tables B.3.3 – B.3.6 which provides summary information on the energy, waste and transport components of each carbon emissions scenario. Further details on scenario estimates for energy and waste are provided in the relevant topic sections in this report.

Table B.3.2 – Summary of Carbon Emissions Scenarios

<table>
<tr><th colspan="4">Carbon Emissions Scenario / Component</th><th>Standard Practice</th><th>Best Practice</th><th>Pioneering Practice</th></tr>
<tr><td rowspan="8">Energy</td><td rowspan="4">Old Oak</td><td colspan="2">Demand</td><td>Standard Practice</td><td>Best Practice</td><td>Pioneering Practice</td></tr>
<tr><td rowspan="3">Low Carbon Energy</td><td>Renewables</td><td>Combined Renewables Technologies Scenario</td><td>Combined Renewables Technologies Scenario</td><td>Combined Renewables Technologies Scenario</td></tr>
<tr><td rowspan="2">Energy from Waste and Anaerobic Digestion</td><td rowspan="2">BAU</td><td>2016 GD: BAU</td><td>2016 GD: BAU</td></tr>
<tr><td>2025/2031 GD: Zero Waste</td><td>2025/2031 GD: Zero Waste</td></tr>
<tr><td rowspan="4">Park Royal</td><td colspan="2">Demand</td><td>Standard Practice</td><td>Best Practice</td><td>N/A</td></tr>
<tr><td rowspan="3">Low Carbon Energy</td><td>Renewables</td><td>Combined Renewables Technologies Scenario</td><td>Combined Renewables Technologies Scenario</td><td>N/A</td></tr>
<tr><td rowspan="2">Energy from Waste and Anaerobic Digestion</td><td rowspan="2">Baseline</td><td>2016 GD: Baseline</td><td rowspan="2">N/A</td></tr>
<tr><td>2025/2031 GD: Low Waste</td></tr>
<tr><td rowspan="2">Waste</td><td colspan="3">Old Oak</td><td>BAU</td><td>Zero Waste</td><td>Zero Waste</td></tr>
<tr><td colspan="3">Park Royal</td><td>Baseline</td><td>Low Waste</td><td>N/A</td></tr>
<tr><td rowspan="2">Transport</td><td colspan="3">Old Oak</td><td>BAU</td><td>Low Car</td><td>Low Car</td></tr>
<tr><td colspan="3">Park Royal</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

Notes: GD: Grid decarbonisation. BAU: Business as Usual.
Source: Atkins analysis.

All scenarios relate to a 2031 development build-out based on master planning figures supplied by OPDC. Due to the importance of electrical grid decarbonisation for several of the parameters underpinning projected carbon emissions, carbon estimates have been calculated using grid carbon factors for 2016, 2025 and 2031 from UK HM Treasury[47]. This allowed the sensitivity of the scenarios to this key factor to be tested

[47] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, UK HM Treasury, October 2012.

ATKINS

Energy Components of Carbon Emissions Scenarios

Energy related carbon emissions estimates have been calculated for both energy demand from buildings and various types of low carbon energy generation, including onsite renewables and energy from waste. The calculations for low carbon energy generation are based on the carbon savings in each case relative to traditional energy supply, i.e. grid electricity and mains gas supply.

Energy Demand Scenarios

Table B.3.3 below sets out a summary of the energy demand scenarios developed for Old Oak and Park Royal. Carbon emissions from building energy consumption were calculated for each of the three scenarios, based on traditional electrical (grid) and thermal (main gas) energy supply.

Table B.3.3 – Energy Demand Scenarios

Energy Demand Scenario		Summary
Standard Practice	Old Oak	Represents current UK average sector-wide performance: • Residential: building fabric specification to meet minimum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes. Lighting, small power and hot water as per SAP 2012 calculation methodology. • Non-residential: current sector benchmarked performance.
	Park Royal	For non-industrial, represents current UK average sector-wide performance: • Residential: building fabric specification to meet minimum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes. Lighting, small power and hot water as per SAP 2012 calculation methodology. • Office and retail: represents current sector benchmarked performance. For industrial, represents assumed current performance in Park Royal based on national average benchmarks.
Best Practice	Old Oak	Represents current UK best practice, improving on the Standard Practice scenario via: • Residential: building fabric specification to meet maximum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes: enhanced fabric insulation, reduced air leakage, optimised solar shading. Improved lighting. Small power and hot water as per SAP 2012 calculation methodology. • Office: higher thermal performance building shell, higher air tightness, energy efficient ventilation, daylighting combined with solar shading. • Retail: Average better performing facilities, based on measured data.
	Park Royal	For non-industrial, represents current UK best practice, improving on the Standard Practice scenario via: • Residential: building fabric specification to meet maximum standard from Fabric Energy Efficiency scale from Code for Sustainable Homes: enhanced fabric insulation, reduced air leakage, optimised solar shading. Improved lighting. Small power and hot water as per SAP 2012 calculation methodology. • Office: higher thermal performance building shell, higher air tightness, energy efficient ventilation, daylighting combined with solar shading. • Retail: Average better performing facilities, based on measured data. For industrial, incorporates improvements on Standard Practice scenario with retrofitting of industrial buildings.
Pioneering Practice	Old Oak	Represents current international pioneering practice, improving on the Best Practice scenario via: • Residential: Stringent building envelope thermal transfer, air tightness, shading specifications, mechanical ventilation with heat recovery to ensure very low energy overall energy demand. • Office: automatic adjustable shading, greater focus on daylighting and solar control (low g-value glazing), LED lighting, continuous monitoring and fine-tuning performance, interactive user feedback; GSHP cooling. • Retail: Per Best Practice, with higher efficiency lighting.
	Park Royal	N/A

Note: all scenarios relate to regulated and unregulated energy.

Source: Atkins analysis. Reproduced from the Energy section of this report.

Low Carbon Energy Generation - Renewable Energy Technologies

Carbon savings from deployment of renewables were calculated based on subtracting carbon emissions associated with each renewable energy technology from carbon emissions associated with the traditional electrical (grid) and thermal (mains gas) energy supply displaced by renewable energy supply.

Table B.3.4 below sets out a summary of the three selected renewable energy technologies explored in the site energy scenarios analysis, reproduced from the Energy section of this report.

Table B.3.4 – Onsite Renewable Energy Technologies

Renewable Energy Technology	Summary
Solar photovoltaic (PV)	A solar PV deployment scenario has been developed for both Old Oak and Park Royal. In both cases it is assumed that 35% of the total roof area is excluded for access and maintenance, and a further 15% of the remaining roof space would be occupied by roof equipment. In the case of Old Oak, a further 25% of the remaining roof space has been assumed to be over-shaded by higher buildings, thus limiting the effectiveness of solar PV deployment. Of the remaining roof space, assumed to be available for solar energy generation, 70% has been assumed for deployment of solar PV panels. The assumed conversion efficiency of solar PV panels is based on an average value for units readily available in the UK market.
Solar thermal	From the available roof space for solar PV estimated above, the remaining roof space not occupied by solar PV (30%) has been assumed for deployment of solar thermal panels. The assumed conversion efficiency of solar thermal panels is based on an average value for units readily available in the UK market.
Ground source heat pumps (GSHP)	The GSHP scenario assumes deployment of borehole fields in six of the main public open spaces in Old Oak, equating to a total area of 26,500 m2. This scenario assumes coefficients of performance of 3 for heating and 3.5 for cooling, with GSHP units providing year round heating / cooling output.

Source: Atkins analysis. Reproduced from the Energy section of this report.

Low Carbon Energy Generation – Energy from Waste and Anaerobic Digestion

The carbon emissions associated with potential energy from waste were calculated based on the three waste treatment/disposal scenarios developed under the Waste topic in this report, identifying waste types and quantities for Old Oak and Park Royal. The three waste treatment/disposal scenarios are set out in Table B.3.5 below. Using gross calorific values applied to each waste stream, an energy from waste scenario was developed, and referenced from World Bank Technical Guidance[48] to have 20% energy recovery efficiency for electrical and 65% for thermal generation. Electrical energy generation from anaerobic digestion was estimated using analysis of UK facility references to derive a generation factor per tonne of waste. Carbon emissions were calculated for energy from waste based on the average non-biogenic carbon and methane intensity of waste streams and methane factors from GPC. Net emissions from combustion of biogenic carbon were assumed to be zero[49]. Fugitive carbon emissions were calculated for anaerobic digestion based on methane factors from GPC. Carbon emissions savings for energy from waste and anaerobic digestion were calculated based on the traditional electrical (grid) and thermal (main gas) energy supply displaced by energy supply from energy from waste and anaerobic digestion, using DECC/Defra factors.

The energy from waste and anaerobic digestion components of the carbon emissions scenarios were based on the Business as Usual waste treatment/disposal scenario for 2016 carbon emissions estimates, and the Zero Waste treatment/disposal scenario (Old Oak) and Low Waste treatment/disposal scenario (Park Royal) for the 2025 and 2031 carbon emissions estimates respectively (see Table B.3.1 above).

Table B.3.5 below sets out a summary of the waste treatment/disposal scenarios developed for Old Oak and Park Royal, reproduced from the Waste section of this report.

Waste Components of Carbon Emissions Scenarios

Estimates of waste related carbon emissions were developed based on the three waste treatment/disposal scenarios set out in Table B.3.5 below. Carbon emissions were estimated for waste disposal only (excluding carbon emissions associated with energy recovery, i.e. energy from waste and anaerobic digestion), using waste carbon factors from DECC/Defra covering emissions from

[48] Municipal Solid Waste Incineration, Technical Paper No. 462, World Bank, 2000. http://documents.worldbank.org/curated/en/886281468740211060/pdf/multi-page.pdf

[49] Assumed to be zero due to combustion of short-cycle carbon sequestered in biomass.

landfill and collection, transport and storage of waste. Estimates of carbon emissions in relation to a) emissions embodied in waste products; b) emissions avoided through use of recycled waste, are not included.

Table B.3.5 – Waste Treatment / Disposal Scenarios

Waste Treatment Disposal Scenario		Summary
Business as Usual	Old Oak	Based on current practice in London, a high percentage of waste combustion is assumed and below average recycling rates, compared to other England regions. A significant landfill disposal rate is also assumed.
	Park Royal	Based on current practice in London, assumes around half of waste is recycled with similar proportion to Old Oak sent to landfill and the remainder combusted.
Zero Waste	Old Oak	Based on London Plan requirements, a very low landfill disposal rate is assumed, together with high recycling rates and minimal waste combustion.
	Park Royal	N/A
Low Waste	Old Oak	N/A
	Park Royal	Based on London Plan requirements, assumes a higher rate of recycling, and lower rates of landfill and combustion compared to business as usual scenario.

Source: Atkins analysis. Reproduced from the Waste section of this report.

Transport Components of Carbon Emissions Scenarios

Table B.3.6 below provides a summary of the transport scenarios developed for Old Oak and Park Royal to facilitate calculation of transport related carbon emissions.

Table B.3.6 – Transport Scenarios

Transport Scenario		Summary
Business as Usual (BAU)	Old Oak	Difference between 'with development' and 'without development' trip kilometres figures from transport model runs for the 2031 'medium development' scenario. 40% of private road vehicle trip assumed to be using electric drive vehicle.
	Park Royal	N/A
Low Car	Old Oak	Private road vehicle mode share (percentage of total trips) reduced to 10%, from assumed BAU average of 32%. Reduced road vehicle trip kilometres reallocated to public transport modes according to model run percentages. 40% of private road vehicle trip assumed to be using electric drive vehicle.
	Park Royal	N/A

Source: Atkins analysis.

Estimates for carbon emissions from transport for Old Oak have been developed using trip kilometre figures by mode derived from the transport modelling carried out for the Old Oak Strategic Transport Study, a supporting study for the OPDC Draft Local Plan issued in February 2016. Transport modelling data were not available to allow estimates of carbon emissions from transport for Park Royal to be calculated.

For Old Oak, the difference between 'with development' and 'without development' figures from model runs for the 2031 'medium development' scenario formed the basis for the BAU transport scenario for the purposes of the carbon emissions analysis reported here. Trip kilometre figures were not available for the 'with interventions' medium development scenario from the Old Oak Strategic Transport Study. Thus, it was not possible to calculate carbon emissions associated with the set of transport interventions recommended in the Old Oak Strategy Transport Study.

For the purposes of the carbon emissions analysis, a basic 'Low Car' scenario for 2031 was developed under the assumptions listed in Table B.3.6. The assumption regarding mode share for private road vehicles was based on the Reduced Highway/ High Public Transport Share scenario reported in the Old Oak Strategy Transport Study as reflecting the proposed interventions underpinning the recommended strategy. The assumption regarding electric vehicle trip kilometres is broadly in line with current projections of electric vehicle UK fleet penetration by 2031. The Low Car transport scenario was used for both the Best Practice and Pioneering Practice carbon emissions scenarios (see Table B.3.2 above).

Carbon emissions for transport were calculated based on UK Department of Energy and Climate Change / Department of Environment, Food and Rural Affairs emissions factors[50], excluding electric drive private road vehicles. For electric drive private road vehicles carbon emissions were calculated using electrical consumption figures from the US Department of Energy / Environmental Protection Agency[51].

Results of Analysis

Old Oak

Total Emissions - 2031 Grid Decarbonisation

Carbon emissions analyses for the three carbon emissions scenarios for Old Oak based using the 2031 projected grid carbon factor are summarised in Figures B.3.1 – B.3.3, which show total emissions, emissions per capita and percentage of total emissions by sector respectively. The analyses clearly demonstrate the substantial increase in performance of the Best Practice and Pioneering Practice scenarios over the BAU scenario (27% and 42% reductions, respectively). They also show that energy related emissions dominate the total carbon footprint, comprising approximately two thirds or more of total emissions across all scenarios. Estimates of per capita emissions indicate that even for the Standard Practice scenario and without offsetting savings from local generation, potential per capita total operational emissions could be well below those required to meet the Mayoral target of 60% reduction on 1990 level by 2025, i.e. two tonnes CO_2e / capita or less.

Figure B.3.1 – Old Oak 2031 Scenarios – 2031 Grid Decarbonisation: Total Emissions

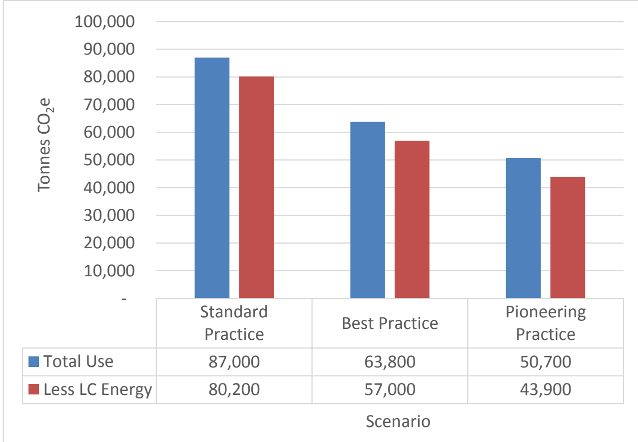


Figure B.3.2 – Old Oak 2031 Scenarios – 2031 Grid Decarbonisation: Per Capita Emissions

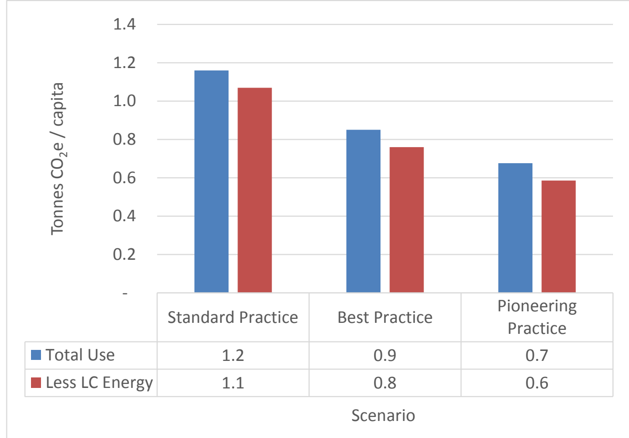
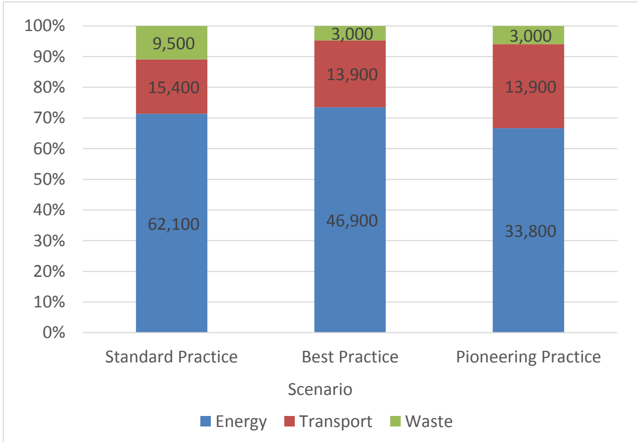


Figure B.3.3 – Old Oak 2031 Scenarios – 2031 Grid Decarbonisation: Emissions Sector Percentages



Note: All figures are indicative estimates only. Assumed total population: 75,000.
Source (all figures): Atkins analysis.

Total Emissions - 2025 Grid Decarbonisation

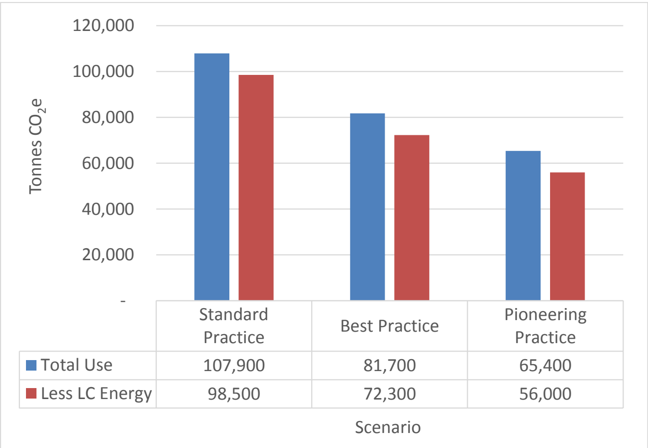
Figures B.3.4 – B.3.6 summarise the carbon emissions analyses for the three carbon emissions scenarios for Old Oak based using the 2025 projected grid carbon factor, showing total emissions, emissions per capita and percentage of total emissions by sector respectively. The analyses indicate the marked sensitivity of the carbon footprints to grid decarbonisation. Increases in performance of the Best Practice and Pioneering Practice scenarios over the BAU scenario (25% and 40% reductions, respectively) are lower compared to the

[50] GHG Conversion Factors for Company Reporting, Department of Energy and Climate Change / Department of Environment, Food and Rural Affairs, 2016. www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016.

[51] Fuel Economy Guide, US Department of Energy / Environmental Protection Agency, 2016. www.fueleconomy.gov/feg/pdfs/guides/FEG2016.pdf.

2031 grid decarbonisation analyses. Not unexpectedly, the proportion of energy related carbon increases significantly across all scenarios, to 72% – 79%, compared to the 2031 grid decarbonisation analyses. Per capita emissions across all scenarios are still well below the rate required (<=2 tonnes CO_2e / capita) to meet the Mayoral target of 60% reduction on 1990 emissions by 2025. To significantly exceed this target, it would be necessary to move beyond business as usual, either in terms of energy efficiency or onsite generation, towards the Best Practice or even the Pioneering Practice carbon emissions scenario, or components thereof.

Figure B.3.4 - Old Oak 2031 Scenarios – 2025 Grid Decarbonisation: Total Emissions



Note: All figures are indicative estimates only.
Source: Atkins analysis.

Figure B.3.5 – Old Oak 2031 Scenarios – 2025 Grid Decarbonisation: Per Capita Emissions

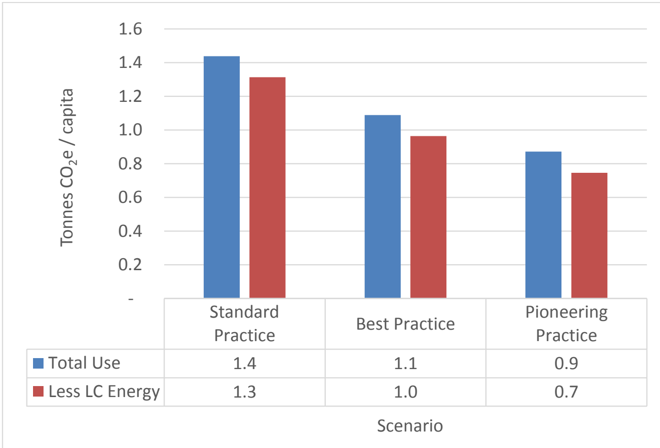
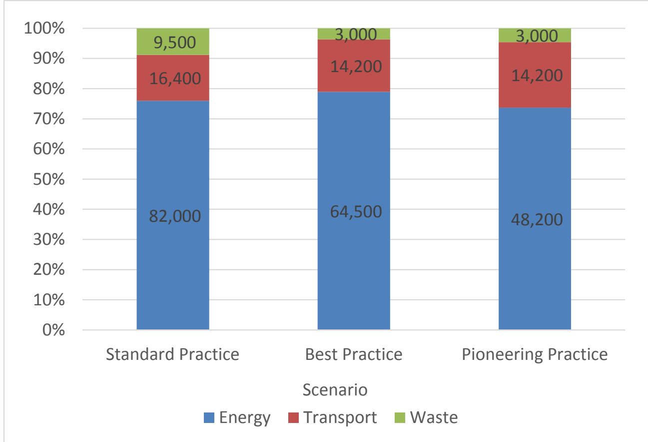


Figure B.3.6 – Old Oak 2031 Scenarios – 2025 Grid Decarbonisation: Emissions Sector Percentages



Note: All figures are indicative estimates only.
Source: Atkins analysis.

Low Carbon Energy Generation Relative to Energy Demand

Figures B.3.7 – B.3.9 summarise the results of the analyses[52] of estimated carbon savings from onsite low carbon energy generation relative to total building energy demand. Further details of the energy analyses which underpin the carbon estimates are presented in the Energy topic section in this report.

The results presented in Figures B.3.7 – B.3.9 suggest that under the less energy efficient demand scenario (Standard Practice scenario) and with 2016 grid decarbonisation, up to around 25% carbon savings are achievable with the mix of potential onsite low carbon energy generation explored in the energy scenarios analyses (see Energy topic section below). However, with projected grid decarbonisation in 2031, even under the Pioneering Practice Scenario (indicating carbon saving of around 18% due to low carbon energy generation) Mayoral guidance regarding carbon 20% emissions reduction from onsite renewable energy would be challenging, but potentially achievable in Old Oak, based on the mix of potential onsite low carbon energy generation explored Energy scenarios analyses. Thus, projected grid decarbonisation could have a marked effect on achievement of this objective. Increasing the proportion of thermal demand which is met by low carbon onsite generation, in particular using electrically powered heat pump technology, could be expected to significantly improve performance against this objective in Old Oak.

[52] The analysis underpinning the results summarised in this section and the similar section below for Park Royal is based on the following assumptions: a) energy supply from energy from waste and anaerobic digestion facilities is classified as 'renewable'; b) energy from waste and anaerobic digestion facilities explored in the waste treatment / disposal scenarios can be accommodated onsite.

Figure B.3.7 – Old Oak Building Energy Carbon: Standard Practice

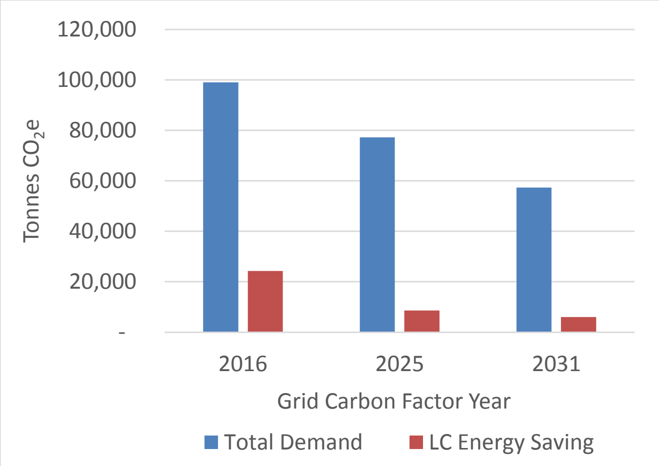


Figure B.3.8 – Old Oak Building Energy Carbon: Best Practice

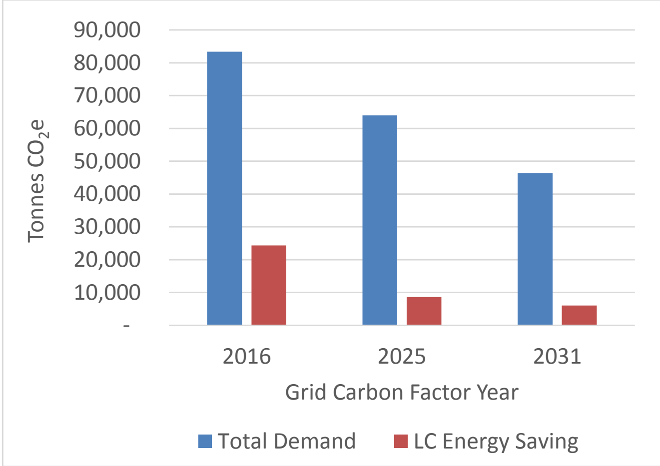
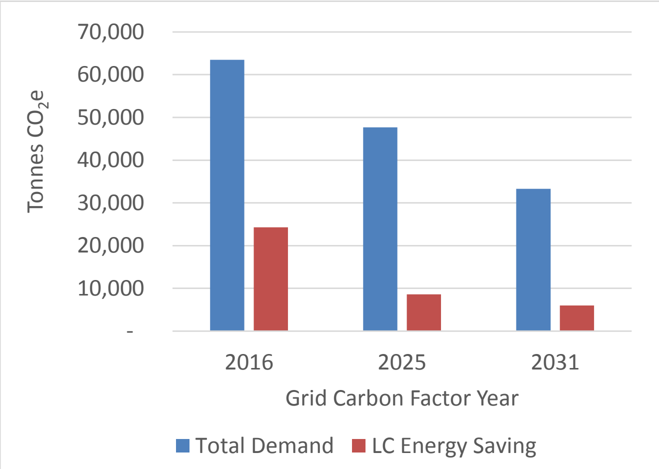


Figure B.3.9 – Old Oak Building Energy Carbon: Pioneering Practice



Note: All figures are indicative estimates only.
Source (all figures): Atkins analysis.

Park Royal

Total Emissions - 2031 Grid Decarbonisation

Carbon emissions analyses for the two carbon emissions scenarios (Standard Practice and Best Practice) for Park Royal based on the 2031 grid carbon factor are summarised in Figures B.3.10 and B.3.11, which show total emissions and percentage of total emissions by sector respectively. Figure B.3.10 suggests that a significant reduction of carbon emissions (around 34%) over the Standard Practice scenario could be achieved. This could rise to around 46% reduction with use of low carbon onsite energy generation. Figure B.3.11 shows that building energy related emissions comprise the great majority (around 97%) of the total carbon footprint, based on energy and waste related emissions only. As noted above, due to data availability it was not possible to include transport related carbon emissions in the scenarios for Park Royal.

Figure B.3.10 – Park Royal 2031 Scenarios – 2031 Grid Decarbonisation: Total Emissions

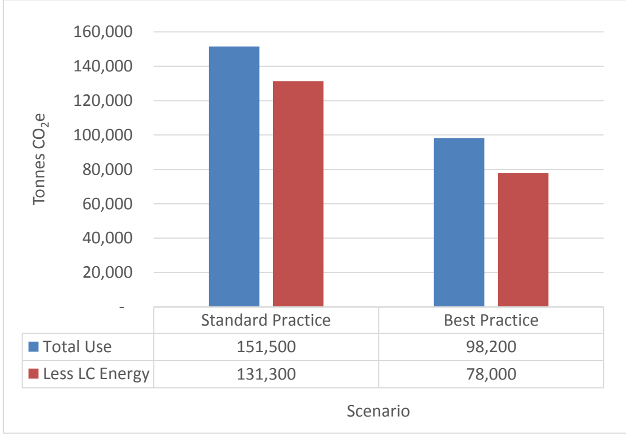


Figure B.3.11 – Park Royal 2031 Scenarios – 2031 Grid Decarbonisation: Emissions Sector Percentages

Note: All figures are indicative estimates only.
Source (all figures): Atkins analysis.

Total Emissions - 2025 Grid Decarbonisation

Figures B.3.12 and B.3.13 summarise carbon emissions analyses for the two carbon emissions scenarios for Park Royal based on 2025 grid decarbonisation, showing total emissions and percentage of total emissions by sector respectively. Figure B.3.12 shows a similar reduction (around 31%) to the 2031 grid decarbonisation figure from the Standard Practice to the Best Practice scenario, without low carbon energy generation, although total emissions are around 44% or more higher with 2025 grid decarbonisation. Figure B.3.13 suggests that the proportion of energy related carbon is similar to 2031 grid decarbonisation levels. This is likely due to the higher unitised energy demand associated with industrial buildings, relative to unitised waste arisings, compared to other land uses.

Figure B.3.12 – Park Royal 2031 Scenarios – 2025 Grid Decarbonisation: Total Emissions

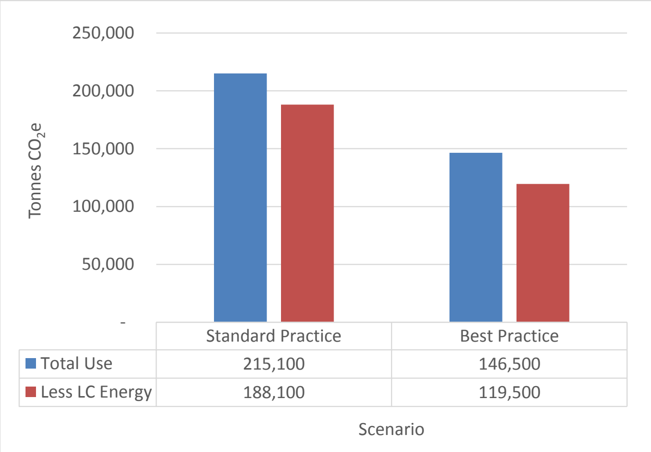
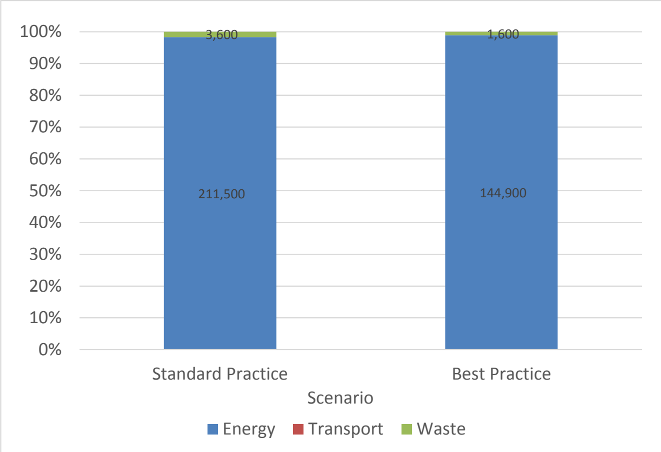


Figure B.3.13 – Park Royal 2031 Scenarios – 2025 Grid Decarbonisation: Emissions Sector Percentages



Note: All figures are indicative estimates only.

Source (all figures): Atkins analysis.

Per capita carbon scenario analyses were not developed for Park Royal due to the largely industrial nature of the area.

Low Carbon Energy Generation Relative to Energy Demand

Figures B.4.14 and B.4.15 summarise the results of the analyses of estimated carbon savings from onsite low carbon energy generation for Park Royal in relation to total building energy demand. Further details of the energy analyses which underpin the carbon estimates are presented in the Energy topic section in this report.

Figure B.3.14 suggests that only around 12% carbon savings are achievable with onsite low carbon energy generation under the Standard Practice scenario, using any of the three grid carbon factors. This is largely due to the high electrical demand from industrial and retail uses on the site. Under the Best Practice scenario, the analysis indicates that, as shown in Figure B.3.15, around 17 - 19% of carbon emissions associated with total energy related demand could be met with onsite low carbon energy supply. Mayoral guidance regarding carbon emissions reduction from onsite low carbon energy generation is thus potentially achievable in Park Royal if energy performance is improved significantly beyond BAU. This could be implemented by retrofitting industrial and retail buildings to reduce their energy related emissions. Alternatively, a strong focus on increasing the proportion of thermal demand which is met by low carbon onsite generation, in particular using electrically powered heat pump technology, could be expected to significantly improve performance against this objective in Park Royal.

Figure B.3.14 – Park Royal Building Energy Carbon: Standard Practice

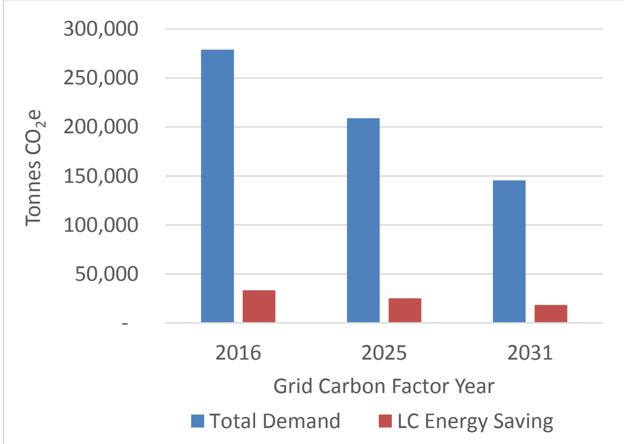
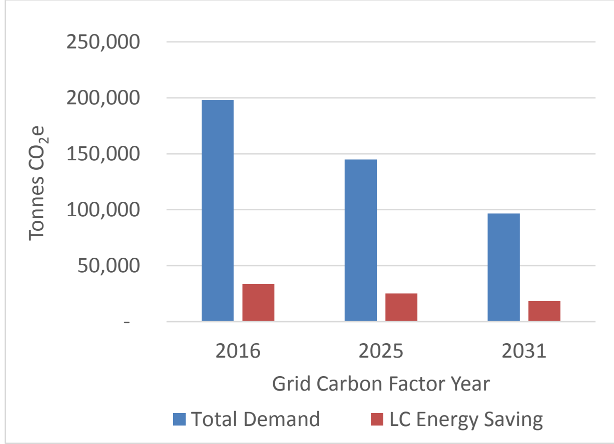


Figure B.3.15 – Park Royal Building Energy Carbon: Best Practice



Note: All figures are indicative estimates only.

Source (all figures): Atkins analysis.

Indicative Costs

Indicative capital costs are provided for energy demand scenarios and low carbon energy generation technologies under the Energy topic of this report. Indicative capital costs for waste treatment technologies are provided under the Waste topic of this report.

The indicative costs suggest that a range of potential energy and waste related carbon reduction measures are financially feasible based on commercially established technologies. Key to overall viability are appropriate financing and management mechanisms to enable investment risk to be extended over longer time frames and risks and benefits shared between developers and service providers. Further work is required to explore site-specific integrated approaches covering financial and management mechanisms as well as system and technical considerations which can then be incorporated into carbon emissions scenario components.

Table B.3.7 provides indicative normalised costs of carbon saved (£ / tonne CO_2e) for the Best Practice energy demand scenario and low carbon energy generation technologies analysed under the Energy and Waste topics and reported in the relevant topic section above.

ATKINS

Table B.3.7 – Indicative Costs of Carbon Savings

Demand Scenario / Energy Generation Technology	Design Life (Years)	Cost (Income) CO_2e Saved (£ / tonne)	Assumptions
Best Practice Building Energy Demand Scenario	60	110 - 180	Overall 5% uplift on current average London construction costs assumed. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Solar photovoltaic (PV)	20	(120) - (190)	FiT assumed to be zero. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Solar thermal	20	(660) - (710)	Currently available grants assumed over design life. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Ground source heat pumps (GSHP)	20	220 - 280	Currently available grants assumed over design life. Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Energy from waste ('Zero Waste' scenario)	25	(150) - (210)	Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.
Anaerobic digestion ('Zero Waste' scenario)	25	(390) - (460)	Energy tarrifs and grid carbon factors based on UK HM Treasury forecasts. Carbon savings based on wholelife average.

Note: All figures are indicative estimates only. Estimated energy savings do not include provision for climate change. Estimated costs exclude operating costs and do not include provision for discounting, taxes, grants or other financial measures other than as indicated.

Sources: Atkins analysis, UK HM Treasury**Error! Bookmark not defined.**, UK Office of Gas and Electricity Markets[53].

Summary and Conclusions

Following are the key messages from the carbon emissions analysis:

Mayoral target of 60% carbon reduction (below 1990 levels) by 2025

- **Old Oak**. Implementing the Best Practice or Pioneering Practice carbon emissions scenarios would be expected to result in substantial reductions in overall carbon emissions compared to the BAU scenario (around 25% and 40% reduction, respectively, using 2025 grid decarbonisation factors). Estimates of per capita emissions based on these overall reductions indicate that this target is achievable. To significantly exceed the target, it would be necessary to move beyond business as usual, either in terms of energy efficiency or onsite generation, towards the Best Practice or even the Pioneering Practice carbon emissions scenario, or components thereof. This assumes the grid decarbonises in accordance with current government predictions
- **Park Royal**. Implementing the Best Practice carbon emissions scenario would be expected to result in a substantial reduction in overall carbon emissions compared to the BAU scenario (around 30%, using 2025 grid decarbonisation factors). It was not possible to determine whether this target could be achieved as the measure used (carbon emissions per capita) was not applicable due to the largely industrial nature of area. Further work is recommended to determine an appropriate measure to evaluate this target for Park Royal.

Mayoral target of 20% reduction in energy related carbon emissions from onsite renewables

- **Old Oak**. At 2016 levels of grid decarbonisation it likely this target is achievable with the mix of low carbon energy generation explored in this study, even under the Standard Practice carbon emissions scenario. With the grid decarbonisation level projected for 2031, the target would be challenging, but potentially achievable. Increasing the proportion of thermal demand which is met by low carbon onsite generation, in particular using

[53] Feed-in Tariff (FIT): Tariff Table 1 April 2017, Ofgem, February 2017. https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-fit-tariff-table-1-april-2017. Tariffs and Payments: Domestic RHI, Ofgem, March 2017. https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi/contacts-guidance-and-resources/tariffs-and-payments-domestic-rhi/current-future-tariffs

electrically powered heat pump technology, could be expected to significantly improve performance against this objective in Old Oak.

- **Park Royal**. Under the Best Practice carbon emission scenario, it is likely this target would be challenging, but potentially achievable, with the mix of low carbon energy generation explored in this study, regardless of predicted grid decarbonisation. However, it should be noted that it was not possible to include transport related emissions in the Park Royal carbon scenarios, due to data availability.

Total emissions offsetting

- **Old Oak**. Total annual emissions estimates range from around 108 thousand tonnes (highest) for the Standard Practice carbon emissions scenario, with no low carbon energy supply and 2025 predicted grid decarbonisation, to around 44 thousand tonnes (lowest) for the Pioneering Practice carbon emission scenario, with implementation of low carbon energy supply as explored in this study and 2031 predicted grid decarbonisation. Offsetting residual emissions thus represents a substantial potential annual financial burden of around £2.6m to £6.5m annually[54].
- **Park Royal**. Total annual emissions estimates for Park Royal are significantly greater than Old Oak (around 78 thousand tonnes to more than 215 thousand tonnes), and do not currently include transport related emissions. Carbon offsetting would not be retrospectively applied to existing uses, which comprise the majority of emissions sources in Park Royal. However, for purposes of comparison with Old Oak, estimated annual emissions represent a theoretical potential cost for carbon offsetting of around £4.7m to £12.9m annually.

Further work is recommended to address the following issues:

- **Transport related emissions**. Estimates of carbon emissions for Park Royal should be developed based on transport modelling data and delineation of appropriate transport scenarios for the area. The Old Oak Zero Car transport scenario should be further developed and the assumptions tested with key stakeholders.
- **Energy demand related emissions**. Given the predominance of energy related emissions in Old Oak, further work is recommended to a) enhance understanding of the level of demand reduction which can be achieved without jeopardising the financial viability of development; b) explore additional onsite low carbon energy opportunities and appropriate financing mechanisms.
- **Embodied carbon emissions**. An appropriate methodology covering both Old Oak and Park Royal should be developed to allow estimation of embodied carbon emissions and evaluating targets. There is currently no London-wide target for embodied carbon emissions. LEGGI data currently only cover operational carbon emissions. There is currently no well-established methodology or set of emissions factors for estimating embodied carbon from broad planning and design data covering land use and/or building types.

[54] Carbon offsetting estimates in this section are based on a carbon price of £60 per tonne, as indicated in the Mayor's Sustainable Design and Construction SPG.

Appendix B.4 - Strategic Site Water Analysis

Introduction

From a set of six water management options presented in the Integrated Water Management Strategy (IWMS) supporting study for the OPDC Local Plan issued in December 2016, all of which meet the core water management IWMS objectives, a preferred option was recommended comprising the following key features:

- Maximise levels of water efficiency and demand management.
- Integrated approach to managing surface water quality and quantity across the development, focusing on the provision of green sustainable drainage infrastructure, delivered to maximise benefit for amenity and biodiversity, including attenuation within plot, strategic SuDS, plus dispersed or centralised attenuation to achieve greenfield discharges for storm events up to 1 in 100 event plus 40% climate change.
- Alternative discharge of attenuated surface water such as controlled discharge to the Grand Union Canal.
- Delivery of a wastewater recycling solution with a single treatment location, providing non-potable water to reduce overall demand from centralised supplies based on strategic network-based solution.

The preferred option draft strategy does not include rainwater harvesting for potable use. However, it does not rule this out. It indicates reclaimed storm water and greywater as also potentially advantageous alternative or complementary solutions, and includes a recommendation to develop a pilot rainwater harvesting scheme. The draft IWMS strategy highlights that flexibility will be needed to allow for future cost and deliverability scenarios as well as changing social and institutional factors.

Indicative Costs

Water Demand / Discharge Scenarios

For the present study, a scenario based approach was used to:

- Estimate indicative capital costs of underground storm water flood attenuation requirements that need to be considered during the design of the site for planning purposes. It was assumed that underground storage will be the most feasible approach to discharge planning constraints in regards to flood risk given that the site's soil and geology is clay based (this is being tested); and
- Estimate indicative high level capital unit costs of achieving "water neutrality" scenarios with a range of rainwater harvesting, greywater, and blackwater solutions while satisfying flood risk planning constraints.

The following development parameter assumptions were used in developing the capital cost estimates:

- Old Oak Common: 25,737 new homes and 65,000 new jobs.
- Park Royal: 1,230 new homes and 4,794 new employment opportunities.
- Total residential population of 66,561 based on 63,525 in Old Oak Common and 3,036 in Park Royal.

All high level capital unit cost estimates have been normalised to the estimated number of new homes (26,967) and rounded to the nearest £100.

The high level capital unit cost estimates were prepared by adopting:

- IWMS calculations for storm water flood attenuation volumes for the sub-areas of the site[55].
- IWMS calculations for water demand and wastewater generation, but based on the above forecasts for new homes, population, and employment capacity[56] which are presented in Table B.4.2.

55 Note: the flood attenuation requirements included in the IWMS do not detail the impermeable areas used for the Park Royal site, so proportional scaling (+6%, based on the new homes in Park Royal) was used to determine the storm water flood attenuation requirements for purely the new homes on the basis that the existing non-developed plots will not be required to attenuate back to Greenfield runoff rates. This requires review because there may be a desire to build in further flood attenuation requirements for the full site.

56 Note: the demand calculations presented in Appendix A of the IWMS do not include Park Royal's employment and housing needs, so this has been rectified in this study.

- A range of typical water reduction measures, and associated unit costs (inflated to 2016 prices), that could be implemented in the different sub-areas, which are presented in Table B.4.3; and
- Development Infrastructure Funding Study (DIFS) supporting study for the OPDC Draft Local Plan, February 2016, water supply and drainage infrastructure development forecasts with proportional scaling (+5%, based on the new homes in Park Royal) to reflect the new homes that will be constructed in Park Royal bringing the total traditional infrastructure cost to approximately £4,684,700.

Comparative high level capital unit costs were estimated for the following water demand / discharge scenarios which were developed for the purposes of this study:

- **Conventional Solution** – the scenario was developed by calculating a capital cost for the storm water flood attenuation requirements predicted in the IWMS using the adopted unit rates in Table B.4.2 and combining this with the scenario and capital costs set out in the DIFS for water and sewerage infrastructure.
- **Rainwater Harvesting** – the scenario was developed by assuming that 60% of all rainfall could be harvested to thereby reduce the storm water attenuated flood volumes and potable water supply demands. For simplicity, it was assumed that 50% of the captured rainfall could be used to offset water supply demands with obviously sewer demands remaining, on the basis that appropriate treatment measures could be implemented for potable needs.

  This rainfall capture percentage, and thus reduction in storm water flood attenuation, was developed using HR Wallingford's Sustainable Drainage – Surface Water Storage Requirements tool[57] for a representative location for the site using a 1 in 100 year return period rainfall to ensure the assessment would be comparable to that used in the IWMS and rainwater harvesting would be implemented en masse and serve a minimum of 10 dwellings. It is acknowledged that the predicted capture percentage is high given the severity of the storm being used (1 in 100 year return period rainfall) and requires further review and justification.

  The Conventional Solution scenario's water and sewerage infrastructure requirements were then proportionally reduced (-25% - see Figure B.4.1 and Table B.4.2) and included in the capital unit cost estimate for this scenario, given that this would still be required to satisfy all of the demands/needs for the development.
- **Greywater Recycling (showers, baths, and washing machine wastewater)** – the scenario was developed by assuming that greywater recycling could result in a demand saving of 40 l/p/d, which is a level of saving used in a previous Atkins study for Anglian Water[58].

  Based on IWMS residential water demand estimates of 110.65 l/p/d for potable supply and 20.6 l/p/d for employment related potable water demand, adopting 40 l/p/d is equivalent to reducing the residential potable water demand to 91.25 l/p/d, which is below the Mayor of London's target of 105 l/p/d as set out in the London Plan, but above the 80 l/p/d water target that is quoted as being achievable/required for sustainable new buildings with greywater recycling[59][60]. The adopted rate is therefore not as optimistic, or stretching, as it could be, but it is a rate that is likely to be achievable and will exceed the Mayor of London's target.

  The adopted 40 l/p/d demand saving was equally applied to potable and non-potable residential uses on the basis that potable savings would be recycled to deliver the non-potable uses. It was assumed that potable employment demands would remain, but non-potable employment demands could be eliminated due to greywater recycling – in essence a non-potable employment water demand saving of circa 20 l/p/d was applied. This was cascaded down into the sewer demands by assuming that the 40 l/p/d saving would reduce the scale of residential grey sewer loadings by 40 l/p/d and all of the employment grey sewer loadings, but not black water sewer demands for both residential and employment demands because this would require a higher level of treatment.

  The Conventional Solution scenario's storm water flood attenuation requirements and capital cost estimates were then included to reflect that this scenario would still need to satisfy these requirements, while conventional water and sewerage infrastructure was proportionally reduced (-31%).
- **Blackwater Recycling (toilet and kitchen wastewater)** – recycled blackwater is more limited in terms of application in the UK and its ability to reduce overall supply demand because it requires more treatment for wider re-use. Given that these types of technologies will lock in a dependency on

---

[57] http://www.uksuds.com/surfacewaterstorage_js.htm.
[58] Anglian Water Supply Demand Strategy, Atkins, 2016.
[59] Achieving Water Efficiency on Projects - Information Sheet, Waste and Resources Action Programme, UK.
[60] Code for Sustainable Homes - Technical Guidance, Department for Communities and Local Government, UK, 2010.

energy, which is not in keeping with the overall aim of the development, it is assumed that blackwater recycling will be used for low quality needs, such as garden watering and further toilet flushing. With toilets and kitchen sinks typically discharging 8.8l and 6.5l[61], respectively, it was assumed that blackwater recycling could reduce non-potable demand by 6% which then cascaded down into reductions of greywater sewer demand.

The Conventional Solution scenario's storm water flood attenuation requirements and capital cost estimates were then included to reflect that this scenario would still need to satisfy these requirements, while conventional water and sewerage infrastructure was proportionally reduced to reflect the overall level of water saving (-2%).

- **Water Sensitive Urban Design** – the scenario was developed through accumulation of the above scenarios and includes:

  1. Rainwater harvesting of 60% capture to reduce underground storm water flood attenuation requirements;
  2. Rainwater harvesting to reduce 50% of the potable water supply demands;
  3. Further 40 l/p/day reduction in water demands due to greywater recycling – applied in unequal measure between potable, non-potable, grey, and black demands because this in combination with the above generated negative values; and
  4. Reduced conventional water and sewerage infrastructure requirements (56%).

  Blackwater harvesting was not included in the Water Sensitive Urban Design scenario on the basis that rainwater harvesting and greywater outweigh the benefits of blackwater recycling, i.e. blackwater recycling is more energy intensive.

The scenarios are visually presented in Figure B.4.1 below.

61 Urban Drainage - Third Edition, Butler, David; Davies, John W., UK, 2011.

Figure B.4.1 – Water Demand / Wastewater Scenarios

Conventional
- Underground stormwater flood attenuation
- Conventional water and sewerage infrastructure

Rainwater Harvesting
- Rainwater harvesting 60%
- Underground stormwater flood attenuation for non-harvested rainfall
- Water demand reduction of 50% for residential and employment
- Reduced conventional water and sewerage infrastructure requirements (25%)

Greywater Recycling
- Greywater recycling reduces water demand by 40l/h/day for residential and 20l/h/day for employment
- Greywater recycling reduces residential greywater by 40l/h/day and employment greywater sewer demands
- Underground stormwater flood attenuation
- Reduced conventional water and sewerage infrastructure requirements (31%)

Blackwater Recycling
- Recycling of toilet & kitchen wastewater for low treatment uses - Water demand reduction of 6%
- Underground stormwater flood attenuation
- Reduced conventional water and sewerage infrastructure requirements (2%)

Water Sensitive Urban Design
- Rainwater harvesting 60%
- Underground stormwater flood attenuation for non-harvested rainfall
- Water demand reduction of 50% for residential and employment
- Greywater recycling reduces water demand by 40l/h/day for residential and 20l/h/day for employment
- Greywater recycling reduces residential greywater by 40l/h/day and employment greywater sewer demands
- Reduced conventional water and sewerage infrastructure requirements (56%)

Source: Atkins analysis.

Results of Analysis

The high level capital unit costs estimated for the respective scenarios are shown in Table B.4.1. Details of water use estimates, sources and assumptions used in estimating costs for each scenario are shown in Tables B.4.2 and B.4.3 below.

Table B.4.1 - Water / Wastewater Scenarios Indicative Unit Costs

Water / Wastewater Scenario	Indicative Unit Cost (£ / new home)
Conventional Solution	900
Rainwater Harvesting	1,600
Greywater Recycling	1,600
Blackwater Recycling	4,400
Water Sensitive Urban Design	2,400

Note: All figures are indicative estimates only.
Sources: Atkins analysis.

The results of the indicative cost analysis indicate that:

- A conventional infrastructure solution will be cheaper to implement, but it will not deliver the vision for the development nor build in sustainability principles that are essential given the future pressures facing London;
- Rainwater harvesting will substantially reduce storm water flood attenuation requirements, and with appropriate treatment measures, could reduce potable water demand pressures;
- Greywater recycling is an effective measure to reduce water and sewer demand pressures;
- Blackwater recycling is the most costly and should only be considered where relevant and necessary;
- The high level capital unit costs of rainwater or greywater led solutions are relatively similar;
- The water sensitive urban design approach will cost considerably more than a conventional infrastructure solution, but it will reduce future customer water bills while increasing site climate resilience and profitability with appropriate marketing. Assuming the 56% water savings of this scenario are carried through to customer bills, this could represent a saving of around £2,200 to potential new home owners – assuming they own the properties for a period of 10 years and the average customer bill (£389) will not fluctuate heavily. This is, however, only one area of potential benefit, and further benefits should be identified and costed, so that the costs can be considered in respect to benefits and allow appropriate funders to be identified for enabling such measures given a more sustainable development is desired by all stakeholders.

The following recommendations are made with regards to extending and strengthening the above analysis:

1. Confirm the parameters, and the basis for the assessment, are appropriate, because there are inconsistencies between studies and a number of assumptions have been made;
2. Review the appropriateness of the assumptions that have been built into the appraisal for this study;
3. Extend the appraisal to consider the longer term, operational, and resilience benefits of embedding water sensitive urban management practices into the development;
4. Consider how an alternative water management approach for the site will be managed, operated, and maintained with roles and responsibilities clearly outlined; and
5. Extend the appraisal to consider what impact embedding water sensitive urban management practices could have on site profitability, which should centre on green infrastructure.

Table B.4.2 - Water Demand / Wastewater Scenarios - Water Use Estimates

Water Demand / Wastewater	Water Use Type	Rate l/p/d	Water Demand / Wastewater Scenario – Water Used (l/day)				
			Conventional Solution	Rainwater Harvesting	Greywater Recycling	Blackwater Recycling	Water Sensitive Urban Design
Water Demand	Residential Potable	110.65	7,365,000	3,682,500	6,033,800	7,365,000	1,807,100
	Residential Non-Potable	20.6	1,371,200	685,600	39,900	1,288,900	-
	Employment Potable	19.53	1,363,100	681,500	1,363,100	1,363,100	96,500
	Employment Non-Potable	18	1,256,300	628,100	-	1,180,900	-
Sewer Discharge	Residential Grey	75.11	4,999,400	4,999,400	2,337,000	4,999,400	2,337,000
	Residential Black	56.14	3,736,700	3,736,700	3,736,700	3,512,500	3,736,700
	Employment Grey	7.34	512,300	512,300	-	512,300	-
	Employment Black	30.19	2,107,100	2,107,100	2,107,100	1,980,700	2,107,100
Total			**22,711,000**	**17,033,300**	**15,617,500**	**22,202,700**	**10,084,400**
Overall Saving in Water Used				**25%**	**31%**	**2%**	**56%**

Note: All figures are indicative estimates only.
Sources: Atkins analysis, and as indicated in Table B.4.3.

Table B.4.3 - Adopted Capital Cost Unit Rates

Solution	Unit Rate (£ Incl. CPI to 2016)	Source	Justification
Underground Storage	652 / m^3	Stovin & Swan[62]	Onsite attenuation through reinforced concrete storage tank solutions on the basis that ground conditions and existing services will prohibit deep trenching works and attenuation will be delivered through highway carriageways.
Rainwater Harvesting	57 / m^2	Environment Agency[63]	Was adopted following comparative build ups with similar rates.
Greywater	750 / property	Anglian Water58	It is assumed that greywater recycling will be implemented on mass throughout the development, so there will be economies of scale. If not undertaken in this manner, this unit rate could be expected to inflate to £3,774 / property based on other unit rates.
Blackwater	3,500 / property	WTE Ltd[64]	Modern extended aeration sewage treatment plant with £2,000 for plant and £1,500 for installation

Sources: As indicated in table.

[62] Retrofit SuDS - cost estimates and decision-support tools, *Water Management*, 207-214, Stovin, V. R., & Swan, A. D., 2007.
[63] Cost-benefit of SuDS retrofit in urban areas (Science Report - SC060024), Environment Agency, 2007.
[64] Septic Tank, Sewage Treatment System Costs. http://www.wte-ltd.co.uk/sewage_treatment_costs.html.

Appendix B.5 - Site Air Quality Analysis

Introduction

During the Local Air Quality Management Review and Assessment process carried out by the London boroughs of Brent, Ealing, and Hammersmith and Fulham, areas within each borough were identified where the relevant health-based national Air Quality Objectives (AQOs) for NO_2 and PM_{10} are exceeded. As a result, each council declared a borough-wide Air Quality Management Area (AQMA) for exceeding annual mean NO_2 and 24-hour mean PM_{10} AQOs. The Old Oak and Park Royal area straddles these AQMAs. Road traffic is the most important source of air pollution in the OPDC area, and this forms the key area of focus of Action Plan measures.

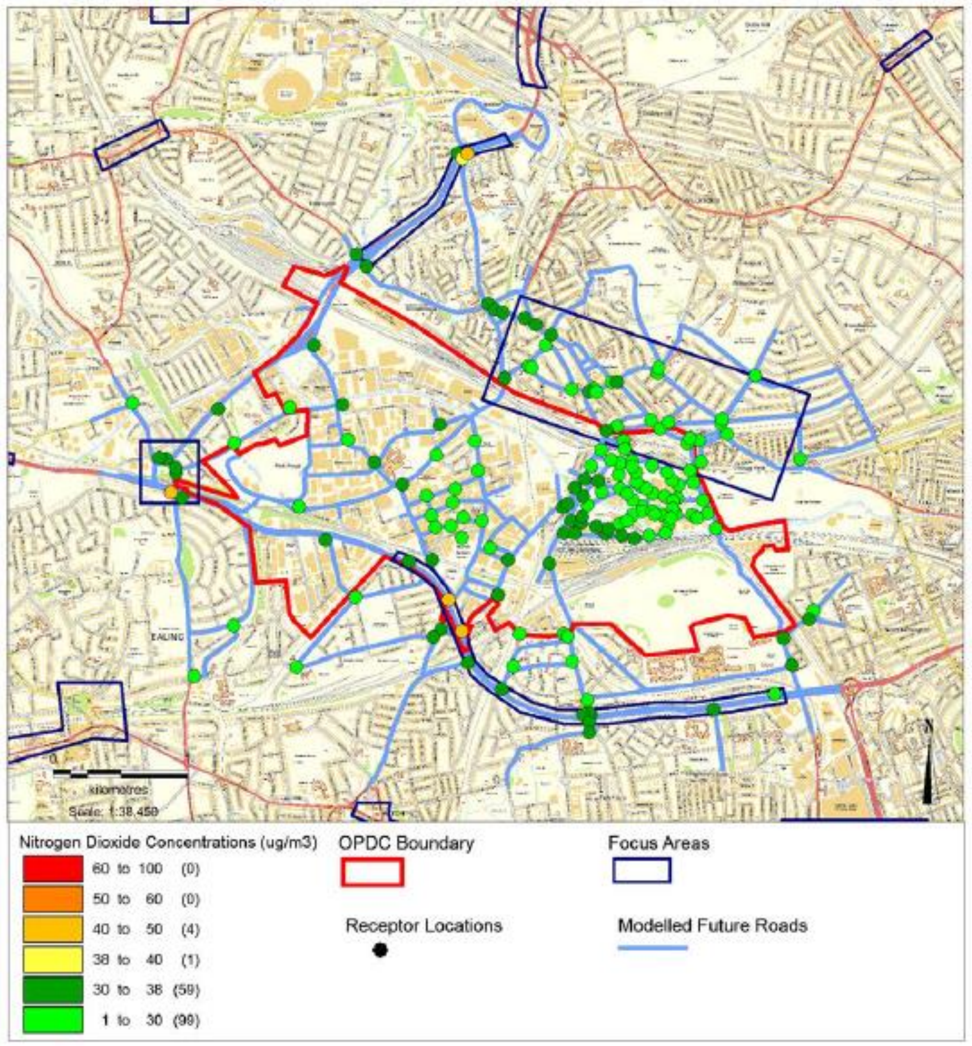
Site Air Quality

The Air Quality Study provides an evaluation of current air quality conditions in the OPDC area and future estimated air quality conditions with the development.

Using a combination of publicly available data and study-specific dispersion modelling the results of the evaluation of current air quality conditions indicate that there are currently a high number of exceedances of the annual mean AQO for NO_2, largely associated with the road network (see Figure B.5.1). Recent monitoring data also indicates that the 24-hour mean AQO for PM_{10} has also been exceeded, and that exceedances appear to be associated with operation of industrial and waste management activities in the area. High NO_2 concentrations measured at NO_2 diffusion tube sites were linked with high numbers of Heavy Duty Vehicles (HDVs) in some areas (e.g. Old Oak Lane) and high levels of congestion in others (e.g. North Acton). Analysis detailed in the Old Oak Strategic Transport supporting study for the OPDC Draft Local Plan confirms that a number of roads and junctions have volumes of traffic that exceed capacity resulting in slow moving traffic and high emissions. Strategic routes such as the A40 and A406 are under stress and junctions on the A40 such as Gypsy Corner, Savoy Circus and Hanger Lane are congested, particularly at peak periods.

The Air Quality Study reports on dispersion modelling which used the Old Oak Transport Study 2031 'with development' scenario and 2030 projected background concentrations to estimate the ambient concentrations of NO_2 and PM_{10} across the site for 2031 build out.

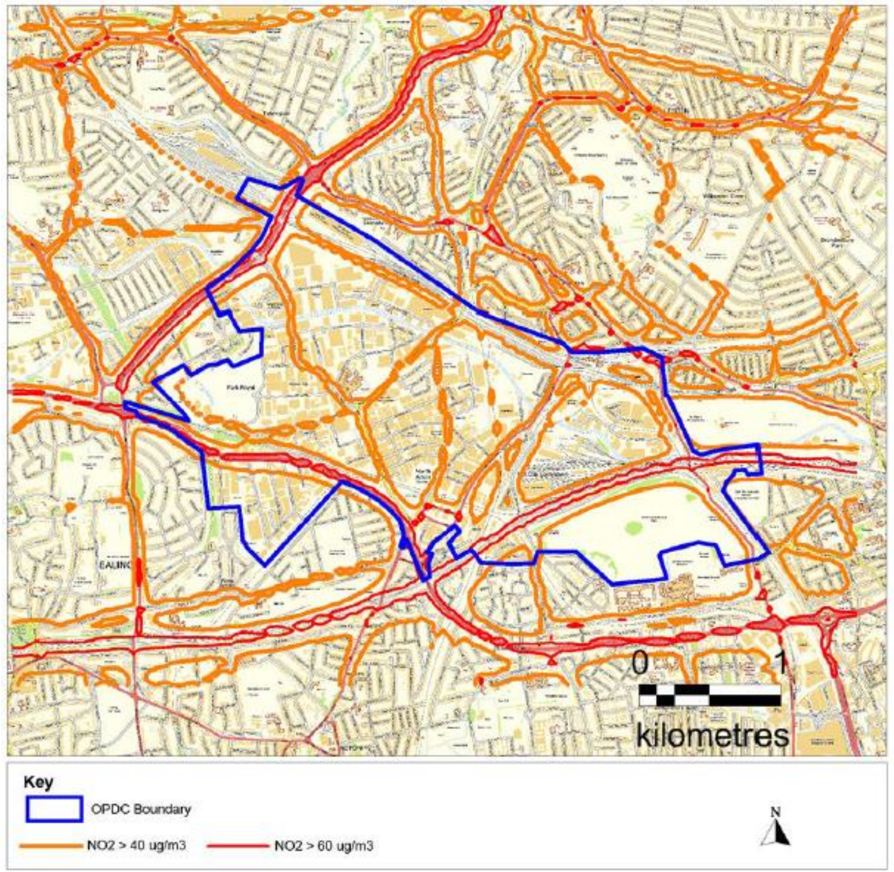
Figure B.5.2 - Thematic Map of Modelled NO_2 Concentrations at Receptor Locations in the 2031 Future Scenario with 2030 Background Concentrations



Source: Old Oak and Park Royal Air Quality Study, OPDC, February 2015

ATKINS

Figure B.5.1 - Contour Map Displaying LAEI 2012 NO_2 Mapped Concentrations



Source: Old Oak and Park Royal Air Quality Study, OPDC, February 2015

The results indicated that, due to turnover in the vehicle fleet, which will see older vehicles replaced by newer vehicles which meet tighter European emission standards, emissions and background and roadside pollutant concentrations are expected to be lower in the future. The area of exceedance of the annual mean AQO for NO_2 is predicted to be reduced (see Figure B.5.2). However, it is likely that exceedances of the AQO will still occur, particularly around busy roads and junctions. Modelled concentrations of PM_{10} and $PM_{2.5}$ were estimated to be below their respective AQOs at all modelled locations.

Freight Consolidation and Zero Emissions Last Mile

Consolidating freight movements using dedicated centres is well recognised as a means of reducing overall freight trip numbers and trip kilometres with benefits in terms of reduced congestion, carbon and other air pollutant emissions, as well as other environmental benefits. The Air Quality Study cites a number of examples of freight consolidation centres (FCC) in the UK:

- **Meadowhall Centre, Sheffield** - over 50% of retailers use the scheme.
- **Broadmead FCC, Bristol** - results indicate that participating retailers have benefitted from a 75% reduction in vehicle movements[65].
- **Gnewt Cargo scheme, Regent Street, London**[66] - freight consolidation coupled with low emission delivery.
- **Waste consolidation at the Olympic Park, London** - reduced offsite vehicle movements by over 80%[67].
- **Heathrow Consolidation Centre, London** - a 66% reduction in the number of vehicle movements to airport terminals[68].
- **FCC for London boroughs of Camden, Enfield, Islington and Waltham Forest, London** - 45% reduction in the total distance travelled by delivery vehicles[69].

A study for South East Scotland Transport Partnership70 gives figures of 660kg NO_x, 19.7kg PM_{10} and 20.3 tonnes CO_2 in annual air pollution savings for the 500m^2 floor area Broadmead FCC, Bristol, and 197kg NO_2, 14.5kg particulates and 22 tonnes CO_2 in annual air pollution savings for the 2,300m^2 floor area Heathrow Consolidation Centre, London. Both these facilities are retail FCCs.

The use of FCCs in relation to construction activities is also highlighted by the Air Quality Study, citing examples in London which have had a major effect in reducing vehicle trips and associated local emissions as well as increased delivery reliability.

The Air Quality Study also emphasises the concept of zero emissions 'last mile' deliveries. This involves use of electric vehicles or cycles. The study cites a pilot in the City of London which showed zero local air pollutant emissions were generated and the amount of space taken up by delivery vehicles dropped by 50%. Based on modelling reported in the London Local Air Quality Management Borough Air Quality Action Matrix[71], the Air Quality Study highlights that, by removing all light goods vehicles emissions, as an approximation of the impact of

[65] WSP for BCSC (2015) Freight Consolidation and Remote Storage.
[66] TfL Freight. Going the Extra Mile http://content.tfl.gov.uk/going-the-extra-mile.pdf.
[67] TfL Freight. Waste Consolidation: An Olympic tale of victory http://content.tfl.gov.uk/veolia-waste-case-study.pdf.
[68] TfL Freight. Expansion of Consolidation at Heathrow http://content.tfl.gov.uk/heathrow-case-study.pdf.
[69] TfL Freight. The London Boroughs Consolidation Centre – a freight consolidation success story http://content.tfl.gov.uk/lbbc-case-study.pdf.
[70] Freight Consolidation Centre Study, South East Scotland Transport Partnership, April 2010. http://www.dryport.org/files/doc/SEStran_Freight%20Consolidation%20Centre%20Study%20-%20Final%20Report.pdf.
[71] https://www.london.gov.uk/sites/default/files/air_quality_action_matrix.pdf.

encouraging zero emissions last mile deliveries, it was shown that NO_2 and PM_{10} concentrations would decrease by 11% and 12% respectively.

Indoor Air Quality

The quality of air within buildings is affected by a range of factors, which can be broadly categorised as[72]:

- **Chemicals** - emitted from building construction materials, fixtures and fittings, as well as user products such as consumer and office products, cleaning products, etc. One of the most important groups of chemicals, in terms of potential health effects and wide range of sources, are Volatile Organic Compounds (VOCs)[73]. One common VOC, formaldehyde, is widely used in the manufacture of building materials and numerous household products, and is also a by-product of combustion and other natural processes.
- **Radon** - a naturally occurring gas present in soil and rock in some regions.
- **Suspended particulates** – from ingress of outdoor pollution, indoor burning of fossil fuels, indoor chemical reactions between ozone and some VOCs.
- **Microbes and allergens** – from mould growth, pets and pests.
- **Ventilation** – circulation of fresh air determined by openness of the building to outside environment and use of mechanical ventilation. Low ventilation relative to level of building occupancy results in build-up of carbon dioxide (CO_2).
- **Humidity**– in addition to high or low levels of humidity being a direct cause of occupant discomfort, high levels of humidity can exacerbate mould and pest growth.
- **Temperature**– in addition to high or low temperatures being a direct cause of occupant discomfort, higher temperatures can aggravate the effects of insufficient humidity.

The Mayor's Sustainable Design and Construction SPG provides guidance on protection of internal air quality as follows:

- Developers should specify environmentally sensitive (non-toxic) building materials and the use of materials or products that produce VOC and formaldehyde which can affect human health should be avoided. The use of 'healthy' material options can contribute towards attaining the BREEAM / Code for Sustainable Homes credits but a clear audit trail will need to be provided to gain these credits.
- Combustion plant and equipment such as boilers should be maintained and measures taken to ensure they are operating at their optimum efficiency to minimise harmful emissions. A maintenance regime should be outlined in an Air Quality Assessment, where required and could be secured by condition or s106 agreement by the borough.

For the present study, the focus is on indoor air pollutant concentrations related to building construction and operation. In particular, pollutants emitted from building materials, fixtures and fittings, and CO_2 concentrations related to building occupation levels, are considered most important to OPDC indoor air quality targets. VOCs are considered the key type of pollutant in relation to emissions from building materials, fixtures and fittings.

Below are listed key UK and international standards and guidance in relation to VOC and CO_2 concentrations for indoor air quality:

UK

- BS EN 15251 (CO_2).
- BS EN 14662-5 (VOC).
- UK Building Regulations, Part F (CO_2).
- EH40/2005 Workplace exposure limits, Health and Safety Executive, 2011 (VOC, CO_2).
- Building Research Establishment (BRE) Environmental Assessment Method (BREEAM), BRE, UK, 2014 (VOC).

International

- ISO 16000-5 (VOC).
- Indoor Air Quality Guide, Best Practices for Design, Construction, and Commissioning, ASHRAE, USA (VOC, CO_2).

[72] http://copublications.greenfacts.org/en/indoor-air-pollution/index.htm.

[73] VOCs are defined as any organic (carbon-containing) liquid or solid that evaporates spontaneously at the prevailing temperature and pressure of the atmosphere with which it is in contact (source: EN ISO 11890). The term VOC refers to any of thousands of organic chemicals that are present mostly as gases at room temperature.

- Promoting actions for healthy indoor air (IAIAQ), EC Directorate General for Health and Communities, 2011 (VOC).
- Guidelines for indoor air quality: selected pollutants, World Health Organisation, Denmark, 2010 (VOC).
- Indoor Air Quality in Commercial and Institutional Buildings, Occupational Safety and Health Administration, USA, 2011 (VOC, CO_2).
- WELL Building Standard, International Well Building Institute, New York, 2016.
- Leadership in Energy and Environmental Design (LEED), US Green Building Council, USA, 2013 (VOC).

From review of the above standards and guidance the following key points can be made:

CO_2

- Limit values range from 5,000ppm (HSE, OSHA – 8 hour exposure) to 800ppm (WELL Building) and 350ppm above outdoor concentration (BS EN 15251).
- Key measures to reduce CO_2 concentrations:
- Ensure design complies with ventilation flow requirements to maintain target CO_2 levels.
- Use CO_2 based demand-controlled ventilation where appropriate.
- Use natural and mixed-mode ventilation where appropriate. Analyse surrounding outdoor air quality levels prior to determining whether natural ventilation is an appropriate strategy and use modelling to ensure target CO_2 levels can be maintained.

VOCs

- Limit values for the broad measure Total VOC (TVOC)[74] range from 500µg/m^3 over 8 hours (LEED, WELL Building) to 300µg/m^3 over 8 hours (UK Building Regulations, BREEAM). Limit values for individual VOCs, which vary widely, are generally accepted as a more useful measure for risk assessment.
- Limit values for formaldehyde range from 2,000µg/m^3 (8 hour exposure - UK HSE) to 100µg/m^3 (30 minute mean - WHO, BREEAM).
- Key measures to reduce VOC concentrations:
  - Specification of low / zero VOC materials for: furniture, flooring, adhesives, paints, flooring, wood panels, suspended ceilings.
  - Control emissions through use of VOC barriers, e.g. coatings, laminates, veneers.
  - Ensure adequate ventilation, particularly during cleaning / maintenance activities.
  - Provide filtration and air cleaning to remove air contaminants.
  - VOC testing during construction and pre-occupation to ensure compliant levels have been met.

CO_2 concentration in indoor environments has long been used as an indicator of ventilation and as a proxy for indoor air quality. However, the results of a recent study[75] indicate that CO_2 should be considered as a pollutant in its own right not just as a marker for other pollutants, with significant decline in cognitive function with CO_2 concentrations even at ASHRAE guideline levels. The same study results also indicated a significant decline in cognitive functions with TVOC concentrations above the 500µg/m^3 LEED guidance level.

Adequate and appropriately maintained ventilation is key to reducing and controlling concentrations of both CO_2 and VOCs. Linking sensor information with dynamically controlled ventilation provision enables not only real-time control of indoor air quality but also has benefits in terms of energy and cost efficiency, particularly in spaces with intermittent or variable usage. Modern smart building technology, either standalone or integrated with building management systems, can provide real time user / occupant information on building performance against indoor air quality criteria.

Cost Implications

The Development Infrastructure Funding (DIFS) supporting study for the OPDC Draft Local Plan provides cost estimates for the set of interventions recommended in the Old Oak Transport Study as part of the proposed transport

[74] TVOC is defined as the sum of the concentrations of identified and unidentified volatile organic compounds eluting between and including n-hexane and n-hexadecane on a gas chromatographic column (source: Building Research Establishment, BREEAM guidance).

[75] Allen JG, MacNaughton P, Satish U, Santanam S, Vallarino J, Spengler JD. 2016. Associations of cognitive function scores with carbon dioxide, ventilation, and volatile organic compound exposures in office workers: a controlled exposure study of green and conventional office environments. Environ Health Perspect 124:805–812; http://dx.doi.org/10.1289/ehp.1510037.

strategy. The proposed transport strategy is based on the Reduced Highway / High Public Transport Share scenario explored in the study in which a 5% commercial and 15% residential car mode share was assumed. The DIFS cost estimates cover highways improvements, rail capacity improvements, bus capacity improvements, bridges and underpasses, cycling and walking improvements. Costs associated with delivering HS2 and Crossrail, with the exception of a Crossrail to WCML spur, have not been included. Costs associated with demand management and 'smarter choices' initiatives have not been included, as these are anticipated to come through normal development processes. The total estimated cost for implementing the proposed transport strategy amounts to £1.066bn.

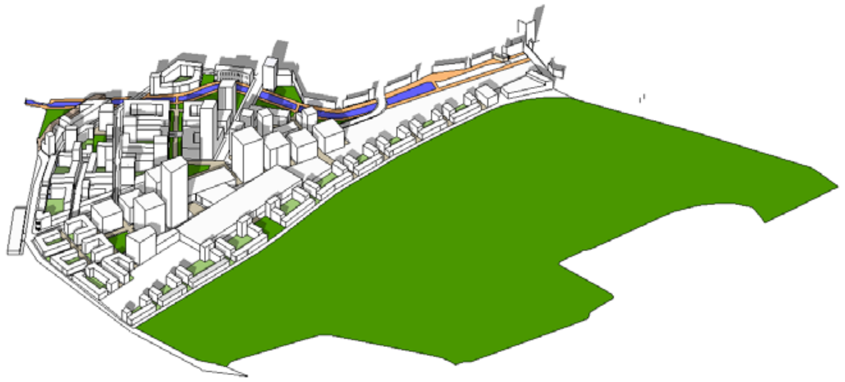
The Old Oak Transport Study proposed transport strategy includes provision for FCCs. This is not covered in the DIFS cost estimates. A study for South East Scotland Transport Partnership[76] gives indicative figures of approximately £1.37m capital cost and £248,000 annual operating cost for a retail FCC of 500m^2 floor area. However, it should be emphasised that costs can vary considerably depending on how FCCs are implemented, in particular whether an existing facility is used or a new facility developed. A study for Birmingham City Council[77] estimated capital costs for the former could be as low as £20 - 50,000.

[76] Freight Consolidation Centre Study, South East Scotland Transport Partnership, April 2010. http://www.dryport.org/files/doc/SEStran_Freight%20Consolidation%20Centre%20Study%20-%20Final%20Report.pdf.

[77] Birmingham Mobility Action Plan, Birmingham Connected Technical Package 3 Servicing and Logistics, Birmingham City Council, November 2014. https://www.birmingham.gov.uk/downloads/file/1931/birmingham_connected_technical_package_3_servicing_and_logistics.

Appendix C: Old Oak Common Urban Heat Island Study, Imperial College London

A preliminary Urban Heat Island study for the Old Oak Common area



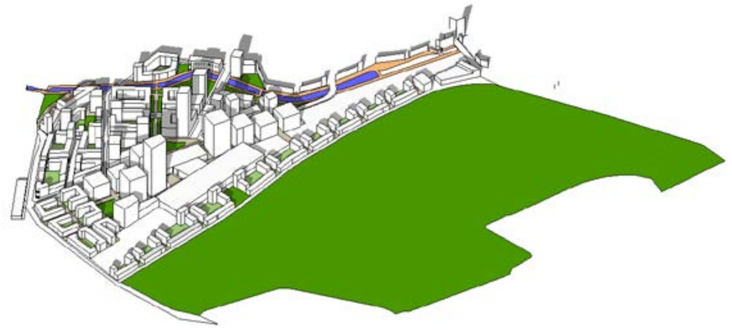
Dr Maarten van Reeuwijk
Department of Civil and Environmental Engineering
Imperial College London
m.vanreeuwijk@imperial.ac.uk

October 17 2016

Introduction

Atkins is currently providing environmental services for the development of Old Oak Common and Park Royal new quarters in order to identify and develop environmental sustainability targets. As part of the general study scope, a study of the development-specific microclimate is being produced. Within the microclimate study, the potential effect of Urban Heat Island (UHI) in the local climate is to be studied.

The proposed masterplan for the Old Oak Common area has been identified as a very high density area (with densities above 600 units per hectare). As a result of this, a potential risk for the area to be adversely affected by UHI effect has been identified amongst other microclimate issues.



The aim of this urban heat island study for the Old Oak Common project is to provide some insight into the temperature reductions that may be obtained using:

1) green roof technology;
2) high reflectivity surfaces.

Modelling technique

As part of the Climate-KIC sponsored Blue-Green Dream (BGD) project (bgd.org.uk), a prototype urban microclimate model was developed for the master planning stage to quantify the Urban Heat Island Effect. The Town Energy Balance model (TEB; Masson, 2000) was used as a starting point; this model has been extensively tested and validated for its use in the urban environment (Grimmond, 2000). The TEB model is based on a surface-energy balance and is used for atmospheric weather predictions by the French weather service. In the UK, a similar surface energy balance model, JULES, is used by the Met Office (Best, 2011). The TEB model was extended in Suter *et al.*, 2016 to be able to consider the effect of spatial heterogeneity and green roofs, and is called the Modified Town Energy Balance (MTEB) model.

MTEB is a neighbourhood scale model and thus does not require highly resolved information of the surrounding area, instead using simple parameters such as the typical building height, road width etc. The orientation of roads and buildings are averaged out in this description. This model can be used to test a large number of scenarios rapidly and efficiently. The model does not produce detailed heat maps of the area; these can be produced with detailed simulations based on Computational Fluid Dynamics in the later design stages.

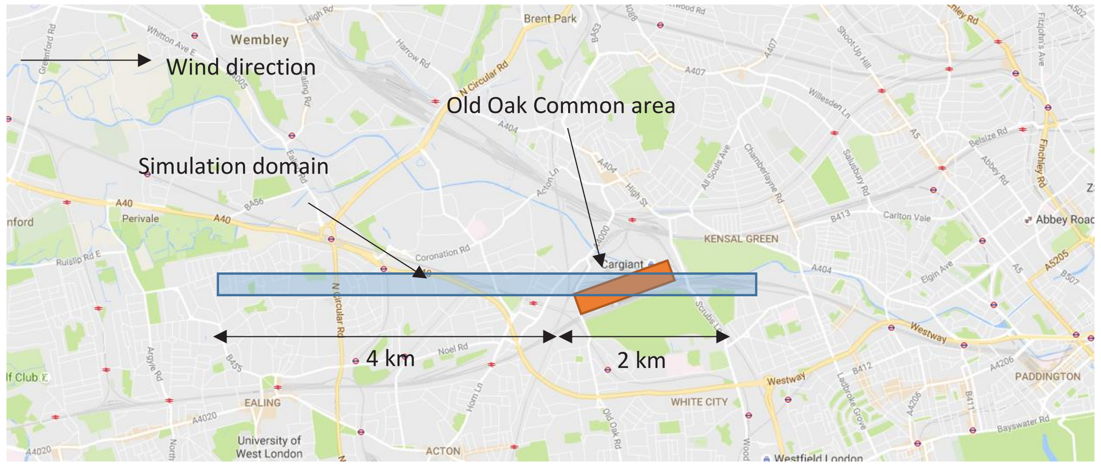


Figure 1: simulation domain for UHI study

Model setup

A highly idealised case study is carried out, where the entire environment around Old Oak Common is characterised by buildings with a typical height of 40 meters (for full details of the parameters used see appendix). The wind is blowing eastwards at 1.5 m/s, and a simulation domain of 6 km length is used which is aligned with the wind direction (Figure 1). The Old Oak site is about 800 m long in the streamwise direction, and the first 400 m of the Old Oak Common area are characterised by buildings which are assumed to be 70 m high, as shown in Figure 2.

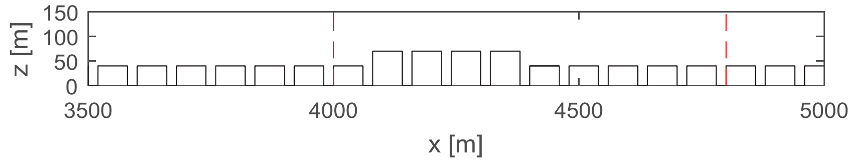


Figure 2: problem geometry

An idealised heat wave event is considered in which the atmospheric temperature T_{atm} and incoming shortwave solar radiation S_{dir} vary in time as shown in Figure 3. The temperature inside the buildings is constant at 24°C. For simplicity, horizontal advection is not considered in this study – in earlier studies the effect of horizontal advection was observed to be relatively small because the vertical fluxes are so large.

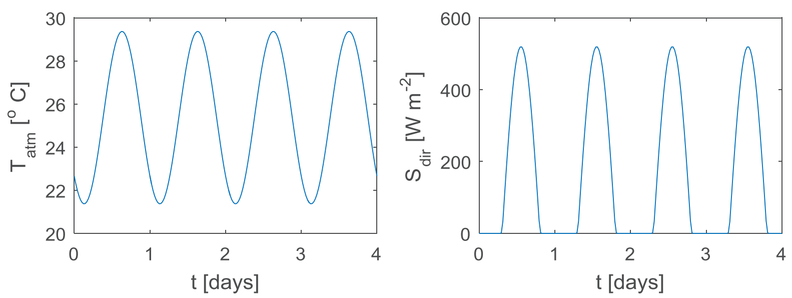


Figure 3: atmospheric forcing

Three cases will be considered:

1. a reference case in which no greening or reflective surfaces are used.
2. a case in which the roofs of the entire site are covered with green roofs (both the high rise and the low rise sections). This case can be thought to be representative of intensive and extensive green roofs, brown roofs, semi-public and public roof gardens.
3. a case in which the roofs are treated with a special reflective paint that increases the albedo of the roofs. This case can be considered for balcony space for penthouses and the retrofitting of roofs.

The parameter values associated with each case are presented in Table 1.

Table 1: Parameter values for the three simulation cases

Case	green roof area [%]	Albedo of roof [-]
1 (reference)	0	0.4
2 (green roof)	100	0.4
3 (reflectivity)	0	0.6

For the green roofs the water content of the green roofs is kept constant, i.e. all the water that evaporates is replenished immediately. This can thus be considered an "ideal" green roof scenario with the maximum cooling that a green roof can provide.

Results

Shown in Figure 4 is the roof, road, surface layer and canyon temperature for the high rise section of the development. It should be noted that the roof and road temperature represent the average temperature across the layer – It is not the surface temperature which will be substantially larger. Data is presented from 2 days onwards, when the urban area is in a forced response to the atmospheric forcing. Days start from midnight; t=2.5 days thus indicates noon of day 2.

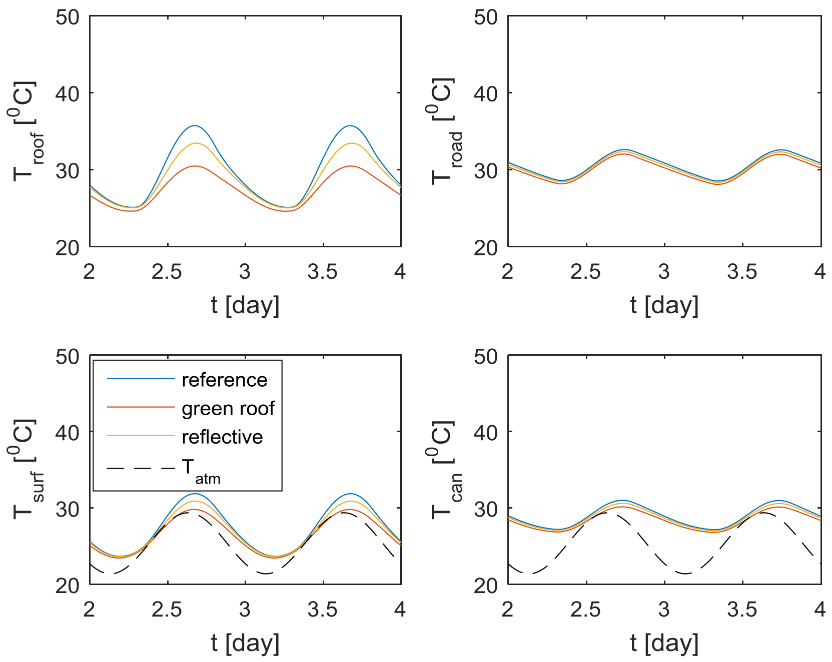


Figure 4: temperatures of roof (T_{roof}), road (T_{road}), surface layer (T_{surf}) and canyon (T_{can}) for the high rise section of Old Oak Common.

The canyon temperature shows the occurrence of a strong urban heat island event, particularly after 2pm. The temperature of the surface layer, which is the layer immediately above the buildings, is reduced by up to 2.1°C and 1.0°C for the green roof and reflective paint scenario, respectively. Inside the canyon, green roofs and reflective roofs bring the maximum temperatures down by about 0.8 °C and 0.4°C, respectively.

Most affected by the presence of green roofs and reflective paints is the temperature of the roof. The maximum temperature difference between the green roof and the reference case is 5.3°C. For the reflective paint, the maximum temperature reduction is about 2.3°C. A small reduction in road temperature can be observed. Table 2 summarises the expected maximal temperature reduction for both the green roof and the reflective paint solutions.

Table 2: Maximum temperature reduction in the high rise (HR) and low rise (LR) areas of Old Oak Common.

Maximum reduction [°C]	Green roof		Reflective paint	
	HR	LR	HR	LR
ΔT_{surf}	2.1	1.4	1.0	0.7
ΔT_{can}	0.8	0.4	0.4	0.0
ΔT_{road}	0.6	0.3	0.3	0.0
ΔT_{roof}	5.3	8.4	2.3	3.4

The temperature profiles for the low rise section are very similar in shape to those in Figure 4 and will thus not be shown. The maximum temperature reductions are presented in Table 2.

The largest advantage of a cooler roof is that a significant energy saving can be achieved. An illustration is given in figure 5, where the average heat-flux through the roof is shown. For the green roof and reflective cases, the heat flux G is much lower than the reference case, for the green roof more than a factor of two. Recently, the MTEB has been extended further to include building energy balances including HVAC (Huo 2016). HVAC units will often expel the heat from the building into the street canyons, amplifying the UHI even further. This effect is not considered in this study.

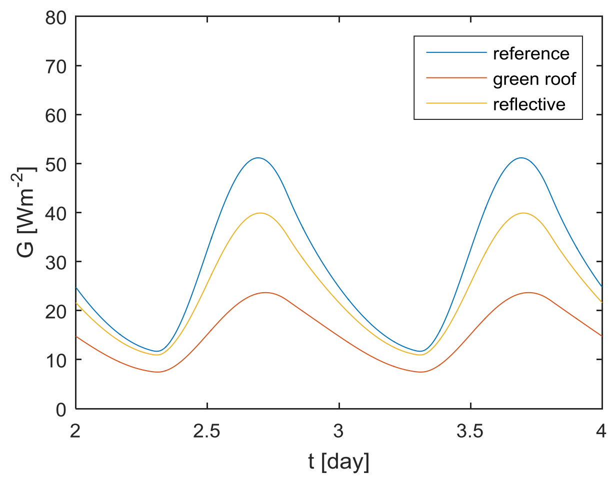


Figure 5: roof contribution to heat flux into buildings for the high rise section

Conclusions

A preliminary Urban Heat Island study has been performed for the Old Oak Common area using the Modified Town Energy Balance (MTEB) model. The case study indicates that

1. In the high-rise area, green roofs reduce the maximum temperatures in the surface layer and canyon by 2.1°C and 0.8°C, respectively. For reflective paints, the maximum temperature reduction for the surface layer and canyon is approximately 1°C and 0.4°C, respectively.
2. These temperature reductions, in particular those in the canyons which is where the people live, are significant given the concerns of UHI effects for the high density sections of Old Oak Common.
3. Green roofs and reflective paints can reduce significantly the roof temperature and the energy requirements for the building.
4. For the cases considered, green roofs are more efficient in reducing temperatures than reflective paints. From a practical perspective, reflective paints are much cheaper to install than green roofs and also easier to retrofit; however they lack the additional benefits for ecology and water management that green roofs provide (Oberndorfer *et al.*, 2007). It is crucial that the green roofs have sufficient moisture to evaporate during UHI events, otherwise they will not be able to reduce the UHI.

The study performed here is idealised and was carried out with a prototype model. As such, it is the trends and not necessarily the values that will be robust. Further work should consider:

1) Improving the accuracy of the predictions by adding important physical processes not considered in this study:
   a. Incorporate HVAC and anthropogenic heating effects which can amplify the UHI;
   b. Incorporate water and greening in the canopies, potentially including green walls;
2) Perform a systematic study on how to minimise the UHI, which will involve studying different greening scenarios.
3) The effect of green roofs on the energy efficiency of the buildings. This may include using part of the roofs for photovoltaic cells.
4) Study the potential of using open water bodies to reduce UHI effects, e.g. by introducing open water in Wormwood Scrubs Park. These open water areas produce a cool "sea breeze" as well as providing a number of other important ecosystem services.
5) For detailed design, it is recommended to carry out Computational Fluid Dynamics simulations that can produce detailed spatial heat and wind maps, highlighting temperature and wind hot spots.

References

M. J. Best, M. Pryor, D. B. Clark, and G. G. Rooney. The Joint UK Land Environment Simulator (JULES), model description - Part 1: Energy and water fluxes. *Geoscientific Model Development*, 4:677, 2011

C. S. B. Grimmond, M. Blackett, M. J. Best, J. Barlow, J.J. Baik, S. E. Belcher, and S. I. Bohnenstengel. The International Urban Energy Balance Models Comparison Project: First Results from Phase 1. *J. Appl. Meteor. Climatol.*, 12681292, 2010.

Y. Huo. *The interaction of HVAC with green roof and its impact on the urban heat island effect*, MEng thesis, Dept. of Civil and Environmental Engineering, Imperial College London, 2016

V. Masson. A physically-based scheme for the urban energy budget in atmospheric models. *Boundary-Layer Meteorology*, 94:357, 2000.

E. Oberndorfer, J. Lundholm, B. Bass, R. R. Coffman, H. Doshi, N. Dunnett, S. Gaffin, M. Kohler, K. K. Y. Liu, and B. Rowe. Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. *BioScience*, 57:823, 2007.

I. Suter, C. Maksimovic, M. van Reeuwijk. A city-scale estimate for the cooling potential of green roofs, *Urban Climate* (under review), 2016

Appendix: overview of parameter values

The parameter values for the standard canyon are displayed below. The high rise area has identical properties but a building height of 70m.

```
h     = 40.0 ;       % Building height                        [m]
l     = 60.0 ;       % Building width                         [m]
w     = 20.0 ;       % Road width                             [m]

zatm  = 120       ;  % Elevation of atmospheric forcing level         [m]
Uatm  = 1.5       ;  % Air velocity at 48 m   [m/s]

days   = 2;       % Duration of simulation            [day]
step_O = 300 ;    % Maximum time-step for ODE solver  [s]

%% Constants
Prt   = 0.9     ;    % Turbulent Prandtl number             [-]
kappa = 0.4     ;    % von Karman's constant                [-]
sigma = 5.670373e-8 ;    % Stefan-Boltzmann constant            [W/(K^4 m^2)]
Lv    = 2260e3  ;    % Latent heat of vaporisation (water) [J/kg]
rho_a = 1.27   ;    % Density of air                       [kg/m^3]
rho_c = 2400    ;    % Density of concrete                  [kg/m^3]
Rd    = 287.058 ;    % Specific gas constant for dry air   [J/(kg K)]
cp    = 1003    ;    % Specific heat capacity of air       [J/(kg K)]
cp_c  = 900     ;    % Specific heat capacity of concrete  [J/(kg K)]

%% Atmospheric variables
patm  = 1029      ;  % Air pressure at atmospheric level      [hPa]
rain  = 0         ;  % Rainfall rate                          [kg/(m^2 s)]
gamma = pi/8;        % Zenith solar angle                     [rad]

%% Radiative parameters
eps_R    = 0.97 ;      % Emissivity coeff. of the roof surface [-]
eps_w    = 0.97 ;      % Emissivity coeff. of the wall surface [-]
eps_r    = 0.96 ;      % Emissivity coeff. of the road surface [-]
eps_GR   = 0.97 ;      % Emissivity coeff. of the roof surface [-]
alpha_R = 0.40 ;      % Albedo of the roof surface            [-]
alpha_w = 0.32 ;      % Albedo of the wall surface            [-]
alpha_r = 0.08 ;      % Albedo of the road surface            [-]
alpha_GR= 0.40 ;      % Albedo of the roof surface            [-]

%% Thermal parameters
dR   = 0.25 ;        % Roof thickness                          [m]
dw   = 0.25 ;        % Wall thickness                          [m]
dr   = 0.35 ;        % Road thickness                          [m]
dGR  = 0.25 ;        % Green roof thickness                    [m]

lamR = 0.8258 ;        % Thermal conductivity of roof (concrete) [W/(m K)]
lamw = 0.8258 ;        % Thermal conductivity of wall (concrete) [W/(m K)]
lamr = 0.5749 ;        % Thermal conductivity of road (concrete) [W/(m K)]

% heat capacities for the roof, wall and road [J/(m^3 K)]:
cR = 1441100;
cw = 1441100;
cr = 1509600;
cs = 1229.6; % heat capacity for the surface level [J/(m^3 K)]:

%% Green roof, soil and vegetation parameters  (short grass)
rsmin   = 110       ;% min vegetation resistance. crops = 180, tall grass = 100, shrubs = 225
LAI     = 2         ;% Leaf area index. crops = 3, tall grass = 2, shrubs = 1.5-3
Wfc     = 313*dGR   ;% soil moisture at field capacity          [kg m^-2]
Wwilt   = 171*dGR   ;% soil moisture at permanent wilting point [kg m^-2]
gD      = 0         ;% 0.03 for trees
WGRmax  = 472*dGR   ;% Maximum soil moisture (at saturation)    [kg/m^2]
dlGR    = 0       ;%fraction of roof covered with "green roof". Rest is concrete.
cveg    = 0.9       ;% percent of which is vegetation. Rest is bare soil.

%% Penman - Monteith
psy   = 0.665*1e-3*patm           ; % Psychrometric constant             [Pa / K]
satlaps = F_dQSATdT(Tatm,patm)     ; % initial lapse rate of saturation specific humidity
```

```
%% Other parameters (constants)
Tibld = 297.16 ;      % Internal building temperature [K]
WRmax = 1.00      ;  % Maximum roof water reservoir  [kg/m^2]
Wrmax = 1.00      ;  % Maximum road water reservoir  [kg/m^2]


%% Additional input energy fluxes
Htraffic   = 0 ;      % Sensible heat from traffic  [W/m^2]
LEtraffic  = 0 ;      % Latent heat from traffic    [W/m^2]
Hindustry  = 0 ;      % Sensible heat from industry [W/m^2]
LEindustry = 0 ;      % Latent heat from industry   [W/m^2]
```

References

OPDC Environmental Standards Study References

Planning Policy Documents

1. Department for Communities and Local Government (2012), National Planning Policy Framework, www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf.
2. Department of Environment, Food and Rural Affairs (2007) UK Air Quality Strategy.
3. Mayor of London (2016) A City for All Londoners, https://www.london.gov.uk/sites/default/files/city_for_all_londoners_nov_2016.pdf.
4. Mayor of London (2015), London Plan www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan.
5. Mayor of London (2014), Further Alterations to the London Plan.
6. Mayor of London (2010) Air Quality Strategy.
7. Mayor of London (2015), London Sustainable Drainage Action Plan.
8. Mayor of London (2011), London Water Strategy.
9. Mayor of London (2011) Climate Change Adaptation Strategy, www.london.gov.uk/sites/default/files/gla_migrate_files_destination/Adaptation-oct11.pdf
10. A Tree and Woodland Framework for London (March 2005), www.forestry.gov.uk/pdf/ltwf_full.pdf/$FILE/ltwf_full.pdf.
11. West London Waste Plan (2014), www.wlwp.net/documents/August2014/SD1%20-%20WLWP%20Submission%20Plan%20Jul%202014.pdf.

London Plan Adopted Supplementary Guidance (SPGs)

1. Housing (March 2016), www.london.gov.uk/sites/default/files/housing_spg_revised_040516.pdf
2. Old Oak and Park Royal Opportunity Area Planning Framework (November 2015), www.london.gov.uk/sites/default/files/oapf_for_web.pdf
3. Sustainable Design and Construction (April 2014), https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/Sustainable%20Design%20%26%20Construction%20SPG.pdf.
4. Play and Informal Recreation (September 2012), www.london.gov.uk/what-we-do/planning/implementing-london-plan/supplementary-planning-guidance/play-and-informal
5. All London Green Grid (March 2012), www.london.gov.uk/what-we-do/planning/implementing-london-plan/supplementary-planning-guidance/all-london-green-grid
6. Mayor of London Control of Dust and Emissions during Construction and Demolition SPG, https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/ Dust%20and%20Emissions%20SPG%208%20July%202014_0.pdf.

Transitional OPDC Planning Policy Prior to OPDC Local Plan Adoption

1. OPDC Draft Local Plan Regulation 18 Stage, www.london.gov.uk/sites/default/files/opdc_draft_local_plan.pdf
2. OPDC Development Infrastructure Funding Study, supporting study for the OPDC Draft Local Plan, February 2016.
3. Old Oak and Park Royal Air Quality supporting study for the OPDC Draft Local Plan, February 2016.
4. Old Oak and Park Royal Industrial Land Review, supporting study for the OPDC Draft Local Plan, 2016.
5. Old Oak Outline Historic Area Assessment, Historic England (February 2016), www.london.gov.uk/sites/default/files/old_oak_outline_historic_area_assessment_2015_new_cover.pdf
6. Old Oak Park (2016), Homes for Londoners: Illustrative Masterplan Fourth Consultation Summary, www.oldoakpark.co.uk/OOP-Summary-Booklet.pdf

London Boroughs of Brent, Ealing and Hammersmith and Fulham DPDs

London Borough of Brent

1. Core Strategy (2010), www.brent.gov.uk/media/188619/Core%20Strategy%20Adoption%20Statement.pdf.
2. Site Specific Allocation DPD (2011), www.brent.gov.uk/media/188763/SSAs.pdf.
3. Draft Development Management Policies DPD (September 2015), www.brent.gov.uk/media/16402949/development-management-policies.pdf.
4. Saved UDP Policies (2014), www.brent.gov.uk/media/186673/20150129-Still-relevant-UDP-policies.pdf.
5. Planning guidance supplementary planning document (SPD) (2012).

London Borough of Ealing

1. Development (or Core) Strategy DPD (April 2012), www.ealing.gov.uk/downloads/download/1322/adoption_of_the_development_or_core_strategy
2. Development Management DPD (2013), www.ealing.gov.uk/info/201164/local_plans/1511/development_management_dpd
3. Development Sites DPD (2013), www.ealing.gov.uk/info/201164/local_plans/1491/development_sites_dpd
4. Policies Map (2013), www.ealing.gov.uk/info/201164/local_plans/1513/adopted_policies_map

London Borough of Hammersmith and Fulham

1. Core Strategy (2011), www.lbhf.gov.uk/sites/default/files/Core_Strategy_2011.pdf
2. Development Management Local Plan (2013), www.lbhf.gov.uk/sites/default/files/Development_Management_Local_Plan_2013.pdf
3. Proposals Map (2011), www.cartogold.co.uk/HammersmithandFulham/map.htm
4. Draft Local Plan (2015), www.lbhf.gov.uk/sites/default/files/section_attachments/consultation_statement_tcm21-192931.pdf
5. Planning Guidance Supplementary Planning Document (2013), https://www.lbhf.gov.uk/sites/default/files/section_attachments/planning_guidance_spd_final_tcm21-181716.pdf

Climate

1. Bulkeley, H. (2013) Cities and Climate Change. Oxfordshire, London: Routledge
2. C40 Cities Climate Leadership Group (2016) Good Practice Guide: Climate Positive Development, www.c40-production-images.s3.amazonaws.com/other_uploads/images/541_C40_GPG_Climate_Positive_EC_FINAL_V2.original.original.pdf?1457001241
3. Givoni, B. (1998) Climate Considerations in Building and Urban Design. New York: Van Nostrand Reinhold
4. Greater London Authority (2008) The London Climate Change Adaptation Strategy Draft Report, www.london.gov.uk/sites/default/files/gla_migrate_files_destination/CCAS%20SA%20Report%20Part%20A.pdf
5. Pandya, S.V. and Brotas, L. (2014) Tall Buildings and the Urban Microclimate in the City of London, Plea Ahmedabad, www.plea2014.in/wp-content/uploads/2014/12/Paper_2B_2546_PR.pdf

Energy

1. Bruhns, H., Jones, P. and Cohen, R. (2011) CIBSE Review of Energy Benchmarks for Display Energy Certificates - Analysis of DEC Results to Date, www.cibse.org/getmedia/24a8eb88-875e-4f21-9629-008d7af7bdc7/Technical-Report_CIBSE-Report-on-45000-DECs.pdf.aspx
2. Cheshire, D. and Menezes, A.C. (2013) TM54: Evaluating operational Energy Performance of Buildings at the Design Stage. London, United Kingdom: Chartered Institution of Building Services Engineers
3. CIBSE (2008) TM46: Energy Benchmarks. London, United Kingdom: Chartered Institution of Building Services Engineers
4. CIBSE (2012) Guide F: Energy Efficiency in Buildings. 3rd edn. London, United Kingdom: Chartered Institution of Building Services Engineers
5. Department of Energy & Climate Change (2011) Government's Standard Assessment Procedure for Energy Rating of Dwellings. Watford, United Kingdom: BRE
6. Department for Environment, Food and Rural Affairs (2015) IAG Spreadsheet Toolkit for Valuing Changes in Greenhouse Gas Emissions www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
7. Heywood, H. (2012) 101 Rules of Thumb for Low-Energy Architecture. London, United Kingdom: RIBA Publishing
8. Maidment, G. (2013) TM51: Ground Source Heat Pumps. United Kingdom: Chartered Institution of Building Services Engineers
9. Thonger, J. (2010) Combined Heat and Power Carbon Savings - Presented at CIBSE ASHRAE Jan 2010, www.cibseashrae.org/presentations/ThongerCarbonDebateJan2010.ppt.pdf
10. Greater London Authority (2013) London's Zero Carbon Energy Resource: Secondary Heat, Report Phase 2.
11. Building Research Establishment Building Research Establishment Environmental Assessment Method (BREEAM), www.breeam.com.
13. Zero Carbon Hub and NHBF (2010) Carbon Compliance for tomorrow's new homes. A review of the modelling tools and assumptions. Topic 4 - Closing the gap between designed and built performance, http://www.zerocarbonhub. org/resourcefiles/topic4_pink_5august.pdf.
14. BSRIA Soft Landings, www.bsria.co.uk/services/design/soft-landings/
15. Mayor of London (2014) Enabling Infrastructure: Green, Energy, Water and Waste Infrastructure to 2050.
16. Greater London Authority (2014) The cost of London's long-term infrastructure, Final report.
17. Building Research Establishment / Department for Energy and Climate Change (2012) The Government's Standard Assessment Procedure for Energy Rating of Dwellings, http://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
18. World Bank (2000) Municipal Solid Waste Incineration: Requirements for a Successful Project, Technical Paper No. 462.
19. Max Fordham (2010) Green Offices Sustainability Matrix, http://www.maxfordham.com/assets/media/images/publications/Sustainability%20-%20Refurbished%20offices/ OFFICES_matrix_website_download.pdf.
20. Chartered Institute of Building Services Engineers, Cheshire D., Butcher K. (2012) CIBSE Guide F: Energy efficiency in buildings.
21. Department of the Environment / Action Agency (1998) Energy Consumption Guide 18 - Energy Efficiency in Industrial Buildings and Sites.
22. Department for Business, Energy and Industrial Strategy (2016) Energy Consumption in the UK, https://www.gov.uk/government/collections/energy-consumption-in-the-uk.
23. Greater London Authority, Williams F. et al (2014) The Park Royal Atlas, https://www.london.gov.uk/sites/default/files/Park%20Royal%20Atlas%20Screen%20Version%201.1_0.pdf.
24. Chartered Institute of Building Services Engineers, Arup (2016) An Operational Lifetime Assessment of the Carbon Performance of Gas Fired CHP led District Heating, CIBSE Technical Symposium.
25. Passivhaus Trust (2015) Passivhaus Research Project.
26. SHINE Network (2009) Sustainability Budgeting: A guide to using whole life costing in sustainable procurement.
27. Passive House Plus, Issue 3 (2013) The Cost of Building Passive.
28. Department of Energy and Climate Change (2015) Small-Scale Generation Cost - Update.
29. Department of Energy and Climate Change (2013) Research on the costs and performance of heating and cooling technologies.
30. Department of Environment, Food and Rural Affairs, (2013) Incineration of Municipal Solid Waste.

Waste

1. Greater London Authority (no date) Energy for Waste Technical Report. Available at: http://www.london.gov.uk/mayor/environment/waste/docs/efwtechnologiesreport.pdf
2. IDeA Knowledge (2005) MRMC site visits: Visit to Prolysis Plant – Hamm, Germany. Available at: http://expertpc.org/gasifier/idea2.pdf
3. Juniper Consulting (2008) Solid Waste Technology Options: Mechanical Biological Treatment (MBT)
4. Macalister, T (2013) Tilbury power station mothballed after investment burns out. Available at: https://www.theguardian.com/business/2013/aug/16/tilbury-power-station-mothballed
5. The New Economy (2015) Pioneering sustainability in the UAE; Bee'ah advises. Available at: http://www.theneweconomy.com/technology/pioneering-sustainability-in-the-uae-beeah-advises
6. Perchard, R (2016) Air Products shuts down Tees Valley Development. Available at: http://resource.co/article/air-products-shuts-down-tees-valley-development-10987
7. Richard Skehens (no date) Energy from Waste Available at: http://www.facilitiesshow.com/files/richard_skehens.pdf
8. SUEZ Recycling and Recovery UK Ltd (2016) Kirklees. Available at: http://www.sita.co.uk/services-and-products/local-authority-customers/public-private-partnerships/kirklees
9. Waste Control (2017) Database of Waste Management Technologies. (Composting – Windrow; Composting -In-vessel; Mechanical Biological Treatment; Energy from Waste; Anaerobic Figestions; Materials Recycling Facility) Available at: http://www.epem.gr/waste-c-control/database/html/costdata-00.htm#AD
10. WRAP (2006) MRF Costing Model. Available at: http://www.wrap.org.uk/sites/files/wrap/MRFCostModelUserGuide.pdf
11. WRAP (2017) List of energy from waste sites. Available at: http://www.wrap.org.uk/content/list-energy-waste-sites
12. UK Parliamentary Office of Science and Technology (2016) Carbon Footprint of Heat Generation, POSTNote Number 523.
13. Westminster City Council Recycling and Waste Storage Requirements Guide for commonly referenced London guidance for waste storage / space allocation, https://www.westminster.gov.uk/waste-storage-planning-advice.
14. Department of Energy and Climate Change (DECC) and the Department for Environment, Food and Rural Affairs (Defra)(2012) 2012 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting
15. Office for National Statistics (2015) Employment by Sector.
16. West London Waste Authority (2009) Addendum to West London's Joint Municipal Waste Strategy.
17. Greater London Authority (2016) London Labour Market Projections, https://www.london.gov.uk/sites/default/files/llmp-2016.pdf.
18. Greater London Authority (2004) Waste Composition Scoping Study.
19. Waste and Resources Action Programme (2011) The Composition of Waste Disposed of by the UK Hospitality Industry.
20. Let's Recycle Local Authority League Tables 2014/15.
21. Department of Environment, Food and Rural Affairs (2013) Forecasting 2020 Waste Arisings and Treatment Capacity, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/251567/pb13883-forecasting-2020-waste-arisings-131017.pdf
22. Department for Environment, Food and Rural Affairs (2015) Digest of Waste and Resource Statistics.

Materials

1. Berge, B. (2009) Ecology of Building Materials. 2nd edn. Architectural Press.
2. Cutting carbon in construction projects, Waste and Resources Action Programme (WRAP) (no date) Cutting Embodied Carbon in Construction Projects [online] Available at: http://www.wrap.org.uk/sites/files/wrap/FINAL%20PRO095-009%20Embodied%20Carbon%20Annex.pdf.
3. HM Treasury (2013) Infrastructure Carbon Review
4. International Organization for Standardization (2017) ISO 14000 Family- Environmental Management
5. Leadership in Energy and Environmental Design (2017) [online] Available at: http://www.usgbc.org/resources/grid/leed
6. London Organising Committee of the Olympic Games and Paralympic Games Ltd 2007-2012 (2012) Lessons Learned from the Planning and Staging the London 2012 Games [online] available at: http://learninglegacy.independent.gov.uk/documents/pdfs/sustainability/cp-london-2012-carbon-footprint-methodology-and-reference-footprint.pdf
7. Building Research Establishment Green Guide to Specification, https://www.bre.co.uk/greenguide.
8. London Organising Committee of the Olympic Games (2012) London 2012 Carbon Footprint Methodology and Reference Footprint – London 2012 Learning Legacy, http://learninglegacy.independent.gov.uk/documents/pdfs/sustainability/cp-london-2012-carbon-footprint-methodology-and-reference-footprint.pdf.
9. Olympic Delivery Authority (2011) Reducing embodied carbon through efficient design – London 2012 Learning Legacy, http://learninglegacy.independent.gov.uk/documents/pdfs/ sustainability/425009-145-reducing-carbon-aw.pdf.
10. UK Green Building Council (2017) Embodied Carbon: Developing a Client Brief, http://www.ukgbc.org/resources/publication/embodied-carbon-developing-a-client-brief.
11. Circular Ecology, Inventory of Energy and Carbon (ICE), http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html#.WJnnPU1XXIU.
12. Waste and Resources Action Programme (WRAP) Cutting carbon in construction projects, http://www.wrap.org.uk/sites/files/wrap/FINAL%20PRO095-009%20Embodied%20Carbon%20Annex.pdf.
13. Building Research Establishment (2016) BES 6001 Framework Standard for Responsible Sourcing, http://www.greenbooklive.com/search/scheme.jsp?id=153.
14. International Organisation for Standards (2015), ISO 14000 Environmental Management Standards, http://www.iso.org/iso/iso14000.
15. European Union Eco-Management and Audit Scheme (EMAS), http://ec.europa.eu/environment/emas/index_en.htm.
16. Department of Environment, Food and Rural Affairs, Central Point of Expertise on Timber Procurement, https://www.gov.uk/government/groups/central-point-of-expertise-on-timber.

17. Olympic Delivery Authority (2011) Innovation in timber supply for London 2012 – London 2012 Learning Legacy, http://learninglegacy.independent.gov.uk/documents/pdfs/sustainability/425009-188-timber-aw.pdf.
18. British Standards Institute (2011) BS EN 15978:2011 Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method, http://shop.bsigroup.com/ProductDetail/?pid=000000000030256638.
19. Royal Institution of Chartered Surveyors (2014), Methodology to Calculate Embodied Carbon, 1st edition, http://www.rics.org/uk/knowledge/professional-guidance/guidance-notes/methodology-to-calculate-embodied-carbon-global-guidance-note-1st-edition/.
20. Barratt Homes (2016) Sustainability Report 2016, http://www.barrattdevelopments.co.uk/~/media/Files/B/Barratt-developments/documents/sustainability-report-2016.pdf.
21. Lendlease Sustainability Materials and Supply Chain, http://www.lendlease.com/au/company/sustainability/our-progress/material-and-supply-chain/.
22. Sir Robert McAlpine (2015) Sustainability Report 2015, http://sustainability.sir-robert-mcalpine.com/_assets/pdfs/McAlpine_Sustainability_Performance_Summary_Download.pdf.
23. David Langdon (2007) Cost of Green Revisited. http://smartenergy.illinois.edu/pdf/Archive/Cost%20of%20Green %20Revisited.pdf.
24. Kollert, W. and Lagan, P. (2005) Do Certified Tropical Logs Fetch a Market Premium?, XXII IUFRO World Congress 2005, Brisbane, Session 168: Environmental goods, institutions, and markets.
25. Yamamoto, Y. et al (2014) Is there a price premium for certified wood? Forestry Politics and Economics, Volume 38, Pages 168–172.
26. Building Research Establishment (BRE) Centre for Sustainable Construction, BRE Trust, and Cyril Sweett, (2005) Putting a price on sustainability.
27. Waster and Resources Action Programme Procurement requirements for reducing waste and using resources efficiently, http://www.wrap.org.uk/sites/files/wrap/WRAP%20Construction%20Guide%20_FINAL.pdf.

Carbon Emissions

1. London Assembly Environment Committee (2015) Cutting Carbon in London, 2015 Update.
2. Mayor of London, London Energy and Greenhouse Gases Inventory (LEGGI), https://data.london.gov.uk/dataset?q=leggi.
3. United Nations Framework Convention on Climate Change (UNFCC), http://unfccc.int/2860.php.
4. UK HM Treasury (2012) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal.
5. National Grid (2016) Future Energy Scenarios.
6. British Standards Institute (2014) Application of PAS 2070: London case study, https://data.london.gov.uk/dataset/application-pas-2070-london-case-study.
7. World Resources Institute, World Business Council for Sustainable Development GHG Protocol, www.ghgprotocol.org.
8. C40 Cities, Clinton Climate Initiative and US Green Building Council (2011) Framework for Climate Positive Communities, http://c40-production-images.s3.amazonaws.com/other_uploads/images/1_Climate_Positive_Framework_v1.1 _Aug_2013.original.pdf?1390706960.
9. World Resource Institute, C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability (2014) Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, http://www.ghgprotocol.org/city-accounting.
10. Office of Gas and Electricity Markets (2017) Feed-in Tariff (FIT): Tariff Table 1 April 2017, https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-fit-tariff-table-1-april-2017.
11. Office of Gas and Electricity Markets (2017) Tarrifs and Payments: Domestic RHI, https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi/contacts-guidance-and-resources/tariffs-and-payments-domestic-rhi/current-future-tariffs.
12. British Standards Institute (2013) PAS 2070:2013 - Specification for the Assessment of Greenhouse Gas Emissions of a City, http://shop.bsigroup.com/Browse-By-Subject/Environmental-Management-and-Sustainability/PAS-2070-2013/.
13. British Standards Institute (2014) Application of PAS 2070 - London, United Kingdom, https://data.london.gov.uk/dataset/application-pas-2070-london-case-study.
14. London Organising Committee of the Olympic Games (2012) London 2012 Carbon Footprint Methodology and Reference Footprint – London 2012 Learning Legacy.
15. World Bank (2000) Municipal Solid Waste Incineration, Technical Paper No. 462, http://documents.worldbank.org/curated/en/886281468740211060/pdf/multi-page.pdf.
16. Department of Energy and Climate Change / Department of Environment, Food and Rural Affairs (2016) GHG Conversion Factors for Company Reporting, www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016.
17. US Department of Energy / Environmental Protection Agency (2016) Fuel Economy Guide, www.fueleconomy.gov/feg/pdfs/guides/FEG2016.pdf.

Water

1. AECOM (2016) Integrated Water Management Strategy. Available at: https://www.london.gov.uk/sites/default/files/iwms_new_cover_low_res.pdf.
2. CIRIA (2007) The SuDS Manual C753. Available at: http://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx (Accessed: 23 November 2016).
3. CIRIA (2012) C713 Retrofitting to Manage Surface Water. Available at: http://www.ciria.org/ItemDetail?iProductCode=C713&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91.
4. Department for Environment, Food & Rural Affairs and Environment Agency (2009) Thames River Basin District River Basin Management Plan: 2009. Available at: https://www.gov.uk/government/publications/thames-river-basin-management-plan.
5. European Union (2000) Introduction to the New EU Water Framework Directive - environment - European commission. Available at: http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm.

6. Greater London Authority (2015) London Sustainable Drainage Action Plan Draft for Public Consultation. Available at: https://www.london.gov.uk/sites/default/files/lsdap_final.pdf.
7. Flood and Water Management Act 2010b, c. Available at: http://www.legislation.gov.uk/ukpga/2010/29/pdfs/ukpga_20100029_en.pdf.
8. London Boroughs, Greater London Authority, Thames Water and Environment Agency (2015) The Drain London Project. Available at: http://www.londoncouncils.gov.uk/our-key-themes/environment/flood-risk-management/drain-london (Accessed: 23 November 2016).
9. Transport for London (2016) SuDS In London: A Design Guide. Available at: https://consultations.tfl.gov.uk/policy/suds-guidance/user_uploads/suds-in-london---a-design-guide_full-document.pdf.
10. WRc (2016) Sewers for adoption 7th edition - A design & construction guide for developer. Available at: http://www.webookshop.com/acatalog/Sewers-for-Adoption-7th-Edition---A-Design---Construction-Guide-for-Developer--DUS038X.html.
11. HR Wallingford Sustainable Drainage Surface Water Storage Requirements tool, http://www.uksuds.com/surfacewaterstorage_js.htm.
12. Atkins (2016) Anglian Water Supply Demand Strategy
13. Waste and Resources Action Programme Achieving Water Efficiency on Projects - Information Sheet
14. Department for Communities and Local Government (2010) Code for Sustainable Homes - Technical Guidance
15. Butler, David; Davies, John W. (2011) Urban Drainage - Third Edition.
16. Stovin, V. R., & Swan, A. D. (2007) Retrofit SuDS - cost estimates and decision-support tools, Water Management, 207-214.
17. Environment Agency (2007) Cost-benefit of SuDS retrofit in urban areas (Science Report - SC060024).
18. Septic Tank, Sewage Treatment System Costs, http://www.wte-ltd.co.uk/sewage_treatment_costs.html.

Air Quality

1. Greater London Authority (2016) London Datastore.
2. London Local Air Quality Management Borough Air Quality Action Matrix, https://www.london.gov.uk/sites/default/files/air_quality_action_matrix.pdf.
3. South East Scotland Transport Partnership (2010) Freight Consolidation Centre Study, http://www.dryport.org/files/doc/SEStran_Freight%20Consolidation%20Centre%20Study%20-%20Final%20Report.pdf.
4. Birmingham City Council (2014) Birmingham Mobility Action Plan, Birmingham Connected Technical Package 3 Servicing and Logistics, https://www.birmingham.gov.uk/downloads/file/1931/birmingham_connected_technical_package_3_servicing_and_logistics.
5. WSP for BCSC (2015) Freight Consolidation and Remote Storage.
6. TfL Freight Going the Extra Mile, http://content.tfl.gov.uk/going-the-extra-mile.pdf.
7. TfL Freight Waste Consolidation: An Olympic tale of victory, http://content.tfl.gov.uk/veolia-waste-case-study.pdf.
8. TfL Freight Expansion of Consolidation at Heathrow, http://content.tfl.gov.uk/heathrow-case-study.pdf.
9. TfL Freight The London Boroughs Consolidation Centre – a freight consolidation success story, http://content.tfl.gov.uk/lbbc-case-study.pdf.
10. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Indoor Air Quality Guide, Best Practices for Design, Construction, and Commissioning.
11. UK Health and Safety Executive (2011) EH40/2005 Workplace exposure limits.
12. EC Directorate General for Health and Communities (2011) Promoting actions for healthy indoor air.
13. World Health Organisation (2010) Guidelines for indoor air quality: selected pollutants.
14. US Occupational Safety and Health Administration (2011) Indoor Air Quality in Commercial and Institutional Buildings.
15. US Green Building Council (2013) Leadership in Energy and Environmental Design (LEED).
16. Allen JG, MacNaughton P, Satish U, Santanam S, Vallarino J, Spengler JD. (2016) Associations of cognitive function scores with carbon dioxide, ventilation, and volatile organic compound exposures in office workers: a controlled exposure study of green and conventional office environments, Environ Health Perspect 124:805–812, http://dx.doi.org/10.1289/ehp.1510037.

Sustainability

1. Bokalders, V. and Block, M. (2010) The Whole Building Handbook – How to Design Healthy, Efficient and Sustainable Buildings. London, United Kingdom: Earthscan
2. Climate-KIC (2015) Smart Sustainable Districts, www.climate-kic.org/wp-content/uploads/2013/04/Smart-Sustainable-Districts_Climate-KIC_external.pdf
3. Desai, P. and Riddlestone, S. (2007) Bioregional Solutions – For Living on One Planet. Devon, United Kingdom: Green Books Ltd
4. Desai, P. (2009) One Planet Communities: A Real Life Guide to Sustainable Living. Chichester, United Kingdom: John Wiley and Sons
5. Edwards, B. (2014) Rough Guide to Sustainability: A Design Primer. 4th edn. London: RIBA Enterprises
6. Fordham, M. (2010) Green Offices Sustainability Matrix, www.maxfordham.com/assets/media/images/publications/Sustainability%20-%20Refurbished%20offices/OFFICES_matrix_website_download.pdf
7. Heywood, H. (2015) 101 Rules of Thumb for Sustainable Buildings and Cities. Oxford, United Kingdom: RIBA Publishing
8. HM Government (2010a) Building Regulation, 'Part E': Resistance to the Passage of Sound. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468870/ADE_LOCKED.pdf.
9. Jacques, P. (2014) Sustainability: The Basics. London, United Kingdom: Routledge
10. Pennycook, K. (2008) Illustrated Guide to Renewable Technologies. Bracknell: BSRIA
11. Sassi, P. (2005) Strategies for Sustainable Architecture. New York, USA: Taylor & Francis
12. Stockholms Stad (2013) Stockholm: A Sustainably Growing City, www.international.stockholm.se/globalassets/ovriga-bilder-och-filer/stockholm-a-sustainably-growing-city.pdf
13. Town and Country Planning Association (2004) Biodiversity by Design: A Guide for Sustainable Communities. London, United Kingdom: TCPA

14. Ween, C. (2014) Future Cities - All That Matters. London, United Kingdom: Teach Yourself Books.
15. World Health Organisation (2012) Health indicators of sustainable cities. Available at: http://www.who.int/hia/green_economy/indicators_cities.pdf.
16. WS Atkins International Ltd (2015) Future Proofing London, www.atkinsglobal.co.uk/~/media/Files/A/Atkins-Corporate/uk-and-europe/uk-thought-leadership/reports/Future_Proofing%20_London_Book_7.pdf

Urban Design

1. Baker, N. and Steemers, K. (2002) Daylight Design of Buildings. London, United Kingdom: James & James
2. BRE (2011) Site Layout Planning for Daylight and Sunlight a Guide to Good Practice. Available at: https://www.brebookshop.com/samples/326792.pdf.CIRIA (2013) Water Sensitive Urban Design (WSUD). Available at: http://www.ciria.org/Resources/Free_publications/Water_Sensitive_Urban_Design.aspx.
3. Design Council Cabe & English Heritage (2007)Guidance on Tall Buildings. Available at: http://www.designcouncil.org.uk/resources/guide/guidance-tall-buildings.
4. Design for London (2007) Recommendations for Living at Superdensity, www.designforhomes.org/wp-content/uploads/2012/03/Superdensity2.pdf
5. Foletta, N. and Field, S. (2011) Europe's Vibrant New Low Car(bon) Communities Institute for Transportation & Development Policy, www.gwl-terrein.nl/files/artikelen/low%20carbon%20communities.pdf
6. Gehl, J. (2010) Cities for People. Washington DC, USA: Island Press
7. HM Government (2010a) Building Regulation, 'Part E': Resistance to the Passage of Sound. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468870/ADE_LOCKED.pdf.
8. Hugh Barton, Marcus Grant & Richard Guise, Shaping Neighbourhoods For Local Health and Global Sustainability, 2nd Edition
7. Ijeh, I. (2015) Can Tall Buildings Ever Be Sustainable?, www.bdonline.co.uk/can-tall-buildings-ever-be-sustainable?/5074042.article
9. Kwok, A. and Grondzik, W. (2006) The Green Studio Handbook. Amsterdam: Architectural Press
10. Levitt, D. (2009) The Housing Design Handbook: A Guide to Good Practice. New York, USA: Routledge
11. Levitt, D (2016) Housing Standards Handbook: A Good Practice Guide to Design Quality for Affordable Housing Providers. United Kingdom: National Housing Federation
12. London Development Agency and Mayor of London (2010) London Housing Design Guide Interim Edition. London, United Kingdom: London Development Agency
13. Maccreanor Lavington Architects, Emily Greeves Architects and Graham Harrington Planning Advice (2012) Housing Density Study. London, United Kingdom: Maccreanor Lavington
14. Passive House Institute (2013) Certified Passive House Certification Criteria for Residential Passive House Buildings, www.passiv.de/downloads/03_certification_criteria_residential_en.pdf
15. Ritchie, A. and Thomas, R. (eds) (2009) Sustainable Urban Design – An Environmental Approach. New York, USA: Taylor & Francis
16. Rogers, R. (1997) Cities for a Small Planet. London, United Kingdom: Faber and Faber
17. Serrats, M. (ed.) (2012) Eco-Architecture: 1000 Ideas by 100 Architects. Barcelona, Spain: Promopress
18. Transport for London (2013) London's street family: Theory and case studies.
19. Transport for London (2016) Streetscape Guidance.
20. United Nations Task Team (2015) HABITAT III Issue Papers 11- Public Space.
21. Urban Design (2016) Urban Design Group Journal, Summer 2016 (139)

Environmental Design

1. Beer, A. and Higgins, C. (2000) Environmental Site Planning for Site Development – a Manual for Sustainable Local Planning and Design. London, United Kingdom: Spon
2. Birkeland, J. (2008) Positive Development: From Vicious Circles to Virtuous Cycles through Built Environment Design. United Kingdom: Earthscan Publications
3. Forestry Commission and Landscape Institute UK (2013) Public Health and Landscape: Creating Healthy Places, Landscape Institute Position Statement, www.forestry.gov.uk/pdf/greenlink.pdf/$FILE/greenlink.pdf
4. Pelsmakers, S. (2014) The Environmental Design Pocketbook. London, United Kingdom: RIBA Enterprises
5. United Nations Task Team (2015) HABITAT III Issue Papers 11- Public Space.
6. Yeang, K. (2008) Ecodesign: A Manual for Ecological Design. Chichester, United Kingdom: Wiley, John & Sons
7. Yeang, K. and Woo, L. (2010) Dictionary of Ecodesign – an Illustrated Reference. Oxfordshire, London: Routledge

Green Infrastructure

1. Atkins (2015) Camley Street Natural Park an Urban Oasis for Wildlife and People: An Economic Valuation of Ecosystem Services.
2. Atkins (2015) Camley Street Natural Park Ecosystem Services Valuation.
3. BBC Health (2013) Green Spaces Boost Wellbeing of Urban Dwellers – Study, www.bbc.co.uk/news/health-22214070
4. Department of Health (2010) White Paper: Healthy Lives, Healthy People, Our Strategy for Public Health in England, www.gov.uk/government/uploads/system/uploads/attachment_data/file/216096/dh_127424.pdf
5. European Commission (2013) The Guide to Multi-Benefit Cohesion Policy Investments in Nature and Green Infrastructure, www.ec.europa.eu/regional_policy/sources/docgener/studies/pdf/guide_multi_benefit_nature.pdf
6. Forest Research (2010) Benefits of Green Infrastructure.
7. GreenSpace (2011) Understanding the Contribution Parks and Green Spaces can make to Improving Peoples Lives, www.csd.org.uk/uploadedfiles/files/value_of_green_space_report.pdf
8. Greater London Authority (2002) Connecting with London's Nature: The Mayor's Biodiversity Strategy. Available at: https://www.london.gov.uk/sites/default/files/biodiversity_strategy.pdf (Accessed: 23 November 2016).

9. Greater London Authority (2005) Connecting Londoners with Trees and Woodlands a Tree and Woodland Framework for London. Available at: http://www.forestry.gov.uk/pdf/ltwf_full.pdf/$FILE/ltwf_full.pdf.
10. Greater London Authority (2008) Living roofs and walls - technical report: Supporting London plan policy.
11. Greater London Authority (2002) Connecting with London's Nature: The Mayor's Biodiversity Strategy. Available at: https://www.london.gov.uk/sites/default/files/biodiversity_strategy.pdf (Accessed: 23 November 2016).
12. Greater London Authority (2005) Connecting Londoners with Trees and Woodlands a Tree and Woodland Framework for London. Available at: http://www.forestry.gov.uk/pdf/ltwf_full.pdf/$FILE/ltwf_full.pdf.
13. Greater London Authority (2010) The Mayor's Transport Strategy. Available at: https://www.london.gov.uk/what-we-do/transport/our-vision-transport/mayors-transport-strategy.
14. Greater London Authority & Forestry Commission (2013) Green Infrastructure & Open Environments: Preparing Borough Tree and Woodland Strategies. Available at: https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/supplementary-planning-guidance/tree-and-woodland.
15. Green Infrastructure Task Force (2015) Green Infrastructure Task Force Report. Available at: https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/green-infrastructure-task-force-report.
16. Landscape Institute (2013) Green Infrastructure: An Integrated Approach to Land Use, www.landscapeinstitute.org/PDF/Contribute/2013GreenInfrastructureLIPositionStatement.pdf
17. London Borough of Hammersmith and Fulham (2006) Open Spaces and Outdoor Recreation Facilities in Hammersmith and Fulham.
18. London Borough of Hammersmith and Fulham Council (2008) Parks and Open Spaces Strategy.
19. Mayor of London & Transport for London (2014) London Cycling Design Standards. Available at: https://consultations.tfl.gov.uk/cycling/draft-london-cycling-design-standards/user_uploads/draft-lcds---all-chapters.pdf.
20. Mayor of London, Royal Horticultural Society and Forestry Commission (2015) Right Trees for London's Changing Climate, www.righttrees4cc.org.uk
21. Mayor of London, Royal Horticultural Society, Forestry Commission (2016) Right Trees for London's Changing Climate. Available at: http://www.righttrees4cc.org.uk/.
22. Natural England (2010) Nature Nearby - Accessible Natural Greenspace Guidance (NE265). Available at: http://webarchive.nationalarchives.gov.uk/20140605090108/http://publications.naturalengland.org.uk/publication/40004?category=47004.
23. National Urban Forestry Unit (2010) Trees Matter! Bringing Lasting Benefits to People in Towns, www.treesforcities.org/wp-content/uploads/2016/07/Trees-Matter.pdf
24. Parliamentary Office of Science and Technology (2013) 'Urban Green Infrastructure', POSTnote 448.
25. Parliamentary Office of Science and Technology (2016) 'Green Space and Health', POSTnote 538.
26. Transport for London (2014) Improving the health of Londoners - transport action plan. Available at: http://content.tfl.gov.uk/improving-the-health-of-londoners-transport-action-plan.pdf.
27. Urban Green Spaces Taskforce (2002) Final Report: Green Spaces, Better Places, www.ocs.polito.it/biblioteca/verde/taskforce/gspaces_.pdf

Case Studies

London

Arundel Square

1. Cassels, A. and Badrock, J. (2016) Landscape Institute - Arundel Square Case Study, www.landscapeinstitute.org/casestudies/casestudy.php?id=231
2. Living Projects (2016) Arundel Square, Islington, www.living-projects.co.uk/films/?page=architecture&film=58
3. Pollard Thomas Edwards (2012) Arundel Square, www.pollardthomasedwards.co.uk/project/arundel-square/
4. United House Developments (2012) Arundel Square, Islington, www.unitedhousedevelopments.net/developments/view/arundel-square

Bermondsey Spa

1. H&H (2009) Case Study Bermondsey Spa Phase 2, www.hhcelcon.co.uk/files/download/26-Bermondsey-Spa-Homes.pdf
2. Hyde Housing (2012) Regeneration at Bermondsey Spa, www.hyde-housing.co.uk/corporate/building-homes/estate-regeneration/bermondsey-spa/
3. RIBA (2014) Bermondsey Spa, www.architecture.com/FindAnArchitect/ArchitectPractices/LevittBernstein/Projects/BermondseySpa-110680.aspx
4. Southwark Council (2010) Bermondsey Spa Masterplan, www.southwark.gov.uk/info/200180/bermondsey_spa/1144/bermondsey_spa_masterplan

Central St. Giles

1. ArchDaily (2011) Central St. Giles Court/Renzo Piano & Fletcher Priest, www.archdaily.com/104147/central-st-giles-court-renzo-piano-fletcher-priest-architects/
2. Camden Gov (2005) St Giles Court Planning Application, Reference 2005/0259/P www.planningrecords.camden.gov.uk
3. Renzo Piano Building Workshop (2012) Central St. Giles Court Mixed-Use Development, www.rpbw.com/project/60/central-st-giles-court-mixed-use-development/
4. United House Developments (2012) Central St Giles, www.unitedhousedevelopments.net/developments/view/central-st-giles

East Village

1. Planning Reference: 07/90208/AODODA London Legacy Development Corporation
2. London Legacy (2007a) Open Space Strategy, www.planningregister.londonlegacy.co.uk/swift/MediaTemp/4174-65149.pdf
3. London Legacy (2007b) Planning Statement, www.planningregister.londonlegacy.co.uk/swift/MediaTemp/2943-45445.pdf
4. London Legacy (2010) London and Continental Railways Stratford City Application for Extension in Time Sustainability Statement, www.planningregister.londonlegacy.co.uk/swift/MediaTemp/2943-45416.pdf

Elephant and Castle

1. Southwark Planning Ref: 12/AP/1092
2. Lend Lease Corporation (2014) Sustainability, www.elephantpark.co.uk/elephant-park/sustainability
3. Lend Lease (2014) Our Plans - Elephant & Castle, www.elephantandcastle-lendlease.com/our-plans
4. Southwark Council (2010) Documents for Case, www.planbuild.southwark.gov.uk/documents/?casereference=12/AP/1092&system=DC

Hale Village

1. Reserved Matters Pavilions Planning No: HGY/2006/1177
2. BDP (2016) Hale Village, www.bdp.com/en/projects/f-l/hale-village
3. Haringey Special Planning Committee (2010) Notice of Meeting, www.minutes.haringey.gov.uk/Published/C00000106/M00004917/$$ADocPackPublic.pdf
4. Lee Valley Estates (2007) Hale Village Design Statement, www.planningservices.haringey.gov.uk/portal/servlets/AttachmentShowServlet?ImageName=298815

King's Cross Central

1. Camden Gov (2015) King's Cross Central, www.camden.gov.uk/ccm/navigation/environment/planning-and-built-environment/major-developments/king-s-cross-central/;jsessionid=FBE4C8310F936E8D558542AF13541460
2. King's Cross Visitor Centre (2015) Who is Developing King's Cross?, www.kingscross.co.uk/whos-developing-kings-cross
3. Milne, R. (2015) King's Cross Development Forum, www.kxdf.wordpress.com/category/plans/camden-frameworks/
4. Urban Land Institute (2014) King's Cross | ULI Case Studies, www.casestudies.uli.org/kings-cross/

Regent's Place

1. Planning Application No: 2007/0823/P Camden Borough
2. Broadgate Estates (2016) British Land, www.regentsplace.com/british-land
3. Ijeh, I. (2010) Terry Farrell's Regent's Place: Regent's Spark, www.building.co.uk/terry-farrells-regents-place-regent%E2%80%99s-spark/5003788.article
4. New London Architecture (2014) London's Growing Up: Project Showcase, www.newlondonarchitecture.org/docs/tb_b2.pdf
5. Wills, J. (2013) British Land - Creating a Masterplan for One of London's Most Deprived Areas, www.theguardian.com/sustainable-business/british-land-masterplan-london-deprived-area

St Andrew's, Phase 3

1. AKTII (2016) St Andrew's Project, http://akt-uk.com/projects/st%20andrews
2. Allies & Morrison (2010) St Andrew's Block A, http://www.alliesandmorrison.com/project/st-andrews-phase-1/
3. Future of London (2012) Presentation on St Andrew's, Bromley-By-Bow, https://issuu.com/futureoflondon/docs/120625_future_of_london_site_visit
4. Landezine (2015) St Andrew's, Bromley-by-Bow by Townshend Landscape Architects, http://www.landezine.com/index.php/2016/06/st-andrews-bromley-by-bow-by-townshend-landscape-architects/

The Library Building, Clapham High Street

1. DLA Design (2016) DLA Design Projects - Clapham One, www.dla-design.co.uk/residential/clapham-one.html
2. Lambeth Council (2009) Clapham One Planning Application, www.planning.lambeth.gov.uk/online-applications/applicationDetails.do?previousCaseType=Property&previousKeyVal=LCE442BO0FC00&activeTab=summary&previousCaseUprn=010090197569&previousCaseNumber=LCE41ZBO0FC00&keyVal=KDVJGOBO0AY00
3. The New Clapham (2013) About the Library Building, www.thenewclapham.com/pages/the-library-building-about.php
4. United House Developments (2012) Clapham One, www.unitedhousedevelopments.net/developments/view/clapham-one

Wood Wharf

1. Planning Ref No: PA/13/02966 and PA/13/02967
2. London Borough of Tower Hamlets (2014b) Wood Wharf Planning Sub-Committee Report, www.moderngov.towerhamlets.gov.uk/documents/s59188/PA-13-02966%2002967%20Wood%20Wharf%2004-07-2014%20agenda.pdf

Woodberry Down

1. Berkeley Group (2014) Woodberry Down Case Study, www.berkeleygroup.co.uk/media/pdf/t/e/FINAL_CASE_STUDY-v1.pdf
2. Hackney Council (2008), Woodberry Down Planning Application, www.idox.hackney.gov.uk/WAM/doc/Additional%20Information%20(Submitted%20By%20Applicant)-249983.pdf?extension=.pdf&id=249983&location=VOLUME1&contentType=&pageCount=1
3. Hackney Council (2016) Woodberry Down Regeneration, www.hackney.gov.uk/woodberry-down
4. Rolfe Judd (2016) Woodberry KSS1 Wins Multiple Design Awards, www.rolfe-judd.co.uk/news/awards/woodberry-downs-kss1/

7 More Riverside

1. Fosters and Partners (2010) 7 More London Riverside, www.fosterandpartners.com/projects/7-more-london-riverside

Europe

Bjørvika Barcode, Oslo, Norway

1. OSU (2016) Barcode, www.osu.no/osu/om-osu/barcode
2. Bjorvik Autvickling AS (2016) Miljørapport for Bjørvikautbyggingen www.bjorvikautvikling.no/ShowFile.ashx?FileInstanceId=551e371e-2df1-4188-99ea-f2f92286d661
3. MVRDV (2016) Bjørvika Barcode, www.mvrdv.com/projects/bjorvika-barcode

Bo01 Western Harbour, Malmö, Sweden

1. Malmö Stad (2003) Vastra Hamnen – The Bo01 Area: A City for People and the Environment
2. Roberts, Hanna (2008) Urban Design Best Practice Case Study – Bo01, Malmö
3. Urban Green-Blue Grids (2004) Bo01, Malmö, Sweden www.urbangreenbluegrids.com/projects/bo01-city-of-tomorrow-malmo-sweden
4. Visit Sweden (2014) Western Harbour Malmö, www.visitsweden.com/sweden/regions--cities/malmo/nature-in-malmo/western-harbour-malmo

HafenCity, Hamburg, Germany

1. HafenCity Hamburg (2016) Facts and Figures, www.hafencity.com/upload/files/artikel/Fact_Sheet.pdf
2. HafenCity Hamburg GmbH (2016) HafenCity Hamburg - Stellar Architecture - Rewarded with the HafenCity Ecolabel www.hafencity.com/en/concepts/stellar-architecture-rewarded-with-the-hafencity-ecolabel-.html
3. Kreutz, S. (2010) Transnational Assessment of Practice Case study Report: HafenCity, Hamburg, www.mp4-interreg.eu/wp-content/uploads/2012/10/HafenCity-Hamburg-Germany.pdf

Hammarsby Sjöstad, Stockholm, Sweden

1. EcoDistricts (2013) Hammarsby Sjöstad, Sweden, www.ecodistricts.org/wp-content/uploads/2013/05/Hammerby.pdf
2. PRP, URBED and Design for Homes (2008) Eco-Towns: Learning from International Experience

Royal Seaport, Stockholm, Sweden

1. Stockholm Stad (2009) Stockholm Royal Seaport: A World Class Urban Environmental District www.ec.europa.eu/ourcoast/download.cfm?fileID=918
2. Stockholm Stad (2016) Stockholm Royal Seaport, www.bygg.stockholm.se/royalseaport

North America

Dockside Green, Victoria, British Columbia, Canada:

1. Dockside Green (2016) Places, www.docksidegreen.com/development/places
2. RJC (2016) The Best in Sustainable Design Dockside Green, Victoria, British Columbia, www.rjc.ca/dockside-green

Hudson Yards, New York

1. Hudson Yards (2016) Sustainability, www.hudsonyardsnewyork.com/office/sustainability

South Waterfront, Eco District, Portland, USA

1. Dakessian, D. (2014) Building Sustainability: South Waterfront District, www.portlandtribune.com/scc/104-features/206098-51873-building-sustainability-the-south-waterfront-district
2. GBD Architects (2011) South Waterfront, www.gbdarchitects.com/portfolio-item/south-waterfront
3. Portland Sustainability Institute (2011) Pilot Report: South Waterfront EcoDistrict Development, www.ecodistricts.org/wp-content/uploads/2013/03/SouthWaterfront-cs51.pdf
4. South Waterfront (2015) South Waterfront Community Relations, http://www.southwaterfront.com.