OPDC
OLD OAK AND PARK ROYAL DEVELOPMENT CORPORATION

Waste Management Strategy

LOCAL PLAN

SUPPORTING STUDY

2017

MAYOR OF LONDON

48. Waste Management Strategy

Document Title	Waste Management Strategy
Lead Author	Arup Associates
Purpose of the Study	• To develop the understanding of a planned approach to resource and waste management in Old Oak and Park Royal by identifying the likely quantities and composition of waste to be generated in the development area. • To propose appropriate waste management options in order to optimise management of waste generated during construction and in occupation
Key outputs	• Review of national, regional and local policy and its relevance to proposals for Old Oak and Park Royal. • Identify roles and responsibilities for all waste streams and clarify existing waste management arrangements • Lessons learned and best practice in waste management on high density development • Establish key objectives and targets to be adopted • Provide forecast of waste that will be generated through construction and once the development is occupied • Provide recommendations for resource and waste management strategies across Old Oak and Park Royal
Key recommendations	• Adopt designing out waste principles during design, procurement, construction and deconstruction • Require contractors to develop detailed strategies for construction, demolition and excavation waste • Segregate waste during construction by type to maximise waste recovery. Coordinate segregation and recovery with waste management companies and keep as much waste within the area as possible for reuse • Engage the public to minimise waste from operational phase through campaigns and other means • Provide waste segregation facilities to stream waste and facilitate recycling • Ensure that best practice standards are used for waste storage and collection and work with estate management teams to optimise collection regimes • Use Anaerobic Digestion and other technologies to treat organic waste and separate wet waste from other waste • Promote community sharing platforms to encourage reuse and repair centres • Adopt automated waste collection systems where viable • Establish an industrial symbiosis platform that supports business to business systems to utilise waste as a resource
Relations to other studies	Outputs cross-relate to the Circular and Sharing Economy Study, Waste Apportionment Study, Waste Technical Paper and Utility Study
Relevant Local Plan Policies and Chapters	• Policy EU6 (Waste), EU7 (Circular and Sharing Economy) and EU8 (Sustainable Materials)

Old Oak and Park Royal Development Corporation

Old Oak and Park Royal

Resource and Waste Management Strategy

REP01

Issue 1 | 20 April 2017

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

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Abbreviations

Abbreviation	Meaning
Arup	Ove Arup & Partners Ltd
AD	Anaerobic Digestion
AWCS	Automated Waste Collection System
Capex	Capital expenditure
C2C	Cradle to Cradle
C&I	Commercial and Industrial
CD&E	Construction, Demolition and Excavation
Defra	Department for the Environment, Food and Rural Affairs
EWC	European Waste Code
GPS	Global Positioning System
LAWMW	Local Authority Collected Municipal Waste
LACW	Local Authority Collected Waste
LB Brent	London Borough of Brent
LB Ealing	London Borough of Ealing
LB Hammersmith & Fulham	London Borough of Hammersmith & Fulham
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
OPDC	Old Oak and Park Royal Development Corporation
Opex	Operational expenditure
PAYT	Pay-As-You-Throw
RCV	Refuse Collection Vehicle
RDF	Refuse Derived Fuel
RRC	Reuse and Recycling Centre
WCA	Waste Collection Authority
WDA	Waste Disposal Authority
WEEE	Waste Electrical and Electronic Equipment
WLWA	West London Waste Authority
WRWA	Western Riverside Waste Authority
WTN	Waste Transfer Note
URS	Underground Refuse System

1 Introduction

1.1 Overview

Ove Arup & Partners Ltd (Arup) has been commissioned by the Old Oak and Park Royal Development Corporation (OPDC) to develop a high level resource and waste management strategy for the Old Oak and Park Royal development area.

The objective of the strategy is to develop the understanding and planned approach to resource and waste management in Old Oak and Park Royal by identifying the likely quantities and composition of waste to be generated in the development area, and proposing appropriate waste management options for this waste.

The strategy has taken into account the specific constraints and opportunities at Old Oak and Park Royal, which include a hyper dense urban development made up principally of dense and tall buildings, a strategic infrastructure area that generates and treats waste within the site, and a major station interchange and related infrastructure.

1.2 Scope

The scope covers resource and waste management in both the construction and operational phases of Old Oak and Park Royal. Only waste generated in the development area is considered in the waste forecast but the strategy takes into account other waste quantities available for use.

2 Policy and guidance

2.1 Overview

To develop the resource and waste management strategy for Old Oak and Park Royal, consideration has been given to the national, regional and local policy framework for resource and waste management in England, London and relevant London Boroughs, respectively. This includes the relevant waste planning and waste management policies, which are summarised in Appendix A.

3 Roles and responsibilities

3.1 Duty of Care

The Environmental Protection (Duty of Care) Regulations 1991 (as amended)[1] state that anyone who imports, produces, carries, keeps, treats, disposes of, or is a dealer or broker that has control of, controlled waste, is a waste holder. The duty

[1] The Environmental Protection (Duty of Care) Regulations 1991.

of care of a waste holder applies throughout all of the stages from waste production up to disposal or recovery.

Householders must ensure that household waste is properly disposed of. If you are a householder, you are required to take reasonable steps to check that people removing waste from your premises are authorised to do so. Reasonable steps to take include, asking the waste carrier to provide you with their full address and telephone number and asking to see their waste carrier licence issued by the Environment Agency (in England).

All businesses produce waste and as a result, each commercial facility has a legal responsibility to ensure that they produce, store, transport and dispose of their business waste without harming the environment.

Overall, all waste producers are responsible for managing their waste in line with the waste hierarchy. Therefore, waste source segregation is required to facilitate reuse and recycling.

3.2 Local authority collected waste

3.2.1 Context

The Old Oak and Park Royal development area is located within three London Boroughs: the London Borough of Brent (LB Brent), the London Borough of Ealing (LB Ealing) and the London Borough of Hammersmith & Fulham (LB Hammersmith & Fulham). The local authorities for each borough are the statutory Waste Collection Authorities (WCAs). WCAs are responsible for arranging household waste collections. They specify the types of waste they collect, the day they collect it and how often, and any special arrangements for collecting waste and recyclables.[2]

The total waste collected by WCAs is referred to as Local Authority Collected Waste (LACW), which includes household waste, business waste that is collected by the local authority and which is similar in nature and composition as household waste, and non-municipal fractions such as construction and demolition waste.[3] Local Authority Collected Municipal Waste (LACMW) is the portion of LACW that includes just household waste and business waste that is collected by the local authority, and which is similar in nature and composition as household waste.

Waste Disposal Authorities (WDAs) are responsible for the disposal of LACW. WDAs must manage waste which is collected by local authorities.[4] West London Waste Authority (WLWA) is the statutory WDA for LB Brent and LB Ealing, and

[2] Environment Agency (2008), *What Does a Waste Collection Authority do?* Available at: http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/subjects/waste/1029679/1029771/?lang=_e (Accessed 9 December 2016).
[3] Department for Environment, *Food & Rural Affairs (2011), Local Authority Collected Waste – Definition of Terms*, Available at: https://www.gov.uk/guidance/local-authority-collected-waste-definition-of-terms (Accessed 9 December 2016).
[4]Environment Agency (2008), *What is a Waste Disposal Authority?* Available at: http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/subjects/waste/1029679/1029794/?lang=_e (Accessed 9 December 2016).

Western Riverside Waste Authority (WRWA) is the WDA for LB Hammersmith & Fulham (see **Figure 1**).

Figure 1: London WDAs (source: WRAP)

3.2.2 Waste storage

For all boroughs, residents are expected to follow the waste collection arrangements specified by the local WCA.

Brent and Ealing Council, which provide wheeled bins to households, advise their residents that any residual waste that is not properly placed inside the wheeled bins at the time of collection (e.g. waste placed beside bins and overflowing waste), will not be collected.[5,6] According to the two councils, this is done in order to encourage reuse and recycling, and simultaneously reduce residual waste generation.

3.2.3 Waste collection

Brent Council has a nine year contract with Veolia, which began in April 2014, for household recycling and residual waste collections, as well as, street cleaning services[7].

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[5] Brent & Kilburn Times (2016), *Bins in Kilburn Left Overflowing for Weeks After Council and Landlord Refuse to Empty Them*, Available at: http://www.kilburntimes.co.uk/news/environment/bins_in_kilburn_left_overflowing_for_weeks_after_council_and_landlord_refuse_to_empty_them_1_4539395 (Accessed 1 December 2016).

[6] Get West London (2016), *New Ealing Wheelie Bins Blamed for Increased Fly Tipping and Uncollected Rubbish as Residents Fume*, Available at: http://www.getwestlondon.co.uk/news/new-ealing-wheelie-bins-blamed-11486843 (Accessed 1 December 2016).

[7] Veolia (2016), *Brent*, Available at: http://www.veolia.co.uk/london/services/services/north-london/brent (Accessed 1 December 2016).

Ealing Council has a 15 year contract with Amey plc, which started in two phases in January and April 2012, for household recycling and residual waste, clinical, bulky and trade waste collections, as well as, street cleaning services.

Hammersmith & Fulham Council has a 13 year contract with Serco Limited, which started in June 2008, for household recycling and residual waste collections, as well as, street cleaning services.[8]

3.2.4 Waste treatment and disposal

WLWA is responsible for waste disposal in LB Brent and LB Ealing as well as the London Boroughs of Harrow, Hillingdon, Hounslow and Richmond upon Thames. WLWA is legally obliged to:

- Provide facilities for receiving waste collected by the six constituent London boroughs. This includes the waste collected from households and at Reuse and Recycling Centres (RRCs).
- Transport and recycle or dispose of the collected household waste.
- Store and dispose of abandoned vehicles removed by the boroughs.[9]

In addition to the waste disposal services provided by WLWA, Brent Council holds direct contracts with Veolia[10] and West London Composting[11] for the treatment of organic waste and dry mixed recyclables, respectively. The Veolia Materials Recovery Facility (MRF) is located in Southwark and West London Composting's facility is located in Harefield. Ealing Council also holds a direct contract with Viridor for the treatment of dry mixed recyclables at the Viridor MRF in Crayford.[12]

WRWA is responsible for waste disposal in LB Hammersmith & Fulham as well as the Royal Borough of Kensington and Chelsea, and the London Boroughs of Lambeth and Wandsworth. WRWA is legally obliged to:

- Provide facilities for receiving waste collected by the four constituent London boroughs. This includes the waste collected from households and at RRCs.
- Transport and recycle or dispose of the collected household waste.

In May 2002, WRWA entered a long-term waste management services agreement contract with Cory Environmental.

[8] Hammersmith & Fulham Council (2016), London Borough of Hammersmith & Fulham Waste Contract, https://www.lbhf.gov.uk/sites/default/files/section_attachments/waste_contract_16-17.xlsx (Accessed 14 December 2016).
[9] West London Waste Authority (2016), *About Us*, Available at: http://westlondonwaste.gov.uk/about-us/ (Accessed 1 December 2016).
[10] Brent Council (2016), *What happens to your recycling?* Available at: https://www.brent.gov.uk/services-for-residents/recycling-and-waste/household-recycling/what-happens-to-your-recycling/ (Accessed 1 December 2016).
[11] Ibid.
[12] Catherina Pack (Waste & Street Services Manager, Ealing Council) via email on 6 December 2016.

3.3 Commercial and industrial waste

3.3.1 Waste storage

In line with the Duty of Care requirements set out in Section 3.1, businesses are responsible for source segregating their Commercial and Industrial (C&I) waste and providing appropriate storage for it. The waste storage receptacles are usually provided by the registered waste contractor providing the waste collection service.

3.3.2 Waste collection

In line with the Duty of Care requirements set out in Section 3.1, businesses are responsible for arranging waste collection services. Arrangements are usually made with private registered waste collection contractors. However, some WCAs provide a limited C&I waste collection service and can be used upon request. Brent Council does not provide commercial waste collection services. Ealing Council and Hammersmith & Fulham Council are registered commercial waste collection contractors.

Waste Transfer Notes (WTNs) need to be completed for every waste load leaving a business premises. The waste producer is required to include a detailed description of the waste being transferred off-site, including the six digit European Waste Code (EWC), the waste quantity of each EWC and the physical form of the waste. Both the details of the transferor and transferee need to be included on the WTN. At a business premises, both the transferor and transferee are responsible for completing the WTN and for ensuring that they are completed to the appropriate standards.

3.3.3 Waste treatment and disposal

In line with the Duty of Care requirements set out in Section 3.1, the registered C&I waste collection contractor is responsible for transporting the waste to a permitted waste management facility where it can undergo appropriate treatment or disposal. Businesses are also responsible for selecting registered waste collection contractors that take their waste to permitted waste management facilities.

3.4 Construction, demolition and excavation waste

3.4.1 Waste storage

In line with the Duty of Care requirements set out in Section 3.1, Construction, Demolition & Excavation (CD&E) waste producers are responsible for source-segregating their waste and providing appropriate storage for it. The waste storage receptacles are usually provided by the registered waste contractor providing the waste collection service.

3.4.2 Waste collection

In line with the Duty of Care requirements set out in Section 3.1, CD&E waste producers are responsible for arranging waste collection services with an appropriate registered waste collector.

WTNs need to be completed for every waste load leaving a construction site. The waste producer is required to include a detailed description of the waste being transferred off-site, including the six digit EWC, the waste quantity of each EWC and the physical form of the waste. Both the details of the transferor and transferee need to be included on the WTN. At a construction site, both the transferor and transferee are responsible for completing the WTN and for ensuring that they are completed to the appropriate standards.

3.4.3 Waste treatment and disposal

In line with the Duty of Care requirements set out in Section 3.1, the registered CD&E waste collection contractor is responsible for transporting the waste to a permitted waste management facility where it can undergo appropriate treatment or disposal. CD&E waste producers are also responsible for selecting registered waste collection contractors that take their waste to permitted waste management facilities.

4 Existing waste management arrangements

4.1 Overview

A review of the existing waste management arrangements was undertaken in order to establish the current baseline conditions within Old Oak and Park Royal. These will form the basis for identifying future improvements and development opportunities.

4.2 Local authority collected waste

4.2.1 Overview

Existing waste management arrangements for LACW can be differentiated by those provided to households and those provided to businesses. The three London boroughs that Old Oak and Park Royal is located in each have different household waste management arrangements, reflecting the different source segregation and waste collection strategies adopted by each WCA. The main household waste management arrangements are summarised in **Figure 2**. These are described further in this section of the report. Ealing Council and Hammersmith & Fulham Council, which are also registered commercial waste collection contractors, would provide appropriate waste storage receptacles and a waste collection service as requested by businesses. Since this can vary from business to business, existing waste management arrangements for businesses are not covered in this section.

Area	LB Brent			LB Ealing			LB Hammersmith & Fulham		
Waste generation (2014/2015)	99,913 tonnes			95,287			52,229 tonnes		
Waste type	Dry mixed recyclables	Organic	Residual	Dry mixed recyclables	Organic	Residual	Dry mixed recyclables	Organic	Residual
Waste storage	-Blue top recycling wheeled bins (240L) and specified recyclable items next to blue top bins for houses and converted flats -Clear recycling bags for flats above shops -Communal recycling bins for blocks of flats	**Food waste:** -Green food waste caddy bin for houses and converted flats -Green food waste caddy bin for blocks of flats **Green waste:** -Optional, chargeable recycling via brown wheeled bins for houses and converted flats	-Grey top bins (140L) for houses and converted flats -Black sacks for flats above shops -Communal bins for blocks of flats	-Blue recycling wheeled bins (240L) and specified recyclable items next to blue bins for houses and converted flats -Mixed clear sack recycling service for each flat (13-24 flats, flats above shops, red routes) - Communal recycling facilities (≥ 25 flats)	**Food waste:** -Green caddy bin for houses and converted flats -Green food waste caddy bin for blocks of flats **Green waste:** -Optional, chargeable recycling via brown wheeled bins or reusable sacks for houses and converted flats	-Black wheeled bins (240L) for houses and converted flats -Communal rubbish bin/disposal area for estates and blocks of flats	-Orange Smart Sacks for houses, small blocks of flats and flats above shops -Reusable orange bag for estates and large blocks of flats	**Garden waste:** -Optional recycling via up to five bags of garden waste in black sacks for houses, small blocks of flats and flats above shops	-Black sacks or own dustbins for houses, small blocks of flats and flats above shops -Black sacks taken to communal bins for estates and large blocks of flats
Waste collection	-Weekly collections for houses and converted flats -Varied arrangements advised on individual basis for flats above shops -Varied arrangements advised on individual basis for flats above shops	**Food waste:** -Food caddy emptied on weekly basis for houses and converted flats -Blocks of flats empty food caddy in larger communal container collected on weekly basis **Green waste:** -Fortnightly collections for houses and converted flats	-Fortnightly collections from houses and converted flats -Varied arrangements advised on individual basis for blocks of flats -Varied arrangements advised on individual basis for flats above shops	-Fortnightly collections for houses and converted flats -Weekly collections for estates and large blocks of flats	**Food waste:** -Food caddy emptied on weekly basis for houses and converted flats -Food caddy emptied on weekly basis for blocks of flats **Green waste:** -Fortnightly collections for houses and converted flats	-Fortnightly collections for houses and converted flats -Weekly collections for estates and large blocks of flats	-Weekly/twice weekly collections for houses, small blocks of flats and flats above shops -Reusable orange bag to Smart Bank , or disposed through recycling chute, or to recycling mini bank for estates and large blocks of flats	**Green waste:** -Weekly collections for houses, small blocks of flats and flats above shops	-Weekly/twice weekly collections assessed on individual basis for houses, small blocks of flats and flats above shops -Weekly/twice weekly collections assessed on individual basis for estates and large blocks of flats
Waste treatment and disposal	Veolia MRF (Southwark, London)	West London Composting (Harefield, London)	Lakeside Energy from Waste (Slough)* SUEZ Landfill (Lincolnshire)* SUEZ Severnside Energy Recovery Centre	Viridor MRF (Crayford, London)	Biogen anaerobic digestion plant (Bedford)	Lakeside Energy from Waste (Slough)* SUEZ Landfill (Lincolnshire)* SUEZ Severnside Energy Recovery Centre	Smugglers Way MRF (Wandsworth, London)	If not composted using household composting bins, taken to Riverside Resource Recovery Facility (Belvedere, London)	Riverside Resource Recovery Facility (Belvedere, London)

Figure 2: Outline of main household waste management arrangements

4.2.2 Waste generation

The quantity of household and non-household LACW generated in each of the three London boroughs for the 2014/15 financial year, as published by Defra[13], is provided in **Table 1**.

Table 1: LACW generation

Area	2014/15 household waste (tonnes)	2014/15 non-household waste (tonnes)	2014/15 total (tonnes)
LB Brent	99,913	7,578	107,491
LB Ealing	95,287	38,617	133,905
LB Hammersmith & Fulham	52,229	22,619	74,848

4.2.3 Waste storage

Brent Council

Brent Council provides residents with a 240litre blue top wheeled bin to recycle the following materials:

- Paper, metal tins and cans, glass bottles and jars, plastic bottles, aluminium foil, mixed plastic containers, food and beverage cartons and cardboard.
- Textiles, shoes, household and car batteries and engine oil are also collected and residents present these materials, next to the recycling bin, contained in clear plastic bags or clearly labelled bags (residents provide their own bags).

The collection of the recycling bin is weekly.

All residents in street level properties are provided with a 23litre food waste caddy bin. In addition, all street level properties are eligible to a separate chargeable garden waste collection service, in which garden waste is collected in 240litre wheeled bins.

Brent Council collects residual waste from a 240litre grey top wheeled bin every two weeks.

Brent Council holds a nine-year public realm contract with Veolia, which started in 2014.[14,15] Veolia has placed 400 lockable bag storage bins throughout the parks and open spaces of the borough. These are duo bins that have both dry mixed

[13] Defra (2015), *Statistical Data Set - ENV18 - Local Authority Collected Waste: Annual Results Tables*, Available at: https://www.gov.uk/government/statistical-data-sets/env18-local-authority-collected-waste-annual-results-tables (Accessed 1 December 2016).
[14] Veolia (2014), *Veolia Launches New Contract in Brent*, Available at: http://www.veolia.co.uk/media/media/veolia-launches-new-contract-brent (Accessed 13 December 2016).
[15] Veolia and Brent Council (2014), *Public Realm Contract - Recycling and Cleansing*, Available at: http://www.loveparks.org/Documents/Files/Brentppt.pdf (Accessed 13 December 2016).

recyclables and residual waste (where organic waste would also be stored) compartments as shown in **Figure 3**. Veolia is constantly reviewing the number of on-street recycling containers and their locations to determine their effectiveness.

Figure 3: Example of public realm duo bins used in LB Brent

Ealing Council

Ealing Council provide blue recycling wheeled bins that accept the following recyclables:

- Paper – newspaper, telephone directories, envelopes and office paper;
- Plastic – pots, tubs, trays and bottles only;
- Metal – tins, cans, foil and aerosols;
- Cardboard – plain, corrugated and cereal boxes;
- Cartons – Tetra Pak, food and drink carton; and
- Glass.

The following items can also be recycled, but should be placed on top of or next to the recycling bin on collection day:

- Textiles – should be placed in a bag; and
- Household batteries – should be placed in a tied up bag.

The collection of the recycling bin occurs every two weeks.

The council offers weekly food waste collections to all eligible street level households. Each household is provided with a 23litre food waste caddy bin.

The council offers a garden waste chargeable service from a 240litre brown wheeled bin or from reusable sacks.

Ealing council provide black wheeled bins for residual waste. These collections also occur every two weeks and they alternate with the recycling collections from the blue recycling wheeled bins.

Ealing Council has seen an 11% improvement in recycling rates over a year, reaching 54% in July 2016 after launching a new waste segregation and collection strategy in June 2016.[16] The new strategy involved collections for dry mixed recyclables compared to individual collections for recyclable materials (plastic, paper, metal) and alternate weekly wheeled bin collections.

In the public realm, Ealing Council provide a number of different bins including Big Belly bins (see **Figure 4**), which have a solar-powered compactor that is able to store five times as much rubbish as a normal bin, and duo bins that have both dry mixed recyclables and residual waste (where organic waste would also be stored) compartments. The council also provides cigarette bins in the lids of some of the duo bins.[17]

Figure 4: Big Belly bin outside Ealing Town Hall (source: Get West London[18])

On-the-go recycling bins are available in parks across the borough including Ealing Common, Northala Fields, Acton Park, Elthorne Park and Norwood Green.[19] These bins offer three-stream source segregation and include the following waste streams: mixed paper, plastic and cans. The on-the-go recycling bins feature artwork by children from the borough, who took part in an environmental art competition (see **Figure 5**).

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[16] Ealing Council (2016), *Latest Recycling Figures for Ealing Show Another Big Increase*, Available at: https://www.ealing.gov.uk/news/article/1527/latest_recycling_figures_for_ealing_show_another_big_increase (Accessed 26 January 2017).
[17] Ealing Council (2014), *Waste & Recycling Collection, Street Cleansing, Grounds Maintenance, Burials and Associated Services*, Available at: http://ealing.cmis.uk.com/ealing/Documents/PublicDocuments.aspx (Accessed 13 December 2016).
[18] Get West London (2015), *'Big Belly' Solar Bin with Very Big Appetite Comes to Ealing*, Available at: http://www.getwestlondon.co.uk/news/west-london-news/big-belly-solar-bin-very-9042299 (Accessed 26 January 2017).
[19] Ealing Council (2016), *On the Go Recycling,* Available at: https://www.ealing.gov.uk/info/201171/recycling_services/1768/on_the_go_recycling (Accessed 13 December 2016).

Figure 5: On-the-go recycling bins in LB Ealing

Hammersmith & Fulham Council

Hammersmith & Fulham Council provides transparent orange recycling sacks, known as Smart Sacks, to street level properties (including small blocks of flats and flats above shops) for storing their recyclables.

Estates or large blocks of flats are provided with orange reusable bags, which are used to store and transfer recyclables to Smart Banks (see **Figure 6**). Smart Banks are usually located in convenient places, normally next to the existing bin store or the entrance of the block of flats.

Figure 6: Example of a Smart Bank in LB Hammersmith & Fulham

The following items can be recycled in the recycling sacks and banks:

- Mixed glass;
- Paper and cardboard;

- Plastic bottles, plastic trays and tubs;
- Cartons;
- Tetra Pak;
- Tins, cans etc; and
- Aerosols.

The collection of the orange recycling sacks occurs weekly or twice weekly and this is assessed on an individual basis for each property.

The council does not offer food waste recycling services. However, it encourages home composting, where possible. Residents with suitable households can order a subsidised home compost bin online, with prices starting at £12. Wormery bins and kitchen composters are also available. Residents are also encouraged to compost their garden waste. The council does not offer garden waste recycling services. Residents who cannot, or choose not to, compost their garden waste, can put out up to five bags of garden waste each week and these are collected together with the rest of the household waste collections.

The council does not offer any receptacles for residual waste. Residents can present their residual waste in black sacks or within their own bins. Communal bins for residual waste are available for estates and large blocks of flats. Residual waste collections occur weekly or twice weekly and this is assessed on an individual basis for each property.

The litter bins used around the public realm of LB Hammersmith & Fulham are duo bins (see **Figure 7**) that have both dry mixed recyclables and residual waste (where organic waste would also be stored) compartments.[20]

[20] Wybone (2014), *News: Hammersmith & Fulham – Litter and Recycling Bins*. Available at: http://wybone.co.uk/hammersmith-fulham-litter-and-recycling-bins/ (Accessed 13 December 2016).

Figure 7: Public realm duo bins in LB Hammersmith & Fulham (source: Wybone[21])

4.2.4 Waste collection

The waste collection arrangements for the three different London boroughs are provided in **Figure 2**.

4.2.5 Waste treatment and disposal

Brent Council

Brent Council has almost 40 RRCs located across the borough. The Abbey Road RRC, which is the largest of these facilities and accepts wide range of household waste streams, is located in the Old Oak and Park Royal development area. Households can dispose of Waste Electrical and Electronic Equipment (WEEE), bulky waste, waste oil, mixed textiles and other household waste.[22]

Dry mixed recyclables are taken to the Veolia MRF in Southwark for sorting into individual materials streams. Food and garden waste is taken to the West London Composting facility in Harefield for in-vessel composting.[23]

Residual waste is taken to the Suez Transport Avenue waste transfer station. From here, a portion of the residual waste is sent to the Viridor Lakeside Energy from Waste facility for thermal treatment. The remaining portion is sent for landfill disposal at a Suez landfill site in Lincolnshire.

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[21] Ibid.

[22] Brent Council (2016), *Abbey Road – Brent Reuse and Recycling Centre*, Available at: https://www.brent.gov.uk/services-for-residents/recycling-and-waste/do-it-yourself-recycling/recycling-sites-in-brent/abbey-road-brent-reuse-and-recycling-centre/ (Accessed 13 December 2016).

[23] Brent Council (2016), *What Happens to Your Recycling?* Available at: https://www.brent.gov.uk/services-for-residents/recycling-and-waste/household-recycling/what-happens-to-your-recycling/ (Accessed 5 December 2016).

However, once the Suez Severnside Energy Recovery Centre in South Gloucestershire is fully operational, all residual waste from LB Brent and other constituent boroughs of WLWA will be sent there via rail for thermal treatment. The Suez Severnside Energy Recovery Centre has an annual throughput capacity of approximately 350,000 tonnes of residual waste. It uses moving grate incineration technology and can generate up to 37.5MW of electricity and 10MW heat.[24] The facility would be able to export up to 34MW of electricity, enough to power 50,000 homes.[25] The facility has been designed so that in the future, any heat generated could be used in a district heat network. Overall, the facility will be able to divert 96% of the residual waste generated by the constituent London boroughs of WLWA from landfill.[26]

Ealing Council

Ealing Council has two RRCs in the borough: one in Acton and one in Greenford. They accept a wide range of waste materials generated by households.

Dry mixed recyclables are taken to the Viridor MRF in Crayford. The MRF sorts paper, cardboard, plastic bottles, cans and glass using optical sorting, mechanical processes and manual quality control.[27]

Food and garden waste is taken to the Biogen Anaerobic Digestion (AD) facility in Bedford.[28] The facility processes 35,000 tonnes of food waste and 12,000 tonnes of pig slurry from nearby farms per year. This generates 1.6MW of electricity, enough to power approximately 3,500 homes.[29] The contract is expected to end in April 2017 although WLWA are planning to renew this contract.

Ealing Council has the same existing and future treatment and disposal arrangements for residual waste as that described for Brent Council (see above).

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[24] Hitachi Zosen Inova (2016), *Severnside / UK: Energy-from-Waste Plant*, Available at: http://www.hz-inova.com/cms/wp-content/uploads/2016/10/Severnside_Online_E.pdf (Accessed 30 January 2017).

[25] Suez (2016), *Operations Begin at Severnside Energy Recovery Centre*, Available at: http://www.sita.co.uk/news-and-views/press-releases/operations-begin-at-severnside-energy-recovery (Accessed 26 January 2017).

[26] Ibid.

[27] Viridor (2016), *Ealing the Latest London Borough Transforming Waste with Viridor*, Available at: https://blog.viridor.co.uk/2016/05/31/ealing-the-latest-london-borough-transforming-waste-with-viridor/ (Accessed 30 November 2016).

[28] Biogen (2016), *Biogen*, Available at: http://www.biogen.co.uk/ (Accessed 5 December 2016).

[29] Biogen (2017), *Where Biogen Operates*, Available at: http://www.biogen.co.uk/Where-we-operate (Accessed 30 January 2016).

Hammersmith & Fulham Council

Hammersmith & Fulham Council has one RRC on Smugglers Way, Wandsworth. It accepts a wide range of materials including WEEE, bulky waste, waste oil, mixed textiles and other household waste.[30]

The Smugglers Way RRC is also co-located with a MRF and a waste transfer station. Dry mixed recyclables are separated at the MRF. Residual waste that is bulked at this waste transfer station or the Cringle Dock waste transfer station is transported via river to the Riverside Resource Recovery Facility in Bexley for thermal treatment. The facility has an annual throughput capacity of approximately 670,000 tonnes of residual waste.[31] It uses moving grate incineration technology and can generate enough electricity each year to power around 110,000 homes.[32] The excess heat is not currently recovered for beneficial use.

4.2.6 Waste management performance

A summary of the proportion of household and non-household LACW sent for different types of waste treatment and disposal (i.e. waste management performance) for the 2014/15 financial year, as published by Defra[33], is provided in **Figure 8** and **Figure 9**, respectively. Please note that for LB Ealing the rates refer to the old waste management strategy, as it represents the latest available data. The new strategy for LB Ealing was launched in June 2016.

The results of **Figure 8** show that LB Ealing has the highest landfill diversion rate of household LACW (40%), while LB Hammersmith & Fulham has the lowest landfill diversion rate (21%). The low landfill diversion rates of household LACW for LB Hammersmith & Fulham, relative to the other two boroughs may be attributed to their lack of separate organic waste collection services. This can be mainly concluded from the fact that their dry mixed recycling rate (20%) is not significantly lower than that of LB Ealing (28%), while it is slightly higher than that of LB Brent (19%).

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[30] Western Riverside Waste Authority (2017), *Reuse and Recycling Centres: Smugglers Way*, Available at: http://www.wrwa.gov.uk/recycle/reuse-and-recycling-centres/smugglers-way,-sw18-1js-information-for-cars,-motorcyclists,-pedestrians-and-cyclists-only.aspx#materialsaccepted (Accessed 30 January 2017).
[31] Cory Environmental (2012), *Riverside Resource Recovery Facility, Belvedere, London Borough of Bexley*, Available at: http://www.coryenvironmental.co.uk/downloads/Cory%20RRR%20leaflet.pdf (Accessed 30 January 2017).
[32] Cory Environmental (2017), *Our Services: Energy from Waste*, Available at: http://www.coryenvironmental.co.uk/our-services/energy-from-waste/ (Accessed 30 January 2017).
[33] Defra (2015), *Statistical Data Set - ENV18 - Local Authority Collected Waste: Annual Results Tables*, Available at: https://www.gov.uk/government/statistical-data-sets/env18-local-authority-collected-waste-annual-results-tables (Accessed 1 December 2016).

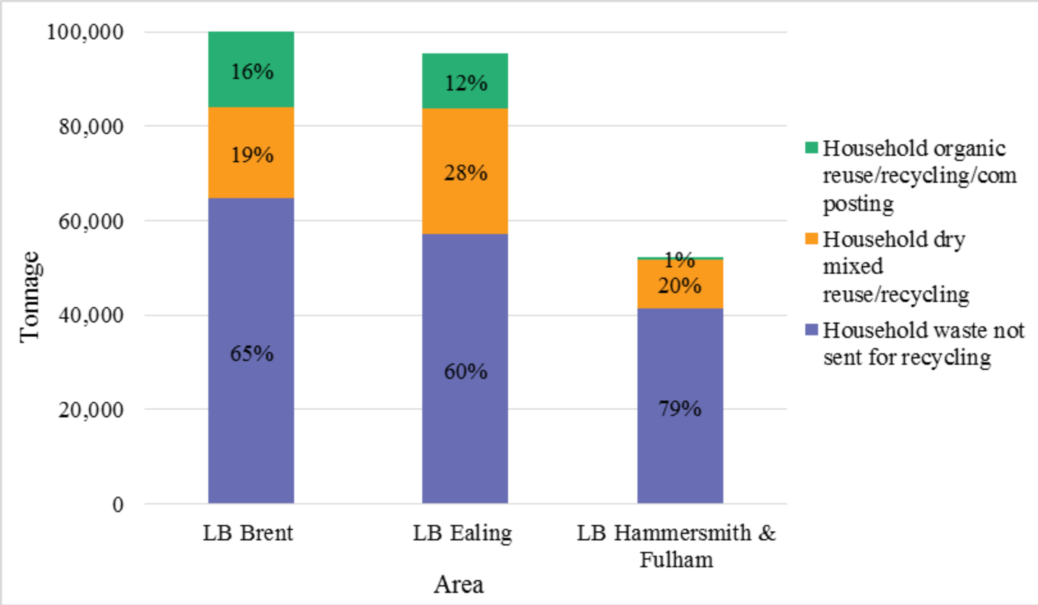

Figure 8: Waste management performance of household LACW in 2014/15

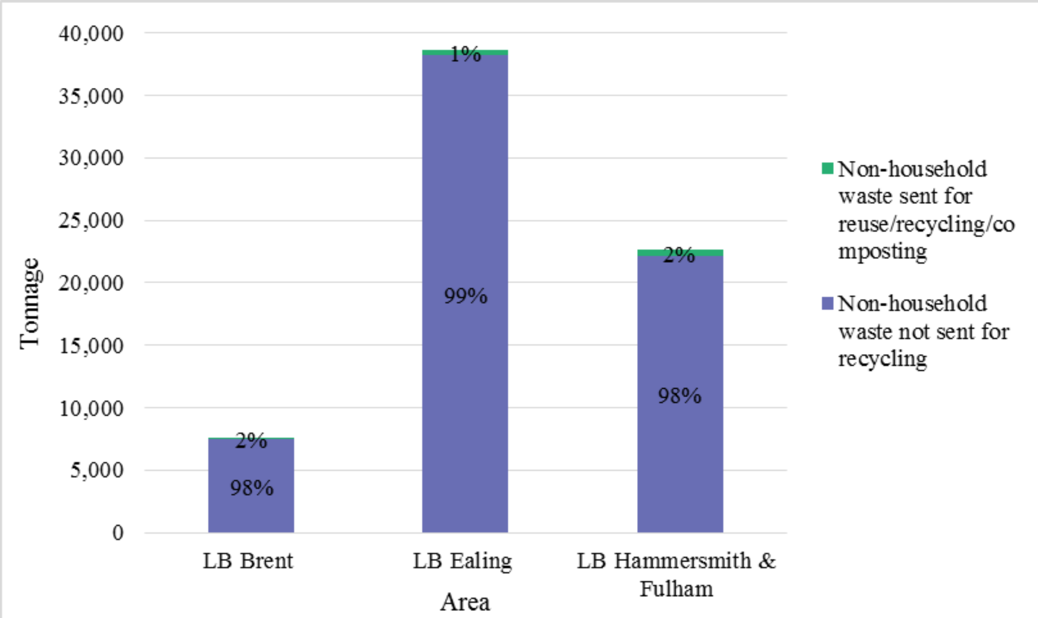

Figure 9: Waste management performance of non-household LACW in 2014/15

However, these are only some high level inferences. The success of a particular waste management strategy may vary from borough to borough, due to a variety of factors, such as the size of the borough, the mix of properties (e.g. the proportion of flats and houses), the mix of land uses (e.g. some boroughs may have a larger number of commercial buildings) and the participation rates of the residents in the waste management strategy adopted by the borough.

4.3 Commercial and industrial waste management

4.3.1 Waste generation

The quantity of C&I waste generated in each of the three London boroughs in 2009 is provided in **Table 2**. This represents the latest available data published for C&I waste arisings. For comparison purposes, the quantity of C&I waste estimated for 2015 is also provided in **Table 2**. Both sets of data has been published by the Greater London Authority.[34]

Table 2: C&I waste generation

Area	2009 C&I waste arisings	2015 C&I waste estimates
LB Brent	142,000	145,000
LB Ealing	174,000	178,000
LB Hammersmith & Fulham	115,000	117,000

Waste storage, collection and transfer

C&I waste management is different for each business as they can arrange for their each commercial facility can choose a different waste contractor (see Section 3.3). As a result, the exact waste management arrangements depend on the commercial waste contractor(s) used.

As certain WCAs, including Ealing Council and Hammersmith & Fulham Council, are registered waste operators, businesses may choose to have a contract with them for the collection and transfer of their waste.

Waste management performance

The estimated proportion of C&I waste sent for different types of waste treatment and disposal (i.e. waste management performance) in 2015, as published by the Greater London Authority[35], is provided in **Figure 10**.

[34] Greater London Authority and SLR Consulting (2014), Waste Arisings Model: Further Alterations to the London Plan.
[35] Ibid.

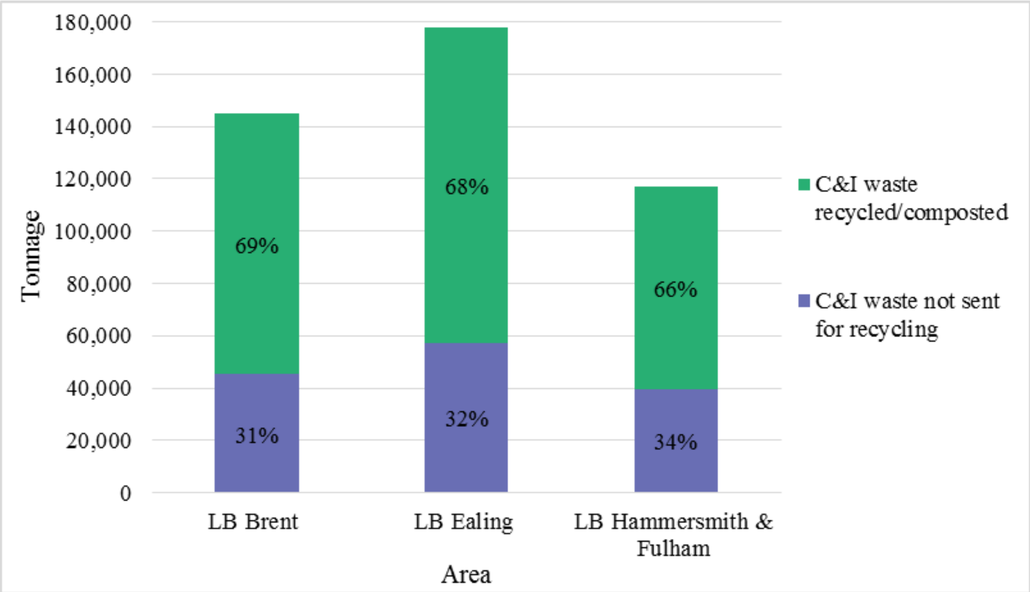

Figure 10: Estimated waste management performance of C&I waste in 2015

4.1 Construction, demolition and excavation waste

Waste generation

The quantity of CD&E waste generated in each of the three London boroughs in 2010 is provided in **Table 3**. This represents the latest available data published for CD&E waste arisings. For comparison purposes, the quantity of C&I waste estimated for 2015 is also provided in **Table 2**. Both sets of data has been published by the Greater London Authority.[36]

Table 3: CD&E waste generation

Area	2010 CD&E waste arisings (tonnes)	2015 CD&E waste estimates (tonnes)
LB Brent	264	282
LB Ealing	287	301
LB Hammersmith & Fulham	155	156

Waste storage, collection and transfer

In line with the Duty of Care requirements (see Section 3.1), CD&E waste holders should make their own arrangements to ensure that their waste will be stored, collected and sent off to appropriate registered waste operation facilities.

[36] Greater London Authority and SLR Consulting (2014), Waste Arisings Model: Further Alterations to the London Plan.

Waste management performance

The estimated proportion of CD&E waste sent for different types of waste treatment and disposal (i.e. waste management performance) is not available individually for the three boroughs. The Greater London Authority published its latest available information on the estimated reuse and recycling of CD&E waste in London in 2005[37]. The results indicate that 93.75% of CD&E waste was sent for reuse or recycling in London in 2005.

5 Lessons learned

A set of key lessons learned have been developed based on case studies provided in Appendix B. These case studies present the challenges and opportunities in relation to waste management at comparable high-density and large scale development projects.

5.1 Waste prevention and reuse

The keys lessons related to waste prevention and reuse include:

- Waste reduction can be achieved during procurement stages. For example, waste reduction and waste management should be an integral part of the tender process for designers, sub-contractors, waste management contractors and materials suppliers (see Appendix B1).
- Local authorities prefer fewer waste and recycling collections per week, which necessitates a larger area for waste and recyclables storage. However, in large developments, land is usually at a premium and thus the council accepts that realistic compromises need to be made (see Appendix B2).
- As awareness to waste reduction and recycling is not well-embedded in some cultures, smart waste technology (e.g. Automated Waste Collection Systems – AWCS) suppliers and facility management companies would need to hold workshops for users, provide a simple user guidance and clear slogans (e.g. ‘recycle little and often’ such as at Wembley City), to make sure that they understand how to use the system in the best possible way. This is a good lesson even for more environmentally-aware regions, such as the UK, to show that with the introduction of any new system, residents have to be well-engaged and should understand the importance of participating in new waste management schemes (see Appendix B8).
- Strict and well-targeted waste policies can result in the successful implementation of waste reduction and recycling schemes, with significantly high participation rates and customer satisfaction (see Appendix B8).
- Implementing a Pay-As-You Throw (PAYT) scheme together with a recycling scheme in a residential area, can have positive synergistic effects, as a successful recycling process is offered, but at the same time a focus on the

[37] Ibid.

waste hierarchy is retained, as people are taught to reduce their waste generation rates rather than simply rely on recycling (see Appendix B9).

5.2 Waste storage

The keys lessons related to waste storage include:

- Although the use of waste chutes can be convenient in medium- and high-rise buildings, the chutes can be easily blocked if wrong items, (e.g. uncrushed pizza boxes), are dropped into the system (see Appendix B2).
- Some premium medium- and high-rise new build residential developments may only act as a temporary place of residence for certain people, such as international investors. As these people come and go, they may not have the same understanding of waste and recycling at the development. This can have significant implications to the effectiveness of waste management practices at the development especially when using slightly more complex and rigid systems such as waste chutes or AWCSs (see Appendix B2).
- There has been a growing acceptance of Underground Refuse Systems (URS) and a rise in their use at developments as a response to residents' complaints about wheeled bins (see Appendix B3).
- In order for a successful scheme to work, waste generation and appropriate waste storage and collection for this waste should be considered in close conjunction. Without understanding waste generation properly, the development risks having too little waste storage space resulting in overflowing waste storage rooms or too much waste storage space resulting in inefficient land-use and loss of economic value due to inefficient space use (see Appendix B3).

5.3 Waste collection

The keys lessons related to waste collection include:

- Whilst local authorities may be supportive of alternative waste collection systems, such as AWCS and URS, it would require the development partner and its appointed managing agent to fund and manage collections from these systems for the life of the development (see Appendix B1).
- A barrier to the introduction of AWCS by developers in the UK is the ability to which a council tax rebate can be obtained from a WCA for managing household waste on its behalf (see Appendix B1).
- The retrofit of an AWCS in developments that currently use waste chutes may be possible upon further assessment. However, there may only be space to retrofit one AWCS inlet for all waste thereby discouraging recycling (see Appendix B7).
- Residents value well-managed communal recycling initiatives, which can generate a positive feedback loop, encouraging residents to participate in the schemes more effectively (see Appendix B3).

- High-rise community recycling schemes can achieve long-term viability of over 15 years, if managed properly. However, it requires appropriate technical management, a good level of resident participation, and appropriate governance in order to ensure long-term profitability for the scheme (see Appendix B4).
- For the success of a recycling scheme, waste collection should match the waste generation in an area and the relevant arrangements need to be made (see Appendix B5).
- Food waste collection schemes can be successful in large metropolitan areas, both in terms of the quantity of waste collected and customer satisfaction. This can be achieved through a gradual introduction, which involves well-designed stages which help to identify the baseline conditions and the main requirements of the development, as well as an appropriate public engagement campaign (see Appendix B6).
- The biggest barrier to food waste collection is financial. WCAs and WDAs should take a 'total budget' approach to balance higher food waste collection costs with savings from the disposal of less residual waste (i.e. food waste is not landfilled), which can make it economic to fund this initiative.

5.4 Waste treatment and disposal

The keys lessons related to waste treatment and disposal include:

- On-site treatment of organic waste, if managed properly, can be viable in the long-term at high-rise and high-density developments. This can be achieved through the choice of a waste collection system that matches the waste treatment system, through appropriate public engagement and through an appropriate level and frequency of maintenance (see Appendix B4).
- Good customer satisfaction and high recycling participation rates can both be closely correlated to low levels of contamination (up to less than 5%), which means that organic waste treatment processes, such as AD and composting can occur at more efficient rates (see Appendix B6).
- Food waste processing is feasible within a residential area if it can be managed underground and, in general, if measures are put in place to ensure that the waste is contained in such a way that odour and other health and safety issues are avoided (see Appendix B9).

6 Objectives and targets

6.1 Guiding principles

The guiding principles are based on the 'circular economy' (see **Figure 11**) and 'waste hierarchy' (see **Figure 12**), which govern the objectives, targets and the overall strategy for resource and waste management at Old Oak and Park Royal.

The guiding principles form the core values on which all future resource and waste management services and infrastructure decisions will be made.

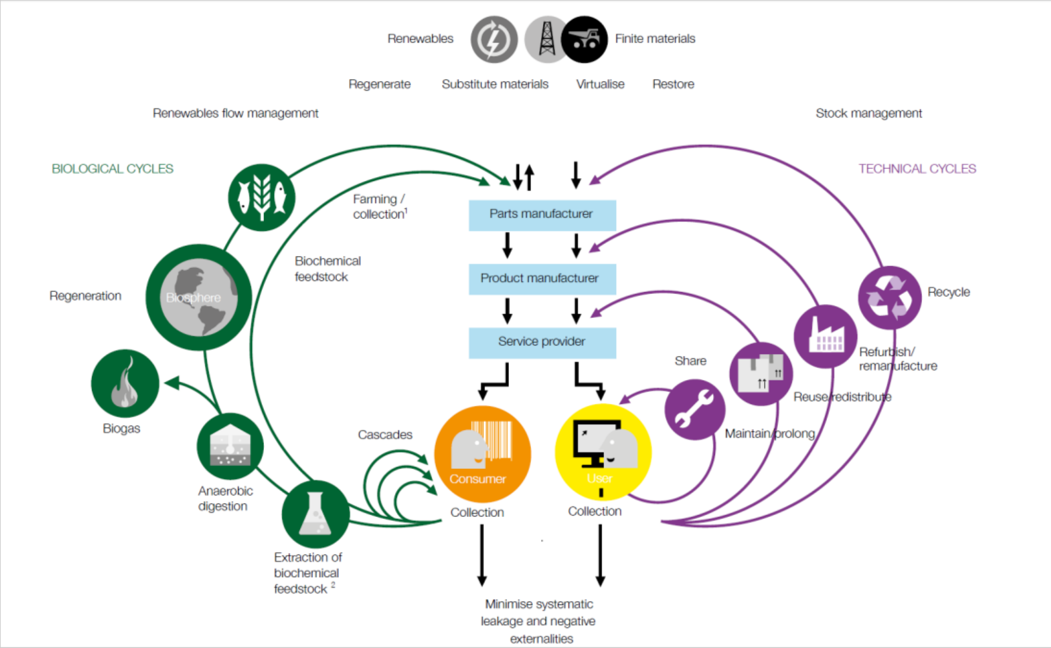

Figure 11: The circular economy[38]

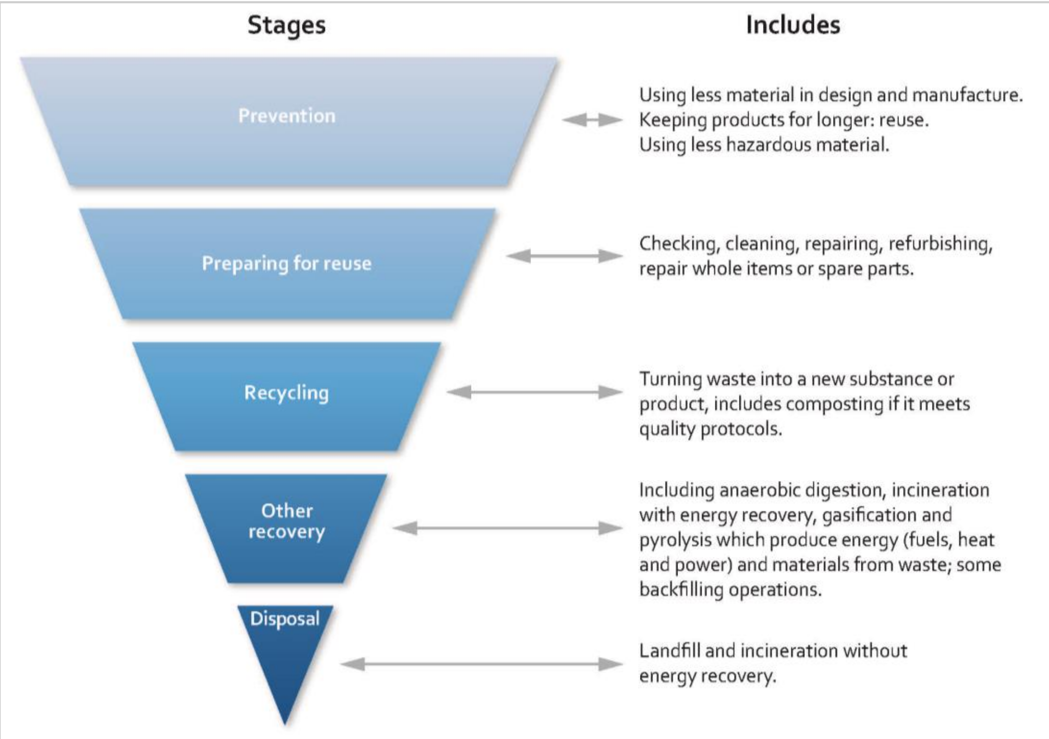

Figure 12: The waste hierarchy

[38] Adapted from Ellen MacArthur Foundation and McKinsey Center for Business and Environment; Adapted from Braungart & McDonough, Cradle to Cradle (C2C).

The proposed guiding principles include:

1. **Circular design and manufacture** – Products and buildings should be designed for easy reuse, disassembly, repair, remanufacture, refurbishment, and recycling. This enables products and buildings to be kept in use for as long as possible with their recovery and regeneration at the end of each service life thereby promoting closed loop materials and product flows. Circular design has a number of features including: modular design for disassembly but also so that different component parts can evolve separately, the use of less material, the use of fewer material types, the use of non-toxic materials and additive manufacture.

2. **Circular procurement** – Effective waste prevention reduces the quantity of waste requiring collection and treatment and is most likely to be achieved through a variety of measures, some of which relate to purchasing behaviour and are therefore best addressed through appropriate procurement strategies rather than waste management strategies. Examples include leasing assets, working with supply chains to minimise the use of packaging and minimising the import of products that are difficult to recycle or generate harmful emissions either during use or end-of-life.

3. **Source segregation** – To support closed loop material cycles, an appropriate source segregation strategy based on the likely quantities and types of waste to be generated and appropriate storage provision for the different materials streams is paramount to ensure uncontaminated materials are collected and processed. This ultimately results in a quality output material or product from the waste treatment process that is marketable and gets a good price on the commodities market.

4. **Reverse logistics** – This approach requires control to be maintained over materials and products throughout their lifecycle to ensure they keep re-entering the product or service economy. This can be done using effective storage, collection and transport systems that enable the capture of valuable resources, and can take the form of RRCs, recycling on-the-go, extended producer responsibility schemes, multi-modal transport (road, rail, water) etc.

5. **The food cycle** – Surplus food (before it becomes a waste) should be used in food sharing schemes, which can take the form of communal kitchens, casserole clubs, food banks etc. Food waste can then be processed into new useful materials and products such as animal feed, compost and proteins, or used in local renewable energy generation (see related bullet point below). Food waste should be captured and processed into compost for use as organic fertiliser to grow fruit and vegetables using urban farming techniques, which can then be distributed back into Old Oak and Park Royal, thereby facilitating a closed loop approach (a perfect virtuous cycle).

6. **Industrial symbiosis** – Industrial symbiosis is the exchange of materials or waste streams between companies, so that one company's waste becomes another company's raw materials. Exchanges can be made with solid, liquid and gaseous raw materials as well as surplus electricity, heat and water.

Companies must be willing to share information about their material inputs and waste outputs so that synergies between companies can be forged.

The benefits of industrial symbiosis include:

- Maximising use of materials by keeping materials or waste streams in use;
- Reduced depletion of primary resource reserves;
- Resilience against increasing volatile market prices of resources;
- Using waste to generate renewable energy for use on-site, sale to developments nearby or sale back to the grid; and
- Reduction in waste management costs.

7. **Local renewable energy generation** – The significant increase in development at Old Oak and Park Royal will increase the energy demand of the area. Local renewable energy generation from local waste materials such as organic waste, biomass and Refuse Derived Fuel (RDF), would provide a clean energy alternative to fossil fuel derived energy. It also helps to make maximum use of the waste generated in the area where reuse, repair and recycling are not possible. Where there are insufficient quantities of waste materials available to make local renewable energy generation economically viable, the development can look to other nearby developments and businesses for feedstock.

6.2 Objectives

The key objectives of this resource and waste management strategy is to achieve efficient use of material resources and to reduce the amount of waste produced from the proposed development. To actively contribute to the economic, environmental and social goals of sustainable development, waste must be dealt with in such a way that it encourages a circular economy (see **Figure 11**), whilst being guided by the waste hierarchy (see **Figure 12**).

6.3 Targets

The targets for resource and waste management at Old Oak and Park Royal are provided in **Table 4**.

Table 4: Targets for waste management performance in Old Oak and Park Royal

Management type	Construction phase	Operational phase	
	CD&E waste	LACW	C&I waste
Reuse and recycling	95%	40%	60%
Composting and AD	-	35%	25%
Diversion from landfill	98%	98%	98%

7 Waste forecast

7.1 Overview

A high level waste forecast has been developed to identify the likely quantities and types of waste that will be generated at Old Oak and Park Royal in both the construction and operational phases of the development. The waste forecast forms the basis of the proposed objectives, targets and waste management options for this strategy, which are set out in later sections of this report.

The full set of assumptions used to develop the waste forecast is provided in Appendix C.

7.2 Construction phase

During the construction phase of the development, CD&E waste would be generated by various construction activities taking place on-site. The construction waste forecast has not taken into account any CD&E waste being processed by waste management facilities located in Old Oak and Park Royal as the CD&E waste being processed may not necessarily have been generated in the development area. However, the proposed strategy should consider this CD&E waste as a potential resource.

The demolition waste that would be generated at Old Oak and Park Royal is based on the demolition schedule provided by OPDC[39]. **Table 5** provides the demolition waste generations rates used in the waste forecast, which are based on the type of building to be demolished.

Table 5: Demolition waste generation rates[40]

Type of building	Demolition waste generation rate (tonnes/m^3)
Steel frame	0.47
Structural concrete	0.48
Masonry	0.54

The construction waste that would be generated in the Old Oak and Park Royal development area is based on floor area of the new residential, office, retail and leisure developments that would be built over the development period as set out in the OPDC Phasing Trajectory (Version 5)[41]. **Table 6** provides the construction waste generations rates used in the waste forecast, which are based on development type.

[39] Provided by Tom Cardis (Head of Planning Policy, OPDC) via email on 8 August 2016.
[40] Waste & Resources Action Programme (2016), *Net Waste Tool - Demolition Bill of Quantities Estimator*, Available at: http://nwtool.wrap.org.uk/ToolHome.aspx (Accessed 11 October 2016).
[41] Provided by Tom Cardis (Head of Planning Policy, OPDC) via email on 4 August 2016.

Table 6: Construction waste generation rates[42]

Development type	Construction waste generation rate (tonnes/m^2)
Residential	0.168
Office	0.238
Retail	0.275
Leisure	0.216

Excavation waste has not been quantified due to the unavailability of information at such early stages of the project that this waste forecast has been developed.

It has been estimated that a total of 1,229,715 tonnes of waste would be generated during the construction phase of the Old Oak and Park Royal development comprising 633,991 tonnes (52%) of demolition waste and 595,724 tonnes (48%) of construction waste.

Demolition and construction waste quantities have been annualised based on an assumption that construction and demolition activities would take place equally each year between 2017 and 2049 (i.e. a 32 year timeframe)[43]. From this, it has been estimated that a total of 40,392 tonnes/annum of waste would be generated during the construction phase of the Old Oak and Park Royal development comprising 21,775 tonnes/annum of demolition waste and 18,616 tonnes/annum of construction waste.

Figure 13 and **Figure 14** illustrate the composition of annualised demolition and construction waste forecast, respectively.

Steel frame buildings would account for the majority (81%) of demolition waste generation, with the remaining waste generated equally by structural concrete buildings (9%) and masonry buildings (9%).[44]

[42] BRE (2012), *Waste Benchmark Data,* Available at: http://www.smartwaste.co.uk/filelibrary/benchmarks%20data/Waste_Benchmarks_for_new_build_projects_by_project_type_31_May_2012.pdf (Accessed 11 October 2016).
[43] The construction period has been assumed as 2017 to 2049 since the OPDC Phasing Trajectory (Version 5) has forecast that residential units will be available each year from 2018 to 2049.
[44] Percentages may not sum to 100% due to rounding.

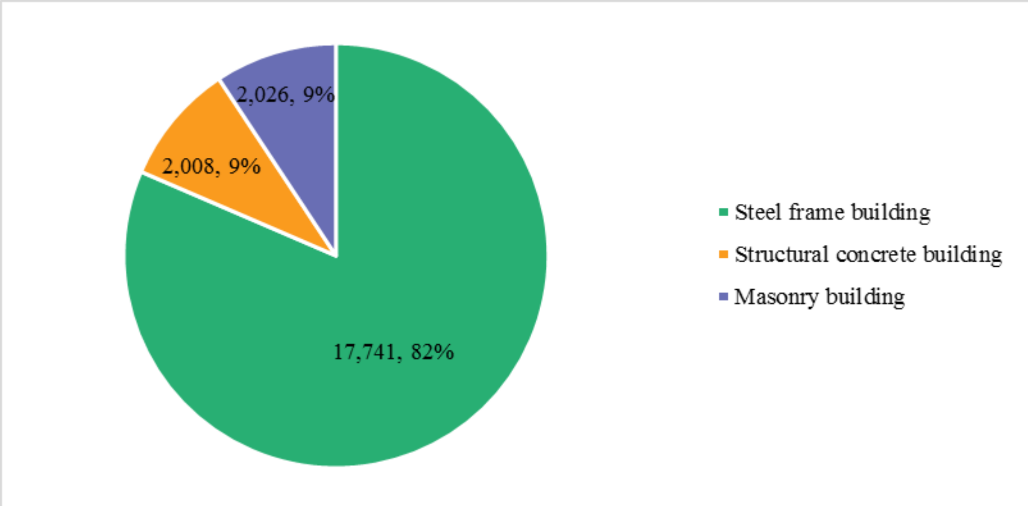

Figure 13: Demolition waste forecast (units: tonnes/annum, %)

Residential buildings would account for the majority (71%) of construction waste generation with office buildings representing about a quarter (26%) of construction waste generation. There would be small quantities of waste generation by the construction of retail buildings (2%) and leisure buildings (1%).

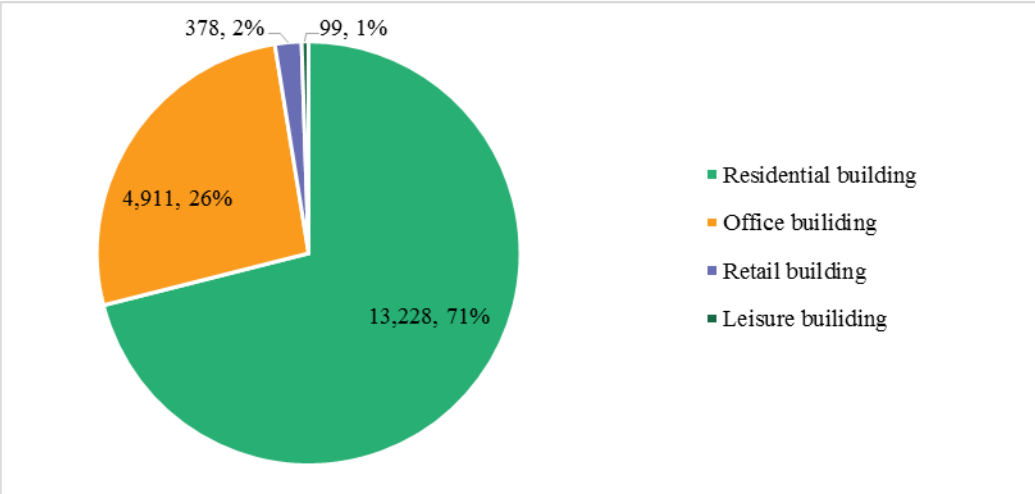

Figure 14: Construction waste forecast (units: tonnes/annum, %)

It should be noted that the quantities of demolition waste and construction waste will in fact vary each year depending on the planned construction activities for that year but in the absence of this information, the quantities have been assumed to be the same each year of the construction period.

7.3 Operational phase

7.3.1 Household waste

Household waste would be generated by the residential population of Old Oak and Park Royal, which is estimated as 75,053 in the first full year that the development is fully operational (i.e. 2050). A household waste generation rate of

0.303 tonnes/capita/annum has been used to forecast the quantities of household waste that would be generated[45]. The waste generation rate used represents the average household waste generation rate of LB Brent, LB Ealing and LB Hammersmith & Fulham, during the period 2011 and 2036.

The composition of household waste that would be generated has been modelled based on the national compositional estimates for LACW and recycling in England in 2010/11[46]. It has been assumed that the household waste composition would remain the same over the development period.

Therefore, it has been estimated that 22,755 tonnes/annum of household waste would be generated at Old Oak and Park Royal in the first year that the development is fully operational. **Figure 15** illustrates the composition of household waste forecast.

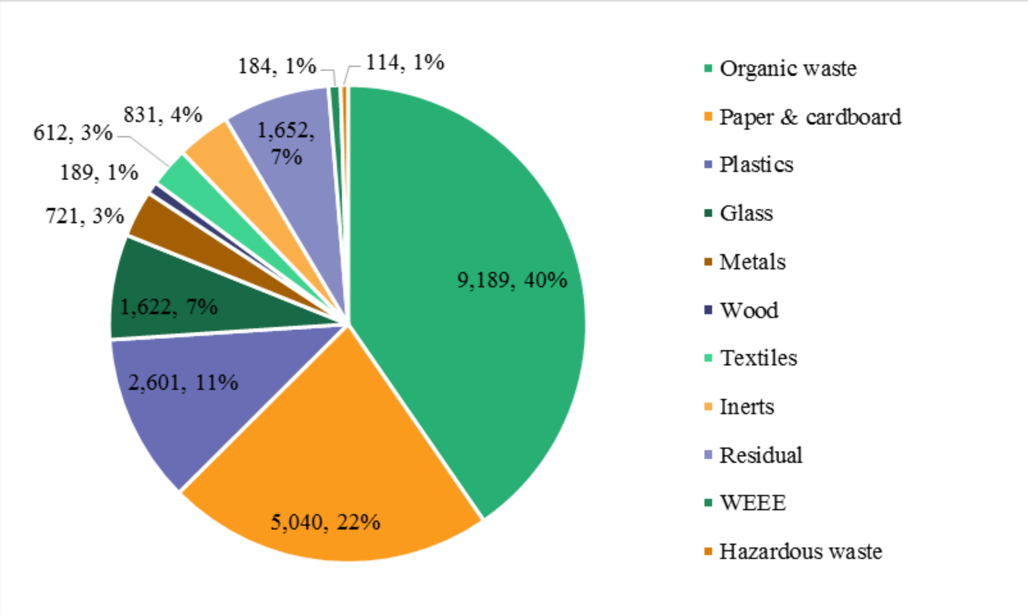

Figure 15: Household waste forecast (units: tonnes/annum, %)

Dry mixed recyclables[47] would represent the largest waste stream (44%) while organic waste would represent the single largest waste stream (40%). Other waste[48] and residual waste would account for almost equal proportions of the remaining waste (8% and 7%, respectively).[49]

[45] Greater London Authority and SLR Consulting (2014), *Waste Arisings Model: Further Alterations to the London Plan*.
[46] Resource Futures (2013), *Defra EV0801 National Compositional Estimates for Local Authority Collected Waste and Recycling in England 2010/11 - Household Waste Composition*. Available at: http://randd.defra.gov.uk/Document.aspx?Document=11715_EV0801ReportFINALSENT05-12-13.pdf (Accessed 11 October 2016).
[47] Paper & cardboard, plastics, glass and metal.
[48] Wood, textiles, inerts, WEEE and hazardous waste.
[49] Percentages may not sum to 100% due to rounding.

7.3.2 Commercial and industrial waste forecast

C&I waste would be generated by businesses and institutions located in Old Oak and Park Royal. It is estimated that there would be total employee population of 107,100 in the first full year that the development is fully operational (i.e. 2050). A C&I waste generation rate of 0.906 tonnes/employee/annum has been used to forecast the quantities of waste that would be generated by businesses, institutions and industry.[50] The waste generation rate used represents the average C&I waste generation rate in London during the period 2016 and 2036.

According to Defra[51], the various C&I waste streams can be defined as:

- Animal and vegetable waste – food, manure, and other animal and vegetable wastes;
- Chemical waste – solvents, acids/alkalis, used oil, catalysts, wastes from chemical preparation, residues and sludges;
- Common sludges – sludges (common) and dredging wastes;
- Discarded equipment – end of life vehicles (ELVs), batteries and WEEE;
- Healthcare waste – healthcare wastes;
- Metallic waste – metallic wastes;
- Mineral waste – combustion residues, contaminated soils, solidified mineral wastes and other mineral wastes;
- Non-metallic waste – glass, paper and cardboard, rubber, plastic, wood and textiles; and
- Non-waste – blast furnace slag and virgin timber i.e. materials that, at the time of publishing the document, were recently declassified as wastes. They were chosen to be recorded by Defra for comparability with previous C&I waste composition surveys.

The composition of C&I waste that would be generated has been modelled based on the average C&I waste generated in LB Brent, LB Ealing and LB Hammersmith & Fulham in 2009, as the latest available data.[52] It has been assumed that the C&I waste composition would remain the same over the development period. It should be noted that the actual C&I waste composition may consist of a higher proportion of organic waste (mainly food waste), as a large number of food manufacturing businesses are located in the Park Royal

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[50] Greater London Authority and SLR Consulting (2014), *Waste Arisings Model: Further Alterations to the London Plan*.
[51] Department for Environment, Food & Rural Affairs (2010), *Survey of Commercial and Industrial Waste Arisings 2010 – Interim Results*, Available at: http://webarchive.nationalarchives.gov.uk/20130123162956/http:/www.defra.gov.uk/news/files/2010/11/1011stats.pdf (Accessed 27 October 2016).
[52] Defra (2009), *Defra Survey of Commercial and Industrial Waste Arisings - Report Tables*, Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/400578/env20-ci-data-tables.xls (Accessed 11 October 2016).

Industrial Estate, compared to the average in each of the three London boroughs under consideration.[53]

Therefore, it has been estimated that 97,053 tonnes/annum of C&I waste would be generated at Old Oak and Park Royal in the first year that the development is fully operational. **Figure 16** illustrates the composition of C&I waste forecast.

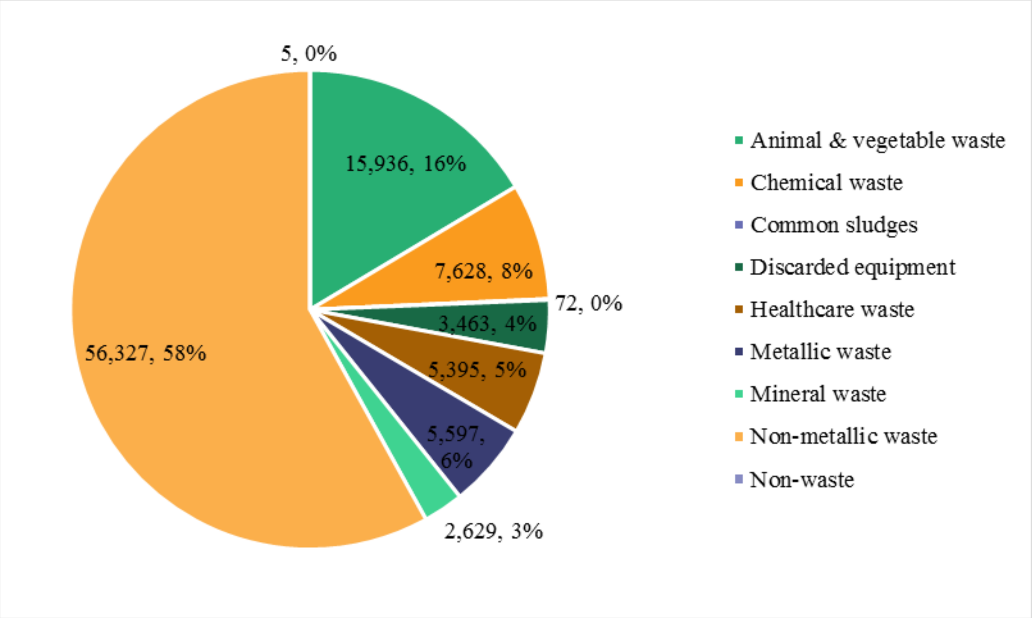


Figure 16: C&I waste forecast (units: tonnes/annum, %)

Non-metallic waste would represent over half of the C&I waste generation (58%) with the animal & vegetable waste representing the next largest proportion of waste generation (16%). Chemical waste would account for half of the animal & vegetable waste generation (8%). Metallic waste, healthcare waste, discarded equipment and mineral waste would make up the bulk of the remaining waste (6%, 5%, 4% and 3%, respectively) with common sludges and non-waste accounting for negligible quantities (<1%).

The C&I waste forecast should be updated as and when real data about waste generation from existing businesses and information about future business land uses becomes available.

[53] Food waste in food and drink manufacturing makes up approximately 78% of total waste. Source: Waste and Resources Action Programme (2013), *Estimates of Waste in the Food and Drink Supply Chain*, Available at: http://www.wrap.org.uk/sites/files/wrap/Estimates%20of%20waste%20in%20the%20food%20and%20drink%20supply%20chain_0.pdf (Accessed 31 January 2017).

8 Resource and waste management options

8.1 Overview

Options for managing waste generated in the construction phase and the operational phase that would assist the development in meeting the objectives and targets are described below.

8.2 Waste prevention and reuse

8.2.1 Construction phase

Designing out waste

The use of materials resource efficiency measures and the reduction of waste can significantly contribute to reducing the environmental impacts of construction. The five principles of 'designing out waste' set out by the Waste & Resources Action Programme (WRAP)[54] provide a comprehensive list of measures to think about implementing:

1. **Design for reuse and recovery** – use of existing materials, structures or components that can be reused/recycled onsite, incorporating site-won materials into design elements, use of materials and components with a recycled content, use of locally available materials and components of sufficient quality and reasonable costs.
2. **Design for off-site construction** – off-site manufacture or prefabrication of design elements, offsite assembly of design elements and use of assembly operations onsite over construction operations.
3. **Design for materials optimisation** – site layout optimisation techniques, consideration of the position and levels of built structures, optimising pile dimensions for specific buildings, simplification of various aspects (e.g. design, building form, structural systems, building services, construction sequence/methodology, layout etc.), lightweight structures, reduction of material use, specific construction methods that maximise opportunities for materials optimisation, using standard dimensions for design elements, repetition and co-ordination of design across the design elements to reduce variables, avoid/minimise excess cutting and jointing of materials that generate waste, use of standardised materials and components to encourage reuse of off-cuts.
4. **Design for waste efficient procurement** – project specifications that been select elements/components/materials and construction processes that reduce waste or have reduced wastage rates, incorporation of key performance

[54] Waste & Resources Action Programme (undated), *Designing out Waste: A Design Team Guide for Buildings*, Available at: http://www.modular.org/marketing/documents/DesigningoutWaste.pdf (Accessed 26 October 2016).

indicators and targets in the procurement specification handbook, optimisation of construction methods and logistics practices, use of supplier take-back schemes.

5. **Design for deconstruction and flexibility** – considering which design elements may require flexibility/adaptability for future uses, potential 'over-specification' at front-end to accommodate increase in future provision (e.g. services), maintained requirements that do not create an excessive amount of waste, incorporating components and materials that can be recovered for reuse or recycling at end-of-life, specifying building elements/components/ materials for easy disassembly, understanding current material and component attributes that would facilitate future reuse, use of Building Information Modelling (BIM) to record which and how elements/ components/materials have been designed for disassembly.

Designing out waste measures should be explored and agreed early in the design phase of the development for effective implementation. The benefits that can be achieved through designing out waste measures include:

Cost savings associated with waste prevention and reuse of existing materials;

- Wider resource efficiency (e.g. energy, water, transport, sustainable procurement, labour productivity and carbon savings);
- Cost and programme efficiencies; and
- Opportunities for use of innovative construction processes and materials.

8.2.2 Operational phase

Public engagement campaigns

Waste prevention and reduction is partly a behavioural issue. Suggested public engagement campaigns targeting waste prevention and reduction may include educational leaflets, emails, localised social media campaigns and workshops at community meetings. Effective awareness campaigns often focus on a specific waste stream and offer practical, easy to follow guidance on waste preventing actions. In support of awareness-raising activities, targeted information on waste prevention techniques should be made available to specific users, such as households, businesses, organisations and industries who have specific needs for particular types of guidance, tools and resources. Early involvement in the process is very important in order to secure ownership of the programme.[55]

Examples of specific waste prevention and reuse campaigns include:

- Food waste prevention;
- Promoting the use of reusable nappies;

[55] European Commission (2012), *Preparing a Waste Prevention Programme*, Available at: http://ec.europa.eu/environment/waste/prevention/pdf/Waste%20prevention%20guidelines.pdf (Accessed 19 December 2016).

- Buying reused and repaired items;
- Home composting;
- Stop junk mail;
- Community clothes swaps;
- Using reusable bags;
- Using charity shops; and
- Smart shopping.

Circular procurement

A strategy should be created on the circular procurement of goods and services within the development. This should begin at the level of public procurement – the buying of works, goods or services by public bodies – as a great lever of boosting circular procurement since it is in the public eye. Examples of circular public procurement include setting waste prevention criteria through tenders; leasing assets based on performance based contracts that promote efficiency; purchasing low-emission buses for better air quality; using low-impact materials for buildings and roads; and buying toxic-free cleaning products. This requires political commitment for effective implementation.[56]

Circular procurement for private businesses could be facilitated by policies that mandate, for example, eco-design requirements for certain products and purchasing a certain percentage of reused products.

Reuse and repair centres

Reuse and repair centres seek to extend the life of a range of consumer products and then redistribute them to individuals or organisations in close proximity that have a need for them. Furniture and electrical items potentially offer the most opportunities for reuse as they already have an existing second hand market. Also, they can often be easily transported, making them accessible waste product streams.

As well as businesses, the centres can be operated by social enterprises working to integrate the long-term unemployed who are trained or can be easily trained in technical repair skills, thus also serving as a social function.

Community sharing platform

A community sharing platform would allow people to lend and borrow underutilised household items such as power tools and surplus food. The platform could be a mobile phone application. Examples of existing community sharing platforms include Globechain, Nextdoor and Streetbank.

[56] European Commission (2016), *Green Public Procurement Drives the Circular Economy*, Available at: https://ec.europa.eu/environment/efe/themes/economics-strategy-and-information/green-public-procurement-drives-circular-economy_en (Accessed 19 December 2016).

Industrial symbiosis platform

Industrial symbiosis can be facilitated through the use of online sharing economy platform, which essentially matches unwanted resources from one business with resource requirements of another business. An example of an existing industrial symbiosis platform is 'Share Peterborough'. It was created by Peterborough Council to enable local organisations to exchange goods and services that are underused or no longer needed, to promote local organisations and to build a collaborative business community in the city.

8.3 Waste segregation

8.3.1 Construction phase

The types of CD&E waste materials generated vary from construction project to another. The construction contractor should develop the exact segregation strategy to be followed using their knowledge of the project.

A seven-stream segregation strategy should be implemented in line with previous guidance from the Institution of Civil Engineers:

1. Inert waste – concrete, broken asphalt, bricks, blocks, soils etc.;
2. Metals – ferrous and non-ferrous;
3. Wood;
4. Plasterboard;
5. Packaging materials (plastics and cardboard);
6. Mixed waste – similar to household waste; and
7. Hazardous waste.

There should be no mixing of inert, non-hazardous and hazardous waste, either whilst stored on-site or upon collection.

8.3.2 Operational phase

A four-stream waste segregation strategy should be implemented as a minimum in all buildings, with a two-stream waste segregation strategy for public realm. A consistent approach to source segregation should facilitate recycling in the development area.

The four-stream waste segregation strategy in all buildings comprises:

1. Organic waste – food waste and occasionally green waste from the maintenance of on-site landscaped areas;
2. Dry mixed recyclables – paper and cardboard, plastic, glass and metals, which are predominantly free of food and liquid contamination;
3. Residual waste – non-recyclables; and
4. Hazardous waste.

Where appropriate, households may need to source segregate bulky waste such as broken furniture and white goods. The weight and volume of this waste stream would necessitate a separate collection by the local authority. For similar reasons, businesses may also source segregate cardboard (from warehouses), glass (from restaurants) and used cooking oil (from commercial kitchens) as individual streams.

To maximise the recycling performance at Old Oak and Park Royal, a segregation strategy that sees six or more waste streams segregated could be adopted by certain businesses and organisations where the generation of a single waste material stream is likely to be high. Potential segregation strategy options for households, and various businesses and organisations is provided in **Table 7**.

Table 7: Segregation strategy options

Designated land use	Segregation strategy	Advantages	Disadvantages
Households	1. Organic waste 2. Dry mixed recyclables 3. Residual waste 4. Bulky waste 5. Hazardous waste	Day-to-day waste segregation is kept to a manageable three streams	Separate collections for bulky waste and hazardous waste need to be organised by the household with the local authority using their ‘on demand’ service
Restaurants	1. Organic waste 2. Dry mixed recyclables (excluding glass) 3. Glass 4. Residual waste 5. Hazardous waste 6. Cooking oil	Recycling can be optimised by having a separate glass waste bin and can help moderate problems associated with storing glass with other recyclables	A separate collection needs to be organised for the glass and cooking oil waste streams
Offices	1. Organic waste 2. Dry mixed recyclables 3. Confidential waste 4. Residual waste 5. Bulky waste 6. WEEE 7. Batteries 8. Toner cartridges	It is advised to securely destroy confidential media to mitigate risks associated with fraud	Confidential waste treatment is often more expensive compared to dry mixed recyclable treatment
Hospitals[57]	1. Infectious clinical 2. Offensive waste 3. Non-medicine contaminated sharps 4. Medicine contaminated	Safe segregation strategy that also seeks to reduce waste management costs by using the	Too many waste streams can be confusing leading to contamination

[57] The Department of Health offers guidance on healthcare waste management through the following key document: Department of Health (2014), *Health Technical Memorandum (HTM) 07-01: Safe Management of Healthcare Waste,* Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/167976/HTM_07-01_Final.pdf (Accessed 19 December 2016).

Designated land use	Segregation strategy	Advantages	Disadvantages
	sharps 5. Cytotoxic & cytostatic waste 6. Medicine waste 7. Medicine contaminated infectious clinical waste 8. Municipal waste	classification of ‘offensive waste’ rather than classifying all waste as ‘infection waste’, which requires lower thermal treatment temperatures	

The two-stream waste segregation strategy in the public realm comprises:

1. Dry mixed recyclables – paper & cardboard, plastic, glass and metals; and
2. Residual waste – all other waste.

8.4 Waste storage, collection and transfer

8.4.1 Construction phase

CD&E waste should be stored in appropriate receptacles or designated storage areas to protect them from damage and to avoid contamination, making each material available for recycling or recovery should this be an option. Some typical types of storage containers are shown in **Figure 17** below. Each container must be appropriate for the waste it contains and be clearly labelled to facilitate the source segregation of waste. It is important to use signage that can be recognised through images to account for the multi-lingual workforce and ensure they are universally comprehendible.

Figure 17: Typical site waste storage containers

It is also necessary to have designated storage areas for excavated material as shown in **Figure 18**. Excavated material, which is surplus to requirements, should be stockpiled on-site without intermixing with other materials to avoid contamination. This can be achieved by using dividers or setting the stockpiles sufficiently apart. The movement of excavated material should be kept to a minimum to avoid double handling.

Figure 18: Examples of stockpiled materials

Potentially dangerous materials such as contaminated excavated material should be appropriately stockpiled or stored in appropriate containers e.g. with the appropriate seals, drainage provisions and signage. Any potentially hazardous waste should be segregated, stored and transferred to an appropriate treatment or disposal facility. **Figure 19** provides examples for hazardous waste storage receptacles.

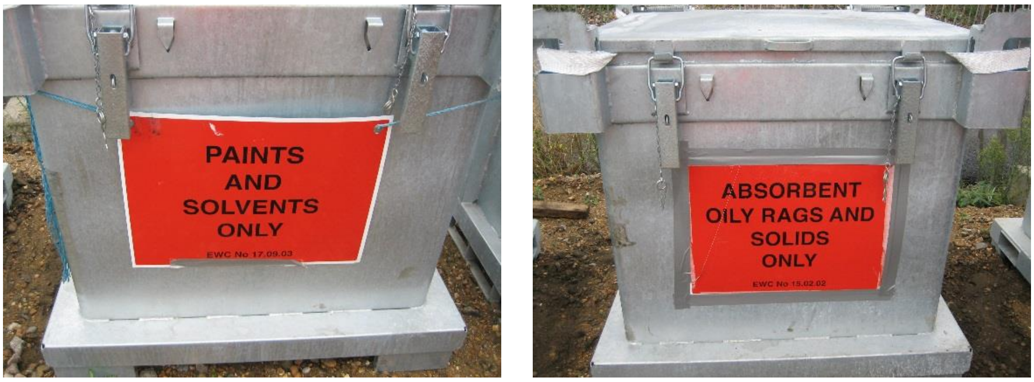


Figure 19: Example containers for hazardous waste storage

All skips and storage receptacles should be sheeted, or otherwise remain lidded or closed, during times when waste is not being deposited into them. They should also be covered to prevent the escape of waste whilst in transit and loaded for maximum payload efficiency.

All skips and storage receptacles should be inspected periodically to ensure they are fit for purpose. Skips and storage receptacles that are not fit for purpose should be taken out of use immediately with appropriate signage used to signify that they should not be used.

Plastic sheeting should be used to prevent leaching from waste soils and aggregates where these are not contained within skips or other storage receptacles.

8.4.2 Operational phase

The appropriate design of waste storage and collection facilities will facilitate the recovery of recyclables and enable efficient waste management at Old Oak and Park Royal. It will also avoid negative environmental impacts associated with poor waste storage such as overflowing waste bins, the need for frequent waste collection, odours, pests and litter.

There are a number of options for the storage, collection and transfer of waste and recyclables from within buildings and the public realm.

To assist the source segregation of waste, all bins should be colour-coded and labelled (text and images) consistently across Old Oak and Park Royal. This will help to produce high quality recyclables without contamination.

Table 8: Waste storage, collection and transfer options in buildings

Strategy	Description	Advantages	Disadvantages
Manual	Occupants take their waste down in a lift to a central waste storage room containing Eurobins (typically 1,100 litre in capacity) to store waste in	• Does not require facilities management to collect waste	• The time and distance occupants may have to travel to the central waste storage rooms may discourage source segregation of waste and result in low recycling rates
Manual + Facilities management	Occupants take their waste to waste storage rooms located on each floor. Facilities management periodically transport this waste via a service lift and/or waste chutes to a central waste storage room containing Eurobins or waste compactors	• Facilities management can inspect the waste and recyclables and ensure waste is being disposed of in the correct bins • Potential use of facilities management to inspect and improve source segregation	• The waste storage rooms on each floor may cause odour, pest and vermin issues • Higher service charge to cover the cost of facilities management
Facilities management	Facilities management collect waste from every occupant and take down the waste in a service lift and/or waste chutes to a central waste storage room containing Eurobins or waste compactors	• Does not require occupants to go down to a central waste storage room • Facilities management can educate occupants on source segregation if they are not doing this correctly	• Labour intensive • Inefficient if occupants are not available to transfer the waste to facilities management • Higher service charge to cover the cost of facilities management
Waste chutes	Occupants dispose of waste down waste chutes with inlets located on each floor of a building. The waste chutes, which are connected to each floor, take the waste to a central waste storage room where waste is stored in containers or waste compactors. **Figure 20** provides a schematic of a waste chute. There are different ways that waste chutes can be designed: 1. Separate chutes for different waste and recyclable streams - the appearance of the chute inlets and accompanying signage should clearly indicate the differences between the chutes in order to maximise recycling and minimise contamination. 2. A bi-separator or tri-separator chute - this is one chute with a separator at the base, which residents control via a button at the chute inlets, depending on the waste stream they are disposing of. The separator determines where the waste	• Does not require facilities management to collect waste • Does not require occupants to go down to a central waste storage room	• Three-stream segregation that all use different waste chutes would require a larger core and therefore use up valuable building space • Blockages from occupants disposing of oversized items • Occupants may have to wait to use bi-separator or tri-separator waste chute systems due to delays caused by the diverter valves. Occupants may want to dispose of their waste as soon as possible and therefore

Strategy	Description	Advantages	Disadvantages
	stream is diverted at the base of the system. Waste chutes should be designed in accordance with BS 1703:2005 Refuse Chutes and Hoppers – Specification.		• Regular cleaning requirements, especially of the organic waste chute, to avoid odour, pest and vermin issues • Confusion over which button to press when using a bi-separator or tri-separator chute may lead to incorrect disposal of waste in the containers at the bottom of the waste chute
AWCS	Occupants dispose of waste at AWCS inlets located in each floor of a building. The AWCS takes the waste to a central waste collection station for compaction. The central waste collection station can also receive waste from other parts of the development. **Figure 21** provides a schematic of an AWCS. The AWCS transports waste from each floor of a building or complex of buildings pneumatically through a set of pipes. The system comprises a series of waste inlet points, linked together by a network of pipes that transports the waste to a central waste collection station for compaction and storage. A typical AWCS might have three inlet points, each one of them accepting one of three waste streams such as organic waste, dry mixed recyclables and residual waste. When waste is deposited into a waste inlet point, it is temporarily stored in a short section of pipe on top of a discharge valve. All of the full waste inlets connected to the central waste collection station are automatically emptied at regular intervals. A computer control system switches on fans, located in the central waste collection station, and a vacuum is created in the pipe network. An air inlet valve is opened to allow transport air to enter the system.	• Does not require facilities management to collect waste • Does not require occupants to go down to a central waste storage room • Reduces the amount of space required for waste storage in buildings and provides an improved street layout due to a reduced need for external storage space • Reduced waste-related transport movements and associated local transport carbon dioxide and particulate emissions • Contained system reduces noise and odour emissions and provides improved pest and vermin control	• Does not deal with bulky waste (e.g. old mattresses, furniture, white goods, large cardboard), liquid or hazardous waste • No glass collection on its own but it can be included in dry mixed recyclables • High capital expenditure compared to other systems

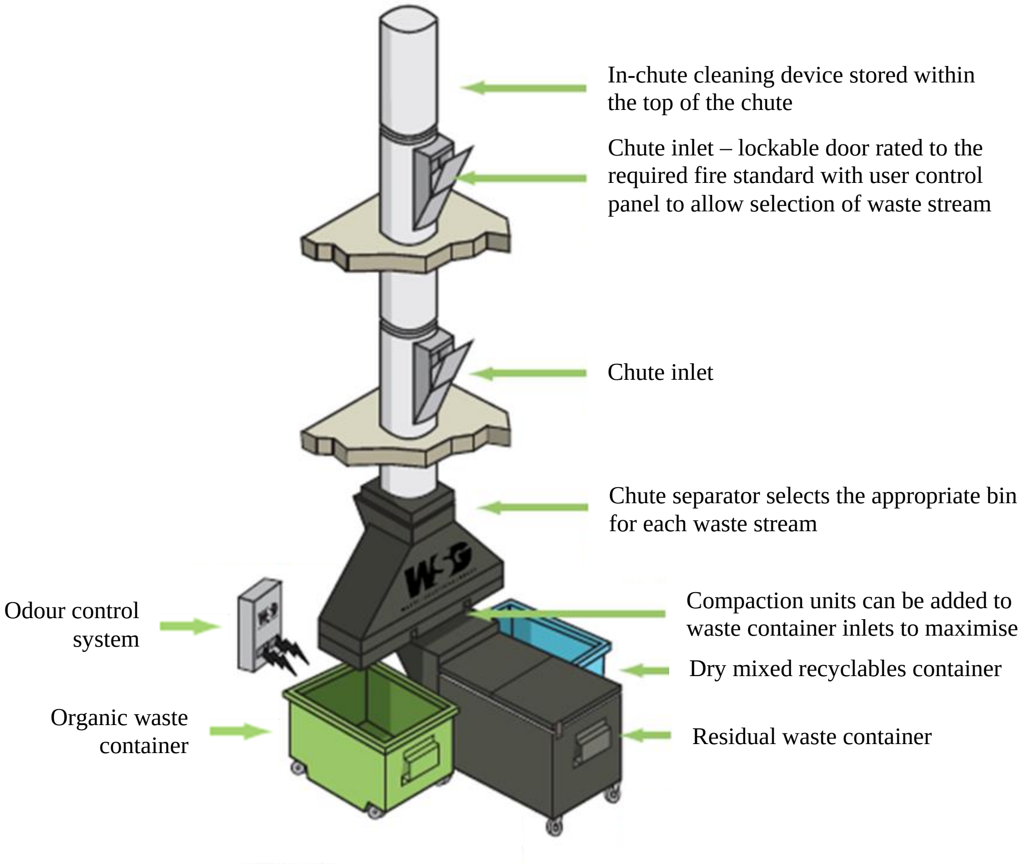


Figure 20: Schematic of a waste chute (source: WSG)

Figure 21: Schematic of an AWCS (source: Ros Roca)

Stationary bins

Waste storage receptacles will be required in the public realm to capture waste generated by passers-by. Examples of multi-stream bins that support a two-stream waste segregation strategy is shown in **Figure 22**. These can vary in size, shape and colour.

Figure 22: Examples of multi-stream public realm bins

Solar bin compactors

In public realm areas, where high volumes of waste are predicted to be generated but where the number of waste movements need to be minimised, solar bin compactors can be used to maximise waste storage capacity.

Solar bin compactors, such as those manufactured by 'Big Belly'[58], contain a solar photovoltaic module, which powers a 12 volt battery that drives the internal compaction system. Each unit only requires the same footprint as a standard litter or recycling bin but can hold up to five times more waste due to the compaction technology used (see **Figure 23**).

Figure 23: Examples of solar bin compactor

Volume sensors within each unit use cloud connectivity to notify street cleansing teams when units are full and need emptying. This makes the technology particularly suitable for use in public thoroughfares where litter and recycling bins are liable to fill quickly but where there is a desire to minimise collection

[58] Big Belly (2016), *Homepage*, Available at: http://bigbelly.com (Accessed 13 December 2016).

frequencies. This also helps in scheduling efficient collections and reducing the overall carbon footprint of the collection service.

Various capacity options are available according to the scenario in which they will be used. For example, Big Belly offers a 'standard' 190 litre bin or 'high capacity' 570 litre bin. Units are modular and can be configured to suit the segregation strategy used. **Figure 24** shows the varying configurations and dimensions of a solar bin compaction system.

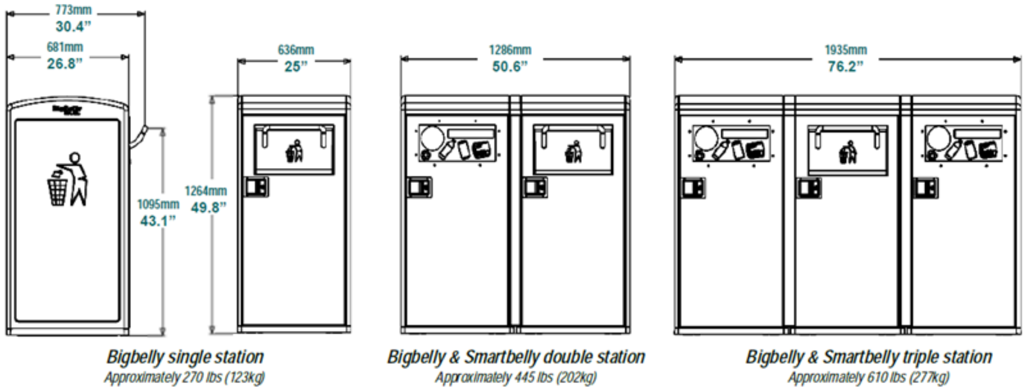


Figure 24: Configurations and system dimensions of solar bin compactors (source: Big Belly)

Underground refuse system

In public realm areas, where high volumes of waste are predicted to be generated but where the number of waste movements need to be minimised, underground refuse systems (URS) can also be used to maximise waste storage capacity.

A URS is a concealed, below-ground facility for the storage and collection of waste. The underground unit consists of a pre-fabricated concrete casing into which fits a large steel or plastic container. The underground unit as a whole is then concealed beneath a walk-on platform onto which the above ground street furniture receiver unit (known as the column) is mounted.

The unique feature of the URS is its ability to provide a large underground waste storage capacity with a small-above ground footprint. This allows more material to be stored than a simple above ground system.

There are two main types of URS available (crane lift system and hydraulic lift system), the key difference being the way in which the underground storage container is lifted out of the ground to be emptied. In a crane lift system, the entire above-ground unit (column and walk-on platform) is lifted out of the ground along with the underground storage container. In a hydraulic lift system, the underground storage container is raised out of the ground on a hydraulic platform and emptied using either a rear-loading (for wheeled containers) or side-loading (non-wheeled containers) refuse collection vehicle (RCV). Examples of each type of system are shown in **Figure 25**.

Figure 25: Examples of URS (left: crane lift system, middle: rear-loading hydraulic lift system, right: side-loading hydraulic lift system)

Consolidation centres

A waste consolidation centre aggregates waste materials from a number of sources. The centres function will be to consolidate collected materials into loads which make it economic for onward transportation. Consolidation may be by mechanical means e.g. compaction or baling, or simply the aggregation of loose material in bays. All operations will take place in climate controlled buildings operating under negative pressure to minimise fugitive odour emissions.

The waste consolidation centres can be located on major through-roads that will allow large goods vehicles to access the centres and collect consolidated loads of material without having to access sensitive areas. Alternatively, the consolidation centres can be located adjacent to rail networks.

Consolidation centres can be coupled with goods delivery centres where there are opportunities to employ reverse logistics.

8.5 Resource recovery

8.5.1 Construction phase

lists a variety of CD&E waste treatment processes that are potentially feasible. There may also be other appropriate technologies depending on the CD&E waste materials generated. These will make each waste material available for recycling should an off-site recycling facility become available. In addition most forms of treatment will reduce the volume of the waste and therefore make it more efficient to handle and remove from site.

Table 9: Construction phase resource recovery technologies

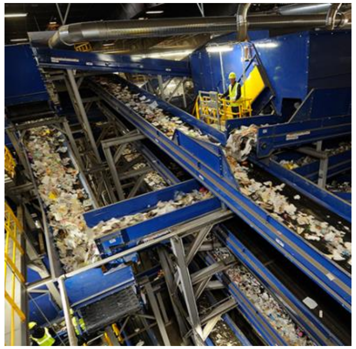
Technology	Description
Construction waste materials recovery facility 	A process where mixed construction and demolition waste materials are sorted into individual materials (e.g. wood, metals, soils, stones and plastics) based on their size, shape, density, electromagnetic properties and other characteristics as they are carried along a series of conveyor belts using various mechanical sorting equipment such as trommel screens, ballistic separators, electromagnetic separators and air classifiers. The facilities can be configured to produce RDF from the combustible components. Some materials may be able to be directly reused while others may require further processing.
Aggregate screening and crushing 	A process where mixed aggregates are screened and sometimes crushed into different particle sizes for appropriate reuse or incorporation in new materials by the construction industry.
Wood chipping 	A process where waste wood is shredded into woodchips for sale to the biomass and composite board industries.
Metals recovery 	For any demolition of composite structures such as reinforced concrete, metal can be separated from other materials using site machinery e.g. specialist steel claws to segregate rebar or magnets to collect ferrous metals. Machines with magnets can also be used to separate ferromagnetic metals. Metals can be sold to scrap metal dealers.

8.5.2 Operational phase

Table 10 provides a summary of resource recovery technologies available for non-hazardous waste generated in the operational phase of Old Oak and Park Royal. Although some technologies are currently less proven than others, the long-time scales of the development may bring about technological advancements from new research and development such that these technologies become feasible resource recovery options in the future.

Hazardous waste treatment can involve biological, physical, chemical and thermal processes as well as specialist disposal. The precise treatment process required would depend on the nature of the hazardous waste.

Table 10: Operational phase resource recovery technologies

Technology	Description	Advantages	Disadvantages	Reliability
Materials recovery facility 	A process where mixed materials are sorted into individual material streams based on their size, shape, density, electromagnetic properties, colour and other characteristics as they are carried along a series of conveyor belts using various mechanical sorting equipment such as trommel screens, electromagnetic separators and optical separators. 'Clean' MRFs process dry mixed recyclables. 'Dirty' MRFs process mixed waste.	• Facilitates closed loop material cycles • Highly adaptable to local waste composition • Facilities tend to be modular making them easier to adapt should feedstock quantities change over time or if new technologies permit additional materials to be separated and recycled	• 'Clean' MRFs rely on good source segregation of dry mixed recyclable from other waste to ensure quality output material streams • Market value of recyclables and the associated business case of material recovery facilities are sensitive to secondary material market commodity price fluctuations	• Status: commercial scale • Proven with several thousand facilities globally
Mechanical biological treatment 	The process combines mechanical sorting to extract recyclables and separate out an organic fraction for biological treatment. The biological treatment can be biodrying, composting or anaerobic digestion, depending on the desired output (either RDF, compost like output or biogas).	• Allows for the recovery of recyclables from mixed waste that have not been source segregated and separately collected • The facility can be configured to produce a high-calorific RDF for thermal treatment to generate energy • Modular facilities making them easier to adapt to changes in feedstock or if new technologies permit additional materials to be separated and recycled	• Quality of recyclables derived from the process are typically of a lower quality than those separated at source, and therefore typically have a lower resale value • RDF has a negative value on the commodities market • Odour and vermin needs to be carefully managed to avoid causing nuisance	• Status: commercial scale • Proven over the past 20 years with over 300 facilities in Europe alone • A variety of process configurations available with different mechanical and biological treatment components

Technology	Description	Advantages	Disadvantages	Reliability
Mechanical heat treatment 	A process where residual waste is 'pressure cooked' in a sealed vessel (typically autoclaves) using heat and pressurised steam. The resulting drier waste then undergoes mechanical sorting to extract recyclables and separate out a fibrous biomass fraction.	• Allows for the recovery of recyclables from mixed waste that have not been source segregated and separately collected • The fibrous biomass fraction can subsequently undergo anaerobic digestion or thermal treatment to generate energy • Heat treatment sterilises the waste, which reduces its odour and also kills pests, pathogens and viruses	• Some plastics are deformed by the heat of the process, potentially making them more difficult to recycle in some cases • It is perceived as a new technology and project bankability is uncertain	• Status: commercial scale • Proven over the past 10 years with several facilities operational in Australia, Europe and the USA but they have a limited track record • Component technologies are relatively simple, with autoclaving used to treat hospital waste and animal rendering waste for many years
Aerobic composting 	This involves the natural decomposition of organic waste by microorganisms in the presence of oxygen, which generates compost that can be used as an organic substitute to chemical fertilisers or as a soil conditioner. The two main types of aerobic composting include windrow composting and in-vessel composting.	• The compost product contains valuable nutrients that enhance soil quality and aid plant growth • In-vessel composting takes place in an enclosed vessel, which enables greater process control and higher operating temperatures making it suitable for composting food waste	• Odour and leachate issues may arise if the treatment process is mismanaged • The compost product may not be marketable if the there is no demand for it • Windrow composting is suited for rural areas as it requires a large area for operations to take place • Windrow composting is only suitable for processing green waste	• Status: commercial scale • Proven with several thousand facilities globally
Anaerobic digestion	This involves the decomposition of organic material in the absence of oxygen using anaerobic microorganisms under controlled conditions. It is suitable for processing all types of organic waste. The process generates biogas and a digestate. The biogas	• A variety of organic wastes can be processed • The process is energy self-sufficient • The process is energy self-	• Requires good source segregation of organic waste from other waste materials to increase the efficiency of the process and to produce a high	• Status: commercial scale • Proven with several thousand facilities globally • Relatively simple

Technology	Description	Advantages	Disadvantages	Reliability
	can be used in combined heat and power (CHP) plants to generate heat and electricity. Alternatively, the biogas can be upgraded to natural gas quality and used as a vehicle fuel or injected into a gas distribution network. The digestate can be used as an alternative to manufactured chemical fertiliser.	sufficient and generates surplus biogas for renewable energy • The digestate may offer additional revenue	quality digestate • An end-market for the digestate must be identified, otherwise it requires further treatment or landfill disposal	technology, however, the quality of feedstock is critical to the successful performance of the anaerobic digestion system
Moving grate incineration 	This involves the combustion of waste in excess oxygen/air conditions as it moves through a mechanically driven grate that has evenly distributed air blowing through it. The heat from the combustion of waste is used to raise steam in a boiler. The steam is used to drive a conventional steam turbine and generator set to generate electricity. The facility can be operated in CHP mode where both heat and electricity are generated and used, which significantly increases the energy efficiency of the facility.	• Can process mixed unsorted waste with large variations in composition and calorific value without the need for waste pre-treatment; • Possible to expand waste throughput of facility by adding further combustion lines if space and environmental permitting allows	• The treatment of wastes with a higher calorific value usually requires a grate cooling system, which increases costs • Extensive flue gas cleaning required to minimise emissions of hazardous substances into the air • Maximum utilisation necessary for economic benefit, therefore a continuous operation is necessary	• Status: commercial scale • Proven with over 1,000 facilities globally • Established for large scale treatment • Most common form of thermal treatment for waste due to fuel flexibility • Long operational history with many established technology providers
Fluidised bed incineration 	This involves the combustion of waste in excess oxygen/air conditions in a furnace with a granular bubbling bed of an inert material such as coarse sand or silica. The bed is suspended by air being blown vertically up through the inert bed material at a high flow rate. Waste material that enters the fluidised bed furnace is quickly and uniformly incinerated using the thermal capacity of the hot fluidised bed. The heat from the combustion of waste is used to raise steam in a boiler. The steam is used to drive a conventional steam turbine and generator set	• The fluidised bed process enhances air reaching the waste particles, which increases the efficiency and rate of combustion • The formation of nitrogen oxides in the furnace is lower than with other thermal treatment technologies due to the lower combustion temperatures present • The technology requires a smaller land-take than other	• Waste typically requires pre-treatment to reduce the particle size of the waste, which increases costs • Extensive flue gas cleaning required to minimise emissions of hazardous substances into the air • Maximum utilisation necessary for economic benefit, therefore a continuous operation is necessary	• Status: commercial scale • Proven with several hundred facilities globally • Established for small and medium scale treatment • Most commonly used in Japan, Europe and the USA

Technology	Description	Advantages	Disadvantages	Reliability
	to generate electricity. The facility can be operated in CHP mode where both heat and electricity are generated and used, which significantly increases the energy efficiency of the facility.	thermal treatment technologies because of the vertical structure of the furnace compared to the horizontal structure of moving grate and rotary kiln furnaces		
Rotary kiln incineration 	This involves the combustion of waste in excess oxygen/air conditions in a cylindrical vessel slightly inclined on its horizontal axis. The vessel is usually located on rollers, allowing the kiln to rotate or oscillate around its axis. The rotation moves the waste through the kiln by gravity with a tumbling action, which exposes the waste to heat and oxygen for combustion to take place. The heat from the combustion of waste is used to raise steam in a boiler. The steam is used to drive a conventional steam turbine and generator set to generate electricity.	• It can handle different types of waste including gases, liquids, sludges and solids • The process is reliable due to the limited number of moving parts within the combustion zone compared to other thermal treatment technologies	• Extensive flue gas cleaning required to minimise emissions of hazardous substances into the air • Maximum utilisation necessary for economic benefit, therefore a continuous operation is necessary	• Status: commercial scale • Proven but mainly used for clinical and hazardous waste than MSW as it offers few benefits over other thermal treatment technologies. Less than hundred facilities globally for the treatment of MSW • Typically used for small scale treatment
Pyrolysis 	This involves the thermochemical degradation of carbonaceous materials (e.g. organic waste, plastic packaging and used tyres) in the absence of oxygen. Pyrolysis typically takes place within rotary kilns that are indirectly heated. The process produces syngas, char and a liquid residue referred to as pyrolysis oil. The syngas is typically converted into electricity by combustion of the syngas. The syngas can also be used in the production of fertilisers and transportation fuels. The char can be used as a solid fuel, in the production of activated carbon or as a soil additive. The	• As pyrolysis takes place in the absence of oxygen, reduced flue gas volumes are generated which reduces the costs associated with flue gas treatment • Facilities can operate at a smaller scale compared to thermal treatment technologies such as moving grate incineration, in which small scale means it can provide local or decentralised waste	• The process typically requires a consistent waste feedstock such as RDF, biomass, or shredded tyres therefore waste pre-treatment is required • Complex process control and engineering is critical to the performance of the facility due to certain operational issues such as the deposition of tars that can cause blockages	• Status: demonstration scale • Unproven with several facilities in Japan for the treatment of MSW but with an unknown track record. There are a greater number of facilities using biomass and shredded tyres as feedstock • Burgau facility was the longest operating facility for treating MSW until it

Technology	Description	Advantages	Disadvantages	Reliability
	pyrolysis oil can be used as a fuel or refined further into various fractions of oil.	management		closed in 2015 due to high operations and maintenance costs • Complex process control and engineering required to ensure optimum performance
Gasification 	This involves the partial combustion of waste. This means that oxygen is added but the amounts are not sufficient to allow the waste to undergo complete combustion. The process produces syngas and char. Some specific processes also produce a slag. The syngas is typically converted into electricity by combustion of the syngas. The syngas can also be used in the production of fertilisers and transportation fuels. The char can be used as a solid fuel, in the production of activated carbon or as a soil additive.	• As gasification takes place in the absence of oxygen, reduced flue gas volumes are generated which reduces the costs associated with flue gas treatment • The slag produced from the direct melting system gasification process is low leaching making it an ideal raw material for the production of cement • Facilities can operate at a smaller scale compared to thermal treatment technologies such as moving grate incineration, in which small scale means it can provide local or decentralised waste management	• The process typically requires a consistent waste feedstock such as RDF, biomass, or shredded tyres therefore waste pre-treatment is required. However, there are specific gasification technologies in Japan, such as the direct melting system, which do not require pre-treatment of the waste • Complex process control and engineering is critical to the performance of the facility due to certain operational issues such as the deposition of tars that can cause blockages	• Status: demonstration/ commercial scale • Unproven with several hundred facilities globally but few perform at commercial scale as reliably as conventional thermal treatment facilities • Japan has the greatest number of facilities having commissioned 97 facilities between 1997 and 2008, and a further 44 facilities between 2000 and 2001 • Most facilities in Japan use a combination of direct melting systems and fluidised bed reactors
Plasma gasification	A variation of gasification where the heat provided for thermochemical decomposition of the waste comes from plasma. When waste comes in contact with plasma, it is superheated to temperatures between 3,000-	• Plasma technology is seen as a sophisticated technology that offers the potential for complete destruction of waste with a very high mass	• There are high thermal stresses in the plasma gasification reactor and abrasion of electrodes • Producing the plasma has a	• Status: demonstration scale • Unproven with a small number of demonstration facilities

Technology	Description	Advantages	Disadvantages	Reliability
	15,000˚C. A hydrogen-rich syngas is generated while the inorganic solids and metals fuse together into vitreous like solids, also known as slag.	and volume reduction • It is electrically powered and thus can be switched-on/switched-off and can be shut down when not required	high electricity demand associated with it	and less than 10 small scale facilities in planning or operation • A number of unsuccessful projects e.g. Air Products Tees Valley case study that stopped project due to significant technical problems making the technology work resulting in a loss of up to £800 million

8.6 Smart technologies for waste monitoring

8.6.1 Data analytics

Using urban analytics in wastes services provision and management, especially in urban centres, can be highly beneficial and help optimise the systems, and enable the identification of system inefficiencies.

Developed by a partnership of waste industry and UK public bodies, edoc[59] is an online system designed to help transform the way waste holders can record what happens to the waste they produce or handle. It does away with outdated paper waste transfer notes, saving time, effort and money in fulfilling the legal duty of care for waste.

Visual display of how much waste is generated through an interactive online tool (see **Figure 26**), for example, could generate comparisons between recycling rates, food waste etc amongst boroughs. This could encourage behavioural change and allow local authorities to target specific areas that have low recycling rates or generate more food waste to launch educational and awareness campaigns. In addition, analysing waste-related datasets can help local authorities improve the efficiency of services.[60]

Citizens may use a chip card to dispose of their waste. This enables local authorities to measure the quantity of waste disposed, but also identify the location and time of disposal. This can help waste collectors to estimate the ideal times at which to empty containers. This system can also be used to introduce a PAYT programme charging households for the amount that they throw away.

The London Datastore shares insights on how waste data can be used by drawing a comparison with New York. Data on waste generation throughout the year produced a model which can predict future service demand and thus help plan more efficient collection routes and times.[61]

[59] edoc (2016), *Home*, Available at: https://www.edoconline.co.uk/what-is-edoc/ (Accessed 14 December 2016).

[60] Arup and Greater London Authority (2016), *Smart City Opportunities for London*, Available at: https://www.london.gov.uk/sites/default/files/arup-gla_smart_city_opportunities_for_london.pdf (Accessed 13 December 2016).

[61] Greater London Authority (2015), *From Waste comes Value: Transferring New York's Expertise on Waste Related Analytics*, Available at: http://data.london.gov.uk/blog/waste-analytics-shall-we-follow-where-new-yorkleads/ (Accessed 13 December 2016).

Figure 26: Example of waste generation data analytics (source: Warwick Institute for the Science of Cities[62])

8.6.2 Smart bins

Technologies that can monitor the fill levels of bins can facilitate more efficient waste collection (see **Figure 27**). Sensor fill alarms monitor how full each bin is, allowing authorities to decide when to collect the bins. Big Belly Solar UK, for example, produces a street waste collection bin powered by the sun, which alerts collection contractors when the bin is 85% full.[63]

Figure 27: Smart waste containers equipped with sensor technology that feeds data directly into computers (source: Smartbin, 2016[64])

[62] Warwick Institute for the Science of Cities (2015), *Urban Waste Analytics*, Available at: http://www.wisc.warwick.ac.uk/files/6414/6222/1818/Nick.pdf (Accessed 13 December 2016).
[63] Arup and Greater London Authority (2016), *Smart City Opportunities for London*, Available at: https://www.london.gov.uk/sites/default/files/arup-gla_smart_city_opportunities_for_london.pdf (Accessed 13 December 2016).
[64] Smartbin (2016), *Smartbin Remote Monitoring*, Available at: https://www.smartbin.com/ (Accessed 13 December 2016).

8.6.3 Collection vehicles logistics optimisation

Optimising the movement of waste collection vehicles can be achieved through the planning of more efficient collection routes. This can be enabled through Global Positioning System (GPS) tracking on collection vehicles and the information collected on their location and speed (see **Figure 28**).

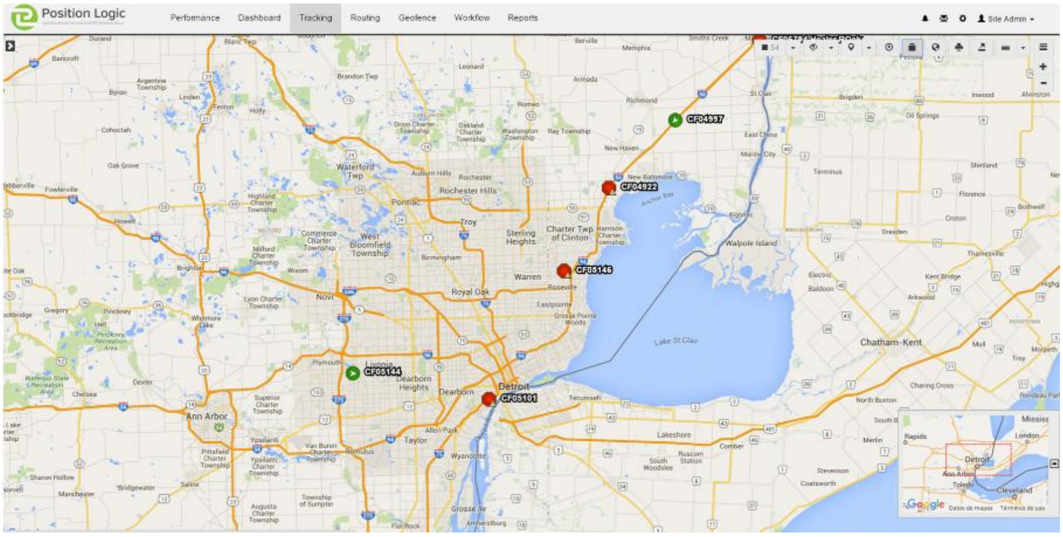


Figure 28: A schematic diagram of how GPS vehicle tracking works (source: Position Logic[65])

9 Proposed resource and waste management strategy

9.1 Overview

Schematics of the proposed resource and waste management strategy for each development type are provided in **Figure 29** to **Figure 35**. **Table 11** that follows the schematics provides more detail of each proposed approach, and the steps that should be taken next to begin the implementation process. This includes stakeholder engagement that OPDC should be conducting (as the local waste planning authority) with relevant organisation and businesses including WCAs and WDAs whose responsibilities still remain.

[65] Position Logic (2017), *Position Logic*, Available at: https://www.positionlogic.com/screenshots (Accessed 1 February 2017).

9.2 Construction phase

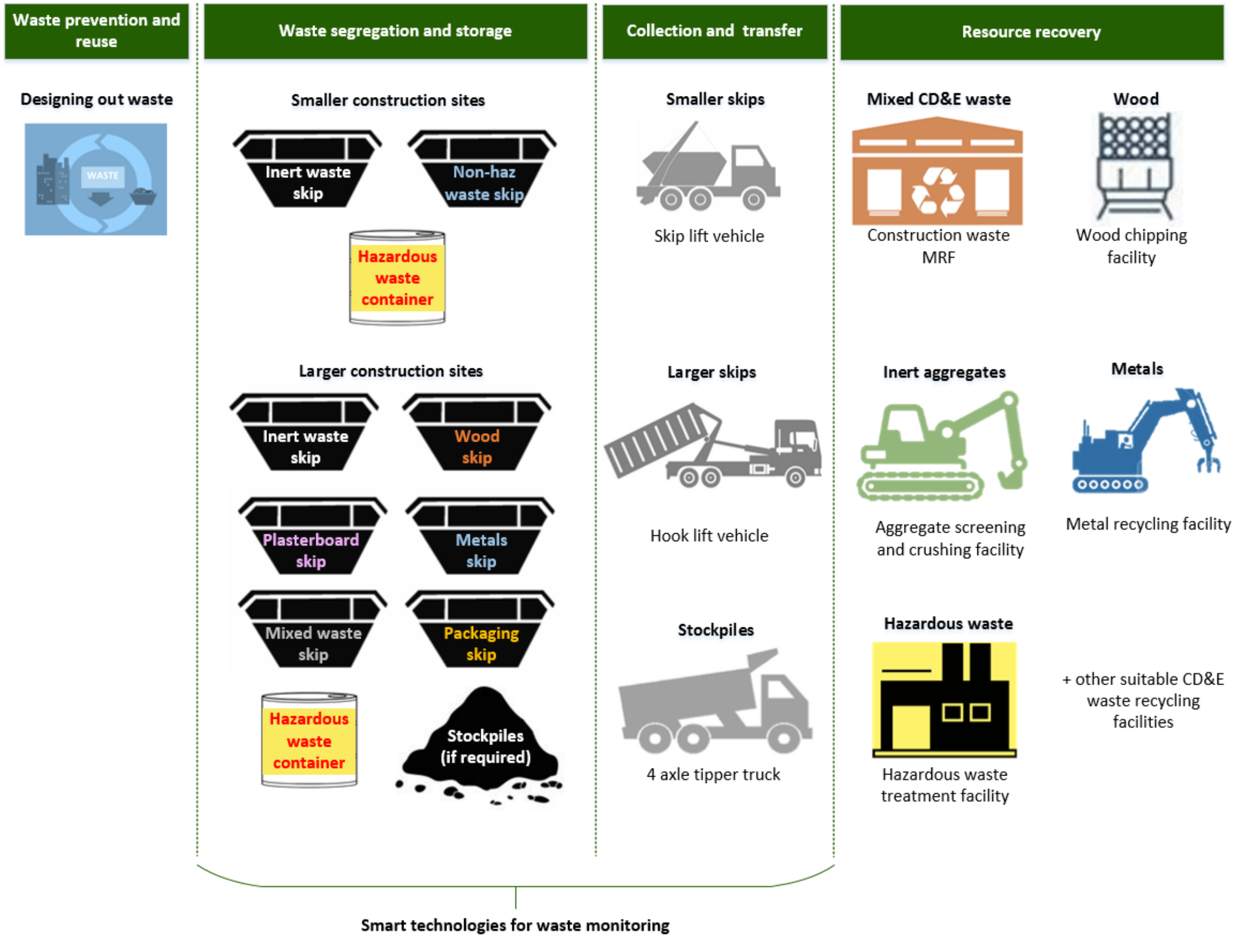


Figure 29: Proposed approach for CD&E activities

9.3 Operational phase

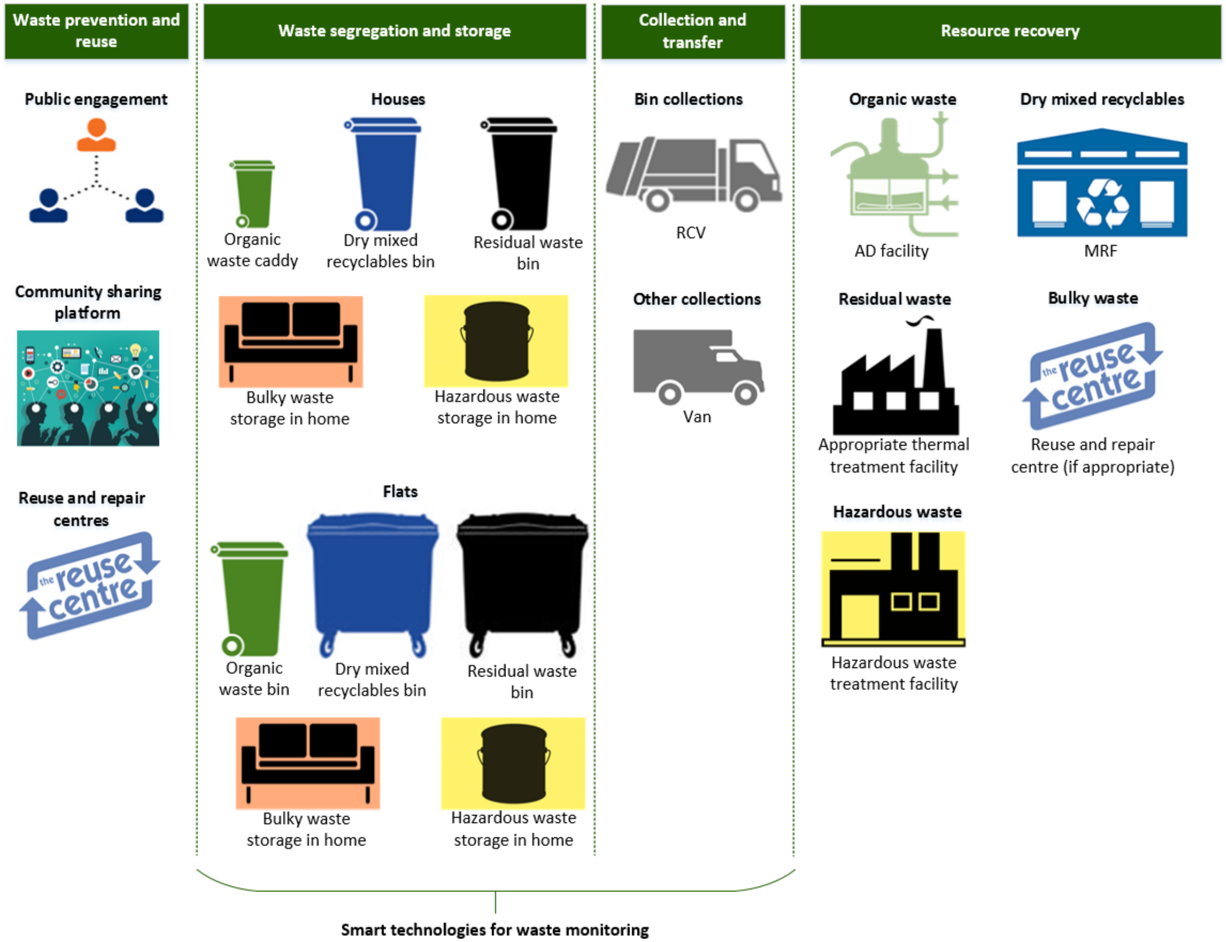


Figure 30: Proposed approach for remaining households

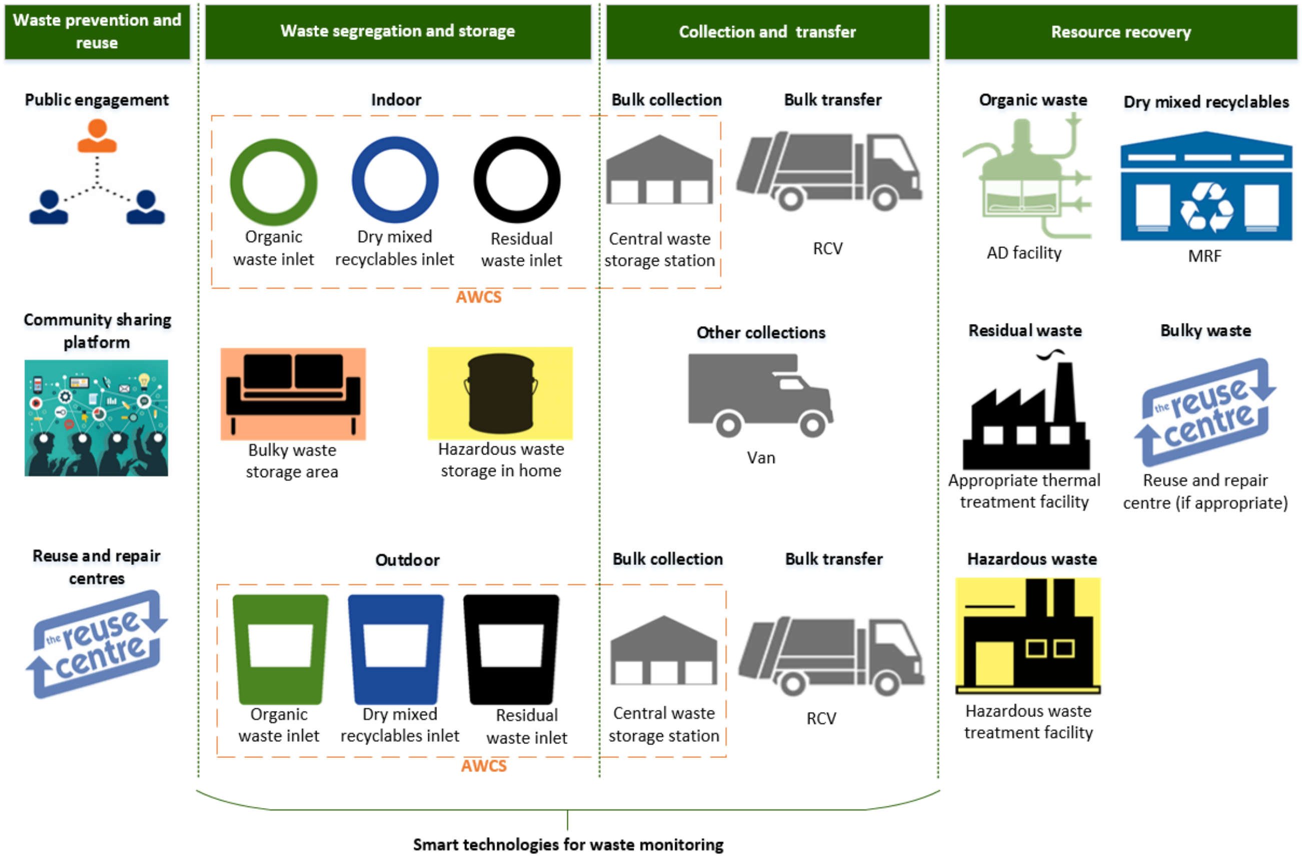


Figure 31: Proposed approach for new households

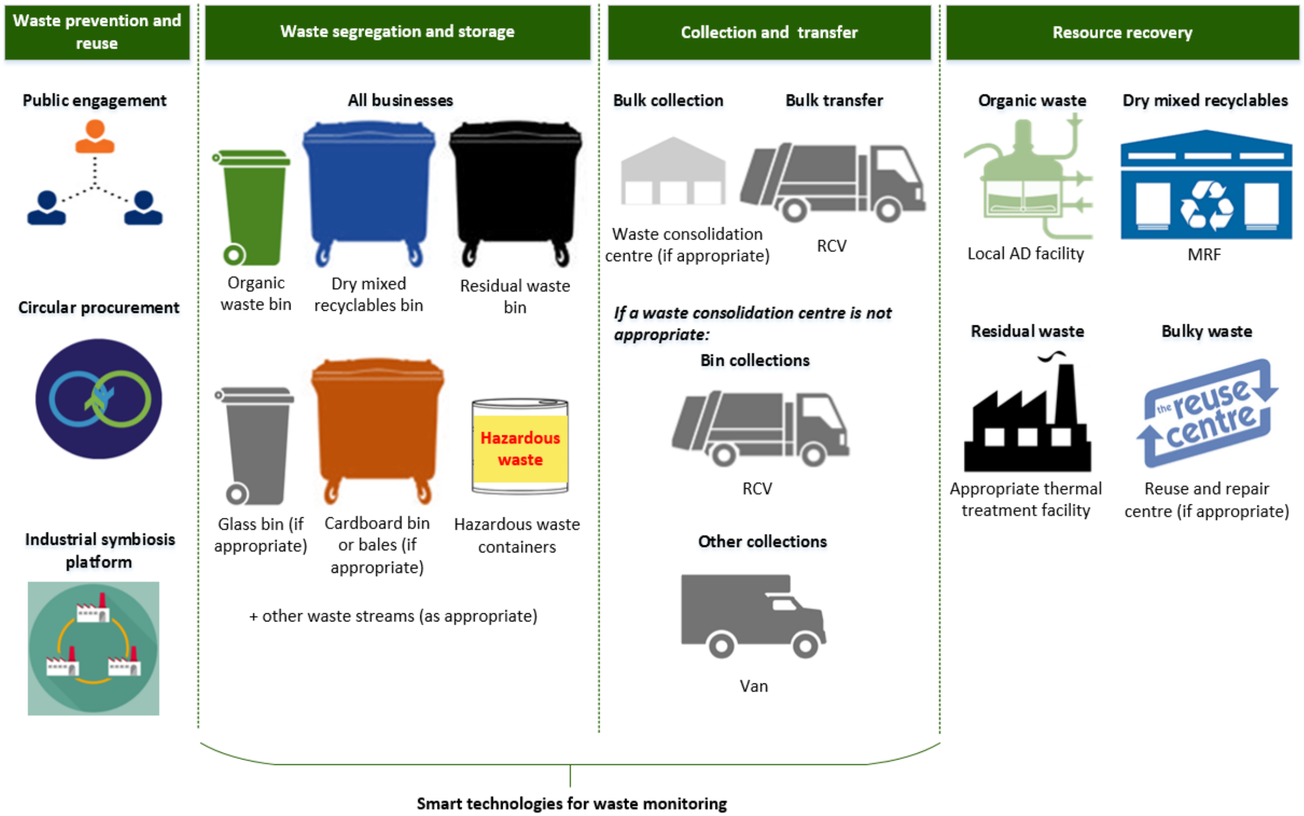


Figure 32: Proposed approach for remaining businesses

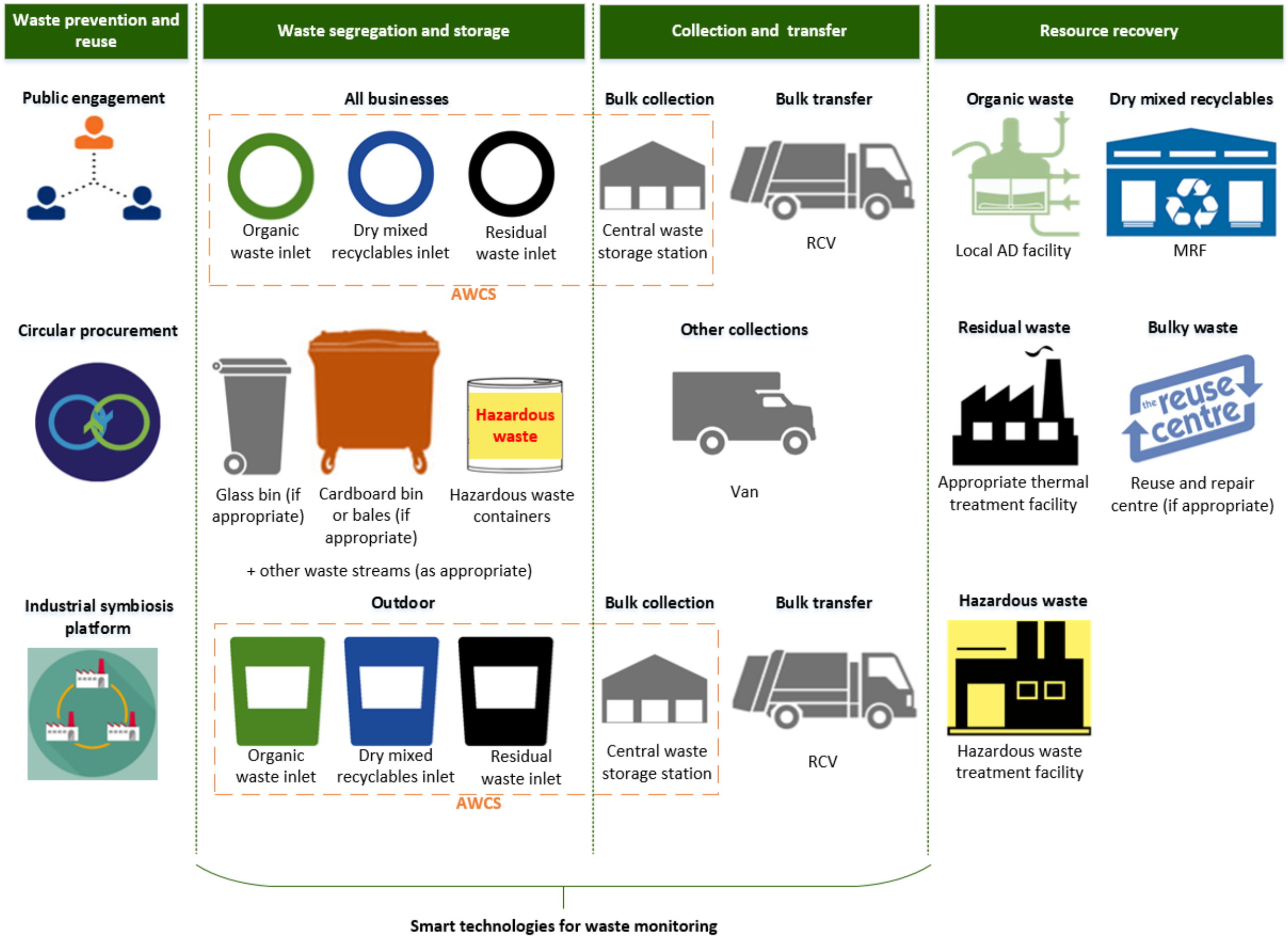


Figure 33: Proposed approach for new businesses

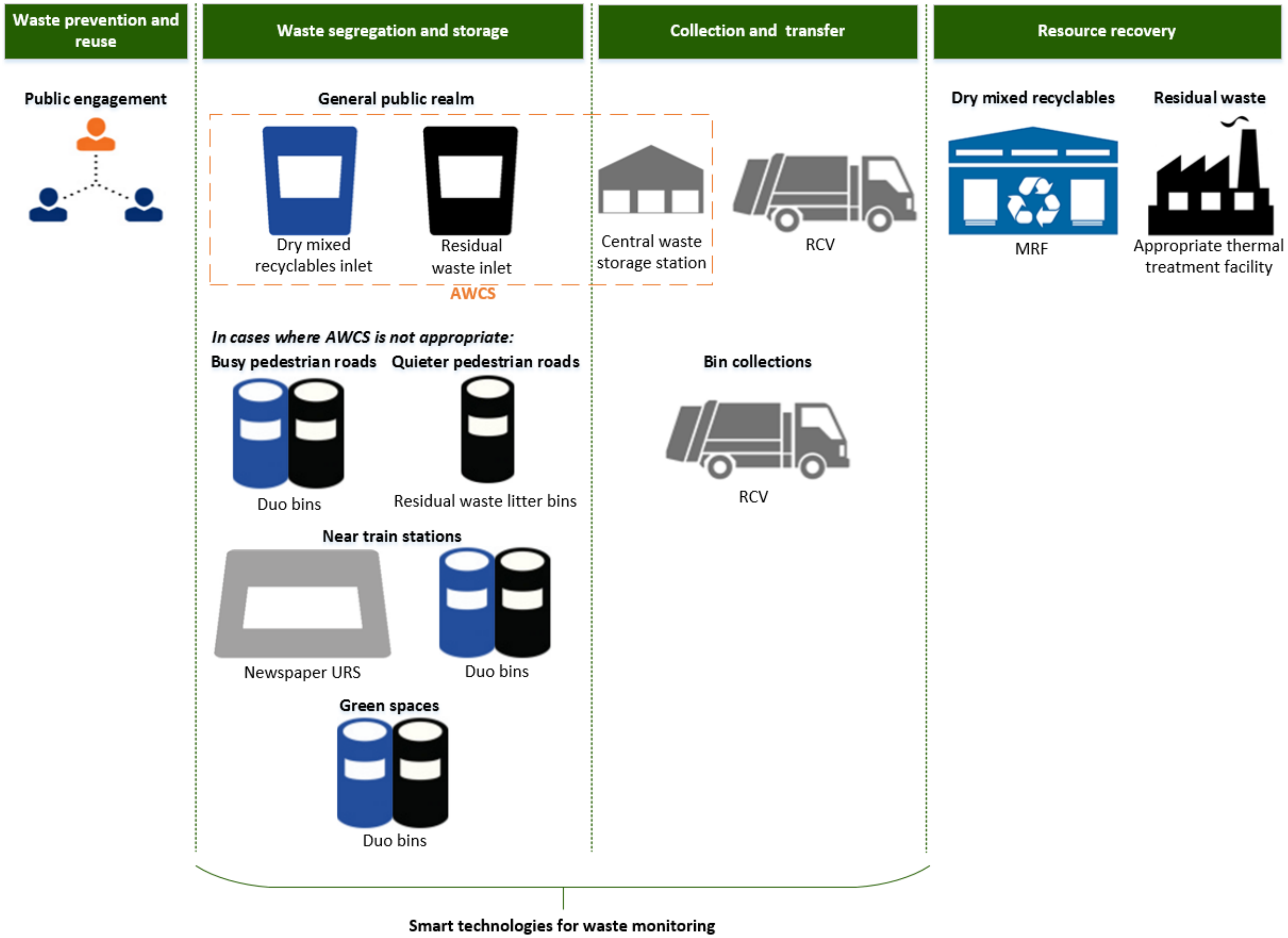


Figure 34: Proposed approach for the public realm

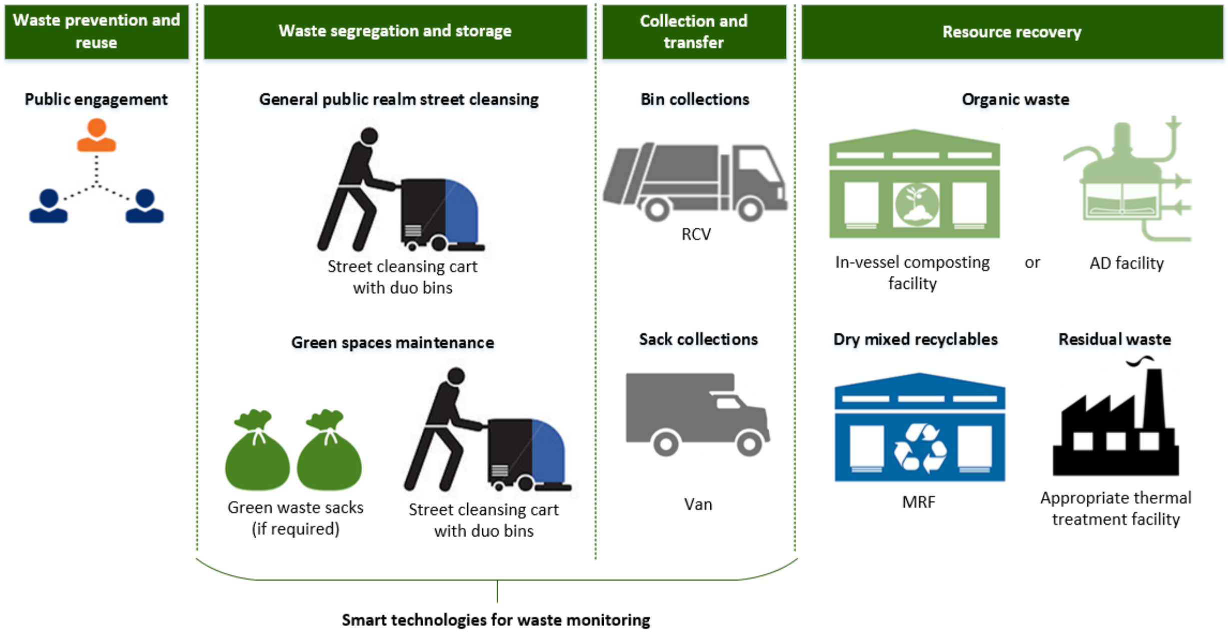


Figure 35: Proposed approach for street cleansing

9.4 Summary of proposed resource and waste management strategy

Table 11: Summary of proposed resource and waste management approach

Development type	Management stage	Proposed approach	Next steps
Construction phase: CD&E activities	Waste prevention and reuse	• Use of designing out waste principles during the design, procurement, construction and deconstruction of buildings	• Setting a requirement for a 'Designing out waste' report to be produced by all awarded construction contracts
	Waste segregation	• The types of CD&E waste generated can vary from project to project; the construction contractor should develop the exact segregation strategy to be followed using their knowledge of the construction programme • For larger projects, it is proposed to a follow a minimum segregation strategy of seven streams (inert, metals, wood, plasterboard, packaging, mixed waste, hazardous). Different grades of each stream should be separated were possible • For smaller projects where it may not be practicable to follow a seven-stream segregation strategy, it is proposed to follow a minimum of a segregation strategy of three streams (inert, non-hazardous, hazardous)	• Setting a minimum segregation strategy requirement in the construction contracts
	Waste storage, collection and transfer	• For larger projects, larger skips (14yd^3, 16yd^3, 20yd^3 and 40yd^3) may be used. The 14yd^3 and 16yd^3 skips are typically collected and transported using skip lift vehicles. The 20yd^3 and 40yd^3 roll on/off skips are typically collected and transported using hook lift vehicles. Large quantities of heavy waste material (e.g. concrete and soils) should be stockpiled. When a sufficient quantity of waste is stockpiled, it should be loaded directly onto 4 axle tipper trucks using a crane or excavator for collection and transport off-site • For smaller projects, smaller skips (8yd^3, 10yd^3, and 12yd^3) may be used. These size skips are typically collected and transported using skip lift vehicles	
	Resource recovery	• Segregated waste streams should be sent to appropriate recycling facilities that have published high resource recovery rates • Skips with mixed construction waste should be sent to modern construction waste MRFs to maximise resource recovery, for example, the Powerday Old Oak Sidings facility	• Setting a minimum diversion from landfill requirement in the construction contracts
Operational phase: Remaining	Waste prevention and reuse	• Public engagement activities should raise awareness and make information available about waste prevention and reduction as well as promote residents'	• Liaising with other similar local authorities to understand how they successfully engaged the

Development type	Management stage	Proposed approach	Next steps
households (i.e. 2,800 existing households that will remain as part of the new development)		involvement in reuse campaigns. This public engagement programme may need to be different from the public engagement for new households due to the different housing typologies and associated waste management arrangements • Well publicised community sharing platforms to facilitate community sharing • Local reuse and repair centres either owned by businesses or social enterprises, or perhaps a community led organisation	public • Liaise with existing phone application developers for community sharing platforms to understand their appetite for expansion • Specifying reuse and repair centres as part of the commercial development of Old Oak and Park Royal
	Waste segregation	• It is proposed to follow a four-stream segregation strategy (organic waste, dry mixed recyclables, residual waste, hazardous waste)	• WCAs to discuss potential incentives for residents to maximise participation in organic waste segregation
	Waste storage, collection and transfer	• For existing houses, organic waste should be stored in 23 litre caddies, and dry mixed recyclables and residual waste should be stored in 240 litre bins. Hazardous waste and other waste streams that require separate collections (e.g. bulky waste) should be stored in the house. Organic waste should be collected every week using RCVs without compaction. Dry mixed recyclables and residual waste should be collected on alternate weeks using RCVs with compaction. Hazardous waste and other waste streams that require separate collections would be arranged by the resident in need of the service with the local authority. Separate collection are likely to be made in vans • For existing flats, there should be an existing central waste storage area. Organic waste should be stored in 10litre caddies inside the flat for emptying into 360litre bins located in the central waste storage area, and dry mixed recyclables and residual waste should be stored in 1,100 bins located in the central waste storage area. A demarcated storage area should be provided for bulky waste. Hazardous waste should be stored inside the flat prior to collection by the local authority. Organic waste should be collected using RCVs without compaction. Dry mixed recyclables and residual waste should be collected using RCVs with compaction. The frequency of collection would depend on the residential population, the number of bins provided and their capacity. Estate management should be responsible for deciding an appropriate collection frequency. Bulky waste collection should be arranged by estate management. Hazardous waste collections should be arranged by the resident in need of the service with the local authority. Separate collection are likely to be made in vans	

Development type	Management stage	Proposed approach	Next steps
	Resource recovery	• Organic waste sent for AD • Dry mixed recyclables sent to a MRF • Residual waste sent for appropriate thermal treatment • Bulky waste sent to a RRC, where possible, otherwise sent for appropriate thermal treatment • Hazardous waste sent for appropriate treatment or disposal at a hazardous waste management facility	• WCAs and WDAs to discuss a new governance approach that joins the responsibilities of the WCA and WDA i.e. the creation of a unitary authority. This would facilitate a 'total budget' approach to waste management and would, for example, help balance the higher costs of organic waste collection with savings from the disposal of less residual waste (from organic waste being diverted from landfilled), and make such initiatives economic to fund
Operational phase: New households	Waste prevention and reuse	• Public engagement to raise awareness and make information available about waste prevention and reduction as well as promoting involvement in reuse campaigns • Well publicised community sharing platforms to facilitate community sharing • Local reuse and repair centres either owned by businesses or social enterprises, or perhaps a community led organisation	• Liaising with other similar local authorities to understand how they successfully engaged the public • Liaise with existing phone application developers for community sharing platforms to understand their appetite for expansion • Specifying reuse and repair centres as part of the commercial development of Old Oak and Park Royal
	Waste segregation	• It is proposed to follow a four-stream segregation strategy (organic waste, dry mixed recyclables, residual waste, hazardous waste)	• WCAs to discuss potential incentives for residents to maximise participation in organic waste segregation
	Waste storage, collection and transfer	• Use of three-stream AWCS (organic waste, dry mixed recyclables residual waste) located on each floor of the buildings and communal court yards. The same AWCS systems would serve new commercial activities. Waste collected as part of the AWCS should be transported to a central waste collection station where RCVs would collect the bulked waste for transport to appropriate treatment facilities • A demarcated storage area in the building should be provided for bulky waste. Bulky waste collection should be arranged by estate management. Hazardous waste should be stored inside the homes prior to collection by the local authority. Hazardous waste collections should be arranged by the resident in need of the service with the local authority. Separate collection are likely to be made in vans	• Indicating a fit-out specification that facilitates three-stream segregation • Meeting with technology providers to understand existing AWCSs that collect both household and C&I waste, and how each waste type is apportioned for opex reasons • Meeting with relevant WCAs to discuss implementation of AWCS, changes to the waste collection services provided and an associated rebate

Development type	Management stage	Proposed approach	Next steps
		•	
	Resource recovery	• Organic waste sent for AD • Dry mixed recyclables sent to a MRF • Residual waste sent for appropriate thermal treatment • Bulky waste sent to a RRC, where possible, otherwise sent for appropriate thermal treatment • Hazardous waste sent for appropriate treatment or disposal at a hazardous waste management facility	• Meeting with relevant WDAs to understand existing treatment capacity and additional treatment capacity requirements. OPDC to work with WDAs to ensure that the treatment capacity is delivered • WCAs and WDAs to discuss a new governance approach that joins the responsibilities of the WCA and WDA i.e. the creation of a unitary authority. This would facilitate a 'total budget' approach to waste management and would, for example, help balance the higher costs of organic waste collection with savings from the disposal of less residual waste (from organic waste being diverted from landfilled), and make such initiatives economic to fund
Operational phase: Remaining C&I businesses (i.e. existing Park Royal Industrial Estate that will remain as part of the new development)	Waste prevention and reuse	• Public engagement activities to promote resource efficient commercial and industrial activities • Existing businesses to move to circular procurement practises • Set up of an industrial symbiosis platform to link local businesses that require each other's resources. This does not only need to be waste materials, but it can also be water and energy	• Existing businesses to review existing procurement routes to understand the opportunities where they can be changed to circular procurement • Investigate the development of an industrial symbiosis platform with Park Royal Business Group or West London Business Partnership
	Waste segregation	• Different businesses generate different waste materials depending on their operations; the business should develop the exact segregation strategy to be followed using their operational knowledge • It is proposed to follow a minimum segregation strategy of four streams (organic waste, dry mixed recyclables, residual waste, hazardous waste). The source segregation of individual materials stream such as cardboard, textiles and glass may be required for practicality during waste collection related to the volume and weight of those materials	
	Waste storage, collection and	• Existing businesses to consolidate waste management (and delivery) arrangements. This will help reduce waste management costs as well as reduce	• To review existing waste management contracts (and deliveries) to understand the opportunities

Development type	Management stage	Proposed approach	Next steps
	transfer	vehicles on the road in the Park Royal Industrial Estate • Waste storage and collections to be specified by the businesses arranging the service. The transfer of waste would typically be made using a RCV	for a consolidation centre
	Resource recovery	• Organic waste sent to local AD facility • Dry mixed recyclable sent to a MRF • Individual recyclable material streams sent to a reprocessing facility • Residual waste sent for appropriate thermal treatment • Hazardous waste sent for appropriate management at a hazardous waste management facility	• Combine data on organic waste generation from existing food manufacturing businesses and new businesses to get an understanding of the AD capacity required • Engage Powerday about potentially locating a local AD facility at their site in Old Oak Sidings. With Powerday's plans to develop an on-site thermal treatment facility (up to 20MW), it could make Powerday the hub for local renewable energy generation • Investigate whether outputs from the treatment processes can be used locally (e.g. composted digestate from the AD process used in local rooftop farming initiatives)
Operational phase: New commercial businesses	Waste prevention and reuse	• Public engagement activities to promote resource efficient commercial and industrial activities • To use circular procurement as a way to reduce waste across the business • Set up of an industrial symbiosis platform to link local businesses that require each other's resources. This does not only need to be waste materials, but it can also be water and energy	• Exploring a circular procurement specification for businesses that would like to be located in the new development area, for example, eco-design requirements for certain products and purchasing a certain percentage of reused products • Investigate the development of an industrial symbiosis platform with Park Royal Business Group or West London Business Partnership
	Waste segregation	• Different businesses generate different waste materials depending on their operations; the business should develop the exact segregation strategy to be followed using their operational knowledge • It is proposed to follow a minimum segregation strategy of four streams (organic waste, dry mixed recyclables, residual waste, hazardous waste). The source segregation of individual materials stream such as cardboard, textiles and glass may be required for practicality during waste collection related to the volume	• Indicating a minimum segregation strategy in the specification for businesses that would like to be located in the new development area

Development type	Management stage	Proposed approach	Next steps
		and weight of those materials	
	Waste storage, collection and transfer	• Use of three-stream AWCS (organic waste, dry mixed recyclables, residual waste) located on each floor of the buildings and communal back of house areas. The same AWCS systems would serve new households. Waste collected as part of the AWCS should be transported to a central waste collection station where RCVs would collect the bulked waste for transport to appropriate treatment facilities • Waste storage and collections for additional waste streams to be arranged by the businesses requiring the service. The transfer of waste would typically be made using a RCV	• Meeting with technology providers to understand existing AWCSs that collect both household and C&I waste, and how each waste stream is apportioned for opex reasons • Meeting with relevant WCAs to discuss implementation of AWCS for collecting C&I waste and how the additional cost can be claimed by them (e.g. business rates)
	Resource recovery	• Organic waste sent to local AD facility • Dry mixed recyclable sent to a MRF • Individual recyclable material streams sent to a reprocessing facility • Residual waste sent for appropriate thermal treatment • Hazardous waste sent for appropriate management at a hazardous waste management facility	• Combine data on organic waste generation from existing food manufacturing businesses and new businesses to get an understanding of the AD capacity required • Engage Powerday about potentially locating a local AD facility at their site in Old Oak Sidings. With Powerday's plans to develop an on-site thermal treatment facility (up to 20MW), it could make Powerday the hub for local renewable energy generation • Investigate whether outputs from the treatment processes can be used locally (e.g. composted digestate from the AD process used in local rooftop farming initiatives)
Operational phase: Public realm	Waste prevention and reuse	• Public engagement activities to reduce litter	• Liaising with other similar local authorities to understand how they successfully engaged the public
	Waste segregation	• It is proposed to follow a two-stream segregation strategy (dry mixed recyclables, residual waste including organic waste) in strategic areas where a higher composition of dry mixed recyclables are likely to generated (e.g. on busy pedestrian roads) and a single stream segregation strategy (residual waste comprising all waste) on quieter pedestrian roads	

Development type	Management stage	Proposed approach	Next steps
		• For the public realm near train and underground stations, it is proposed to follow a three stream segregation strategy (newspapers, dry mixed recyclables, residual waste including organic waste) • For green spaces, it is proposed to follow a two stream segregation strategy (dry mixed recyclables, residual waste including organic waste)	
	Waste storage, collection and transfer	• Use of two-stream AWCS (dry mixed recyclables, residual waste including organic waste) located in strategic places across the development. Waste collected as part of the AWCS should be transported to a central waste collection station where RCVs would collect the bulked waste for transport to appropriate treatment facilities • There may be areas of Old Oak and Park Royal that are not appropriate for AWCS (e.g. in the middle of existing green spaces). For the general public realm, duo bins are proposed where a two-stream segregation strategy is being followed and litter bins are proposed for where single stream segregation is being followed. For the public realm near train and underground stations, it is proposed to use URSs for newspapers due to the high quantity expected to be generated per day and limited access to empty them during the day, and duo bins are proposed where a two-stream segregation strategy is being followed. For green spaces where two-stream segregation is being followed, it is proposed to use duo bins. These bins should be periodically collected with an adjustment to the collection frequency if overfilling is observed. URS bins would require specialised vehicles for waste collections. Other bin collections would typically be made using RCVs	• Meeting with relevant WCAs to understand their URS collection capacity
	Resource recovery	• Dry mixed recyclables sent to a MRF • Residual waste sent for appropriate thermal treatment	
Operational phase: Street cleansing	Waste prevention and reuse	• Public engagement activities to reduce litter	• Liaising with other similar local authorities to understand how they successfully engaged the public
	Waste segregation	• For street cleansing activities in the general public realm and the public realm near train and underground stations, it is proposed to follow a two stream segregation strategy (dry mixed recyclables, residual waste including organic waste)	

Development type	**Management stage**	**Proposed approach**	**Next steps**
		• For green space maintenance activities, it is proposed to follow a three-stream segregation strategy (green waste, dry mixed recyclables, residual waste including organic waste)	
	Waste storage, collection and transfer	• For street cleansing activities in the general public realm and the public realm near train and underground stations, it is proposed to use street cleaning carts with two compartments (i.e. duo bins). Bin collections would typically be made using RCVs • For green space maintenance activities, it is proposed to use street cleaning carts with two compartments (i.e duo bins). Green waste is likely to be generated in large quantities so it proposed to place the green waste in sacks. Bin collections would typically be made using RCVs. Sack collections would typically be made using vans	
	Resource recovery	• Organic waste sent for in-vessel composting or AD • Dry mixed recyclables sent to a MRF • Residual waste sent for appropriate thermal treatment	

Appendix A

Waste policy

A1 National policy

A1.1 National Planning Policy for Waste

The National Planning Policy for Waste[66] published in October 2014 replaces the former Planning Policy Statement 10 (PPS10): Planning for Sustainable Waste Management. It sets out the criteria for waste planning authorities as follows:

1. Use of a proportionate evidence base on which to set waste planning policies;
2. Identification of the need for waste management facilities;
3. Identification of suitable sites and areas for waste management infrastructure;
4. Determination of planning applications for new waste management infrastructure; and
5. Monitoring and reporting of allocated sites and areas, changes in the type and capacity of waste management facilities, changes in waste arisings, and quantities of waste recycled, recovered and disposed.

A1.2 2010-2015 Government Policy: Waste and Recycling

The most recent Government policy on waste and recycling[67] was published in May 2015, which sets out how the priorities and strategic framework for moving towards a ‘zero waste economy’. Guided by the waste hierarchy, the policy sets out actions and associated programmes for:

1. Waste prevention;
2. Recycling;
3. Helping businesses reduce and manage waste;
4. Single-use plastic bag charging;
5. Infrastructure and supporting energy from waste;
6. Dealing with waste crime;
7. Regulating landfill Sites and waste to landfill;
8. Controlling hazardous waste; and
9. Ship recycling.

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[66] Department for Communities and Local Government (2014), *National Planning Policy for Waste*, Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/364759/141015_National_Planning_Policy_for_Waste.pdf (Accessed 1 December 2016).
[67] Department for Environment, Food and Rural Affairs (2015), *2010 to 2015 Government Policy: Waste and Recycling, Updated 8 May 2015*, Available at https://www.gov.uk/government/publications/2010-to-2015-government-policy-waste-and-recycling/2010-to-2015-government-policy-waste-and-recycling (Accessed 1 December 2016).

A1.2.1 Waste Management Plan for England

The Waste Management Plan for England[68] provides an analysis of the current waste management situation in England and a framework to support further implementation of the objectives and provisions of the European Waste Framework Directive (Directive 2008/98/EC).[69]

Its purpose is to consolidate a number of existing policies within the context of a single national waste management plan that are relevant to the management of:

1. municipal solid waste (MSW);
2. commercial and industrial (C&I) waste;
3. construction and demolition waste; and
4. hazardous waste.

The plan adopts key targets from the European Waste Framework Directive such that, by 2020:

5. At least 50% by weight of waste from households is prepared for reuse and recycling; and
6. At least 70% by weight of construction and demolition waste is subjected to material recovery.[70]

A1.2.2 National Policy Statement for Hazardous Waste

Government policy on hazardous waste is contained within the National Policy Statement for Hazardous Waste: A Framework Document for Planning Decisions on Nationally Significant Hazardous Waste Infrastructure[71]. This document sets out the need for large scale hazardous waste infrastructure and the framework for decision making on relevant development consent applications within England.

[68] Department for Environment, Food and Rural Affairs (2013), *Waste Management Plan for England, December 2013*, Available at: https://www.gov.uk/government/publications/waste-management-plan-for-england (Accessed 1 December 2016).
[69] European Parliament and European Council, Strasbourg (2008), *.Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives*, Available at: http://www.ecolex.org/details/legislation/directive-200898ec-of-the-european-parliament-and-of-the-council-on-waste-and-repealing-certain-directives-lex-faoc083580/ (Accessed 1 December 2016).
[70] Excluding hazardous waste and naturally occurring material falling within code 17 05 04 in Schedule 1 to the List of Wastes (England) Regulations 2005 (as amended).
[71] Department for Environment, Food and Rural Affairs (2013), *National Policy Statement for Hazardous Waste: A Framework Document for Planning Decisions on Nationally Significant Hazardous Waste Infrastructure*, Available at: https://www.gov.uk/government/publications/hazardous-waste-national-policy-statement (Accessed 1 December 2016).

A2 Regional policy and guidance

A2.1 The London Plan

The current London Plan[72] is the overall spatial strategic plan for London that sets out an integrated economic, environmental, transports and social framework for development of London over the next 20-25 years. It brings together the geographic and locations aspects of the Mayor's other strategies based on three cross-cutting themes:

1. Economic development and wealth creation;
2. Social development; and
3. Improvement of the environment.

Chapter 5 of The London Plan includes comprehensive range of policies to underpin London's response to climate change, including underlying issues of resource management. These policies cover climate change mitigation and adaptation, waste, aggregates, contaminated land and hazardous substances.

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.

On a more strategic level, Policy 5.16 (Waste Net Self-Sufficiency) requires the relevant authorities and other organisations to manage the equivalent of 100% of London's waste within London by 2026 (Policy 5.16 A). It also seeks to work towards zero biodegradable or recyclable waste to landfill by 2026 (Policy 5.16 A). It states that this will be achieved by implementing the waste hierarchy to achieve the following targets for:

1. Local authority collected municipal waste (LACMW): recycle and compost a minimum of 45% by 2015, 50% by 2020 and 60% by 2031;
2. Commercial and Industrial (C&I) waste: recycle and compost a minimum of 70% by 2020; and
3. Construction, demolition and excavation (CD&E) waste: reuse and recycle 95% by 2020 (Policy 5.16 B).

These targets are supported by the Mayor's municipal[73] and business[74] waste management strategies.

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[72] Greater London Authority (2016), *The London Plan: Spatial Development Strategy for London Consolidated with Alterations Since 2011, March 2016*, Available at: https://www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan (Accessed 9 December 2016).

[73] Greater London Authority (2011), *London's Wasted Resource: The Mayor's Municipal Waste Management Strategy*, Available at: https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/mayors-municipal-waste-management-strategy (Accessed 9 December 2016).

Policy 5.17 (Waste Capacity) requires suitable waste and recycling storage facilities to be provided in all new developments (Policy 5.17 E).

Policy 5.18 (Construction, Excavation and Demolition Waste) requires CD&E waste to be reused or recycled on-site, 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).

A2.2 Towards a Circular Economy

The Towards a Circular Economy[75] report prepared by the London Waste & Recycling Board sets out the context and opportunities for a London circular economy route map covering the period to 2036. It aims to:

1. inform thinking around upcoming environmental, economic and spatial policy development in the capital;
2. raise awareness within both private and public sectors of what a circular economy is;
3. engage stakeholders who want to work with the London Waste & Recycling Board and the Greater London Authority in this area; and
4. achieve a greater understanding of how a circular economy can contribute to London's greenhouse gas emissions reduction targets.

A3 Local policy and guidance

A3.1 Western Riverside Waste Authority Waste Policy

WRWA has established integrated waste management systems for its four constituent London Boroughs, which ensure the 'best practicable environmental option' is pursued for each particular waste stream in line with its waste policy[76]. The policies established define the parameters within which waste will be managed and look to:

1. embrace the concepts of waste prevention;

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[74] Greater London Authority (2011), *Making Business Sense of Waste: The Mayor's Business Waste Strategy for London*, Available at: https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/mayors-business-waste-management-strategy (Accessed 9 December 2016).
[75] London Waste and Recycling Board (2015), *Towards a Circular Economy Context and Opportunities*, Available at: http://www.lwarb.gov.uk/wp-content/uploads/2015/12/LWARB-circular-economy-report_web_09.12.15.pdf (Accessed 13 December 2016).
[76] Western Riverside Waste Authority (2013), *Waste Policy – July 2013*, Available at: http://www.wrwa.gov.uk/media/44808/waste-policy-statement-july-2013.pdf (Accessed 9 December 2016).

2. seek to achieve a continued reduction in the amount of waste produced;
3. increase the amount of waste that is re-used;
4. recycle, compost or recover energy from the waste that is collected;
5. minimise the environmental impact of transporting the waste;
6. encourage the creation of new, meaningful, job opportunities;
7. minimise disruption to others; and
8. reduce the costs of operations to provide the best possible deal for council tax payers.

A3.2 West London Waste Authority Waste Prevention Strategy[77]

WLWA aims to prioritise and work together to encourage waste prevention and reuse initiatives within its six constituent London Boroughs. This is in accordance with the west London joint municipal waste management strategy[78]. The main objective stated in the Waste Prevention Strategy is to develop material specific implementation plan for each year of the waste prevention plan which are agreed by all partners before the beginning of each financial year. This strategy focuses on materials that have a high negative impact on the natural environment, cannot also be recycled or have a higher value when either prevented or reused such as:

1. food (preventing waste);
2. textiles and shoes (encouraging reuse);
3. disposable nappies (preventing waste);
4. electrical items (encouraging reuse); and
5. furniture (encouraging reuse).

A3.3 Brent Waste and Recycling Storage and Collection Guidance for Residential Properties

The Waste and Recycling Storage and Collection Guidance for Residential Properties document[79] issued by the London Borough of Brent provides waste planning guidance to architects and developers to ensure effective storage and

[77] West London Waste Authority (2011), *Municipal Waste Prevention Strategy for West London 2011-2015*, Available at: http://westlondonwaste.gov.uk/wp-content/uploads/West-London-Waste-Prevention-Strategy-2011-2015.pdf (Accessed 9 December 2016).
[78] West London Waste Authority (2009), *Addendum to West London's Joint Municipal Waste Strategy*, Available at: http://westlondonwaste.gov.uk/wp-content/uploads/West-London-Waste-Strategy-update-2009.pdf (Accessed 9 December 2016).
[79] London Borough of Brent (2013), *Waste and Recycling Storage and Collection Guidance for Residential Properties*, Available at: https://www.brent.gov.uk/media/16403175/waste-planning-guidance-revised-2015.pdf (Accessed 29 November 2016).

collection of recyclable and non-recyclable waste is included at the design and planning stage of new developments. This guidance applies to residential properties only and does not include commercial properties. This document sets out:

1. Strategy objectives, targets and vision;
2. Brent's waste and recycling schemes;
3. Waste and recycling storage requirements; and
4. Access requirements for waste and recycling operatives.

A3.4 London Borough of Hammersmith and Fulham

The Planning Guidance Supplementary Planning Document[80]issued by the London Borough of Hammersmith & Fulham provides policy guidance which includes a brief identification of the overarching policy context in each topic area, namely national, London and local policy. This guidance supplements the waste policies in the London Plan, particularly Policy 5.16 (Waste Self-sufficiency) and Policy 5.17 (Waste Capacity). This guidance provides information for developers in designing waste storage and collection access within new developments. The document sets out:

1. Collection requirements for waste and recycling storage;
2. Technical specification of containers used by the council;
3. Guidance on storage of segregated waste - Residential Waste Storage and Internal Storage; and
4. Bin requirements (quantity, capacity and dimensions for spacing) for houses and flats.

[80] London Borough of Hammersmith and Fulham (2013), *Planning Guidance Supplementary Planning Document*, Available at: https://www.lbhf.gov.uk/sites/default/files/section_attachments/planning_guidance_spd_final_tcm21-181716.pdf (Accessed 29 November 2016).

Appendix B

Case studies

B1 Case study: Wembley City, London, UK

B1.1 Overview

This case study was prepared based on publicly available information.[81]

The development in Wembley Park is 100% serviced by the Envac AWCS (**Figure B 1**). The developer, Quintain, chose to use the AWCS from Envac at Wembley Park in order to contribute to its plans of achieving a highly advanced new development for London. The system, whose first stage became operational in 2008, is the first, and currently the only municipal scale development serviced by an AWCS in the UK.

The Wembley case study is included in this RWMS in order to understand better the potential opportunities and constraints associated with the installation of an AWCS within a new, densely built residential development in London.

Figure B 1: Wembley City

B1.2 Strategy

The AWCS is operated by Quintain, with support from Envac, and it includes the following elements:

1. 500 households;
2. A hotel; and
3. A shopping centre.

[81]Envac (2010), *Wembley City Project*, Available at: http://www.lsx.org.uk/docs/events/3440/envac.pdf (Accessed 8 December 2016).

Three waste streams are being collected:

1. Mixed dry recyclables (plastic, metal, paper, glass);
2. Food waste (including high volume food waste from commercial premises); and
3. Residual waste from private households and commercial premises

The three stream system adheres to the waste collection strategy of Brent council, which is the local council. Residents can dispose of their waste in the numerous inlets that can be found within their courtyard (see **Figure B 2**).

The AWCS at Wembley Park currently achieves a recycling rate of 40%. It consists of 500mm steel pipes, while the main pipe has a length of 800m, which will be extended to 2,500m upon completion.

There are several waste streams that are still collected by the conventional collection system. This includes commercial glass, because of the material's abrasive nature, which would reduce the pipes' lifespan, and commercial bulky waste, as it may block the pipes. WEEE, batteries, construction and demolition waste, and garden waste are also not accepted. For bulky waste collection, Brent Council has built an onsite bulky waste storage facility. Residents may also take bulky waste to one of the council's RRCs.

Figure B 2: Waste inlets at the courtyard of the Wembley City development

B1.3 Lessons learned

During the first year of operation, Veolia, as the waste collection contractor within LB Brent, was handling the waste received at the central waste collection station. However, when commercial waste was also received at the station later on, the council informed Quintain that they would only collect household waste, as it is the only type of waste paid for via the residents' council tax. However, Quintain decided to take ownership for all types of waste collected by the AWCS, as there is no way of distinguishing between commercial and household waste received via the AWCS. Brent Council pays a contribution towards household waste collection to Quintain, which is based on household numbers and waste disposal quantities.

Quintain relies on the contributions from Brent Council in order to recover their capital expenditure (CAPEX), which is a demonstration of the lack of establishment of payment structures to account for the high CAPEX.

As Wembley Park housing is expanding, it is becoming difficult for the AWCS to handle all the waste generated on site. This highlights the importance of including some contingency in the AWCS design.

The Wembley AWCS is an example of demonstrating the need of good communication and engagement with the residents not just at the time of commencement of the operations, but throughout the lifespan of the system. This is mainly because, it is more difficult to reject and control contaminated loads compared to conventional collection systems. Subsequently, enforcement officers are still required in order to ensure compliance.

Envac recommends the installation of CCTV surveillance at the AWCS inlets, in order to achieve a better monitoring of compliance levels. They also recommend that frequent audits are carried out. These actions may ensure that the communication campaigns are carried out in an effective and more targeted way.

B2 Case study: St George's Wharf Tower, London, UK

B2.1 Overview

This case study was prepared based on publicly available information.[82]

Battersea Reach is an award winning waterfront development with buildings cascading towards the River Thames' edge (**Figure B 3**). It is a medium-rise mixed-use development of apartments, gymnasium, office accommodation and commercial units situated within five residential apartments, which were built in four phases over a six year construction period and it also includes affordable homes. The development was built on a brownfield site by St George South London Limited. The first phase of construction started in 2003.

[82]London Waste & Recycling Board (2014), *Waste Management Planning Advice for Flatted Properties – Case Studies*, Available at: http://www.lwarb.gov.uk/wp-content/uploads/2015/05/Waste-management-planning-advice-for-flatted-properties-case-studies.pdf (Accessed 12 December 2016).

Figure B 3: Battersea Reach residential development

Each floor in each of the buildings of the development has waste chutes.

The St George's Wharf Tower case study is included in this RWMS as it is a good example of the installation of a waste chute system in a modern residential development with medium-rise buildings in London.

B2.2 Strategy

The development has been designed to include a single waste chute with a bi-separator system installed at the base of the waste chute, which allows the waste to be separated into two 1,100 litre wheelie bins located in the basement waste room, one to take residual waste and the other to take mixed dry recyclables.

The recyclables and residual waste are deposited by the residents into waste inlets located near the lifts on each floor of the building by pressing the appropriate button. The inlet point and waste selection buttons are shown in **Figure B 4**.

Figure B 4: Bi-separator chute system inlet point

The management team employs one person who is permanently stationed in the basement storage room, exchanging bins at the bottom of the waste chute as soon as they become full (**Figure B 5**).

Figure B 5: Chute-fed dry recycling container

Residual waste is deposited from the chute, into a hopper, which directs it into a small compactor. This compresses the waste into the side of blue 1100 litre Eurobins. Recycling materials are also chute-fed into non-compacted green 1100 litre Eurobins.

The 1,100 litre Eurobins are taken from the basement waste rooms to the ground level using a small electric vehicle unit by the facility management team on the collection day designated by the local waste collection authority.

Waste collections are carried out six times a week (Monday to Saturday) and recycling is carried out three times a week.

The waste chute system is cleaned approximately every two weeks in order to avoid odour problems.

B2.3 Lessons learned

There have been numerous incidences of the waste chutes becoming blocked by pizza boxes.

The development acts like a hotel for many of its residents, who often have little connection to the property. This is because residents are mostly international investors and these properties may be one of many that they own around the world. As these people come and go, they may not have the same understanding of waste/recycling issues in the UK as others.

The local authority, which is Lambeth council, stated that they would like one collection a week for waste and recycling, however, in developments this large, space for waste is always at a premium and thus, the council accepts that realistic compromises need to be made.

B3 Case study: Tower Hamlets, London, UK

B3.1 Overview

This case study was prepared based on publicly available information[83,84,85].

The Tower Hamlets council installed its first URS in 1999 around high-density social housing developments and privately-owned apartments.

While a number of bin providers had installed URS across the borough, the largest provider has been Plastic Omnium Urban Systems/Sulo, which first became involved in 2006. The company began replacing the existing units from a previous supplier with its own Iceberg Optima system.

The decision to install the bins first came about after the council received Government funding to modify and update its housing stock.

[83] Plastic Omnium (2016), *Poplar Harca Housing Association*, Available at: https://www.plasticomnium.com/env/uk/en/news/item/228-poplar-harca-housing-association.html (Accessed 9 September 2016).
[84] Poplar Harca (undated), *Underground Refuse Collection Issue*, Available at: http://www.poplarharca.co.uk/mediareleases/underground-refuse-collection-issue (Accessed 9 December 2016).
[85] Edie.net (2012), *Tower Hamlets Goes Underground to Pioneer Waste Solution*, Available at: http://www.edie.net/library/Tower-Hamlets-goes-underground-to-pioneer-waste-solution/6196 (9 September 2016).

The Tower Hamlets case study is included in this RWMS because it is a success story on the use of communal URS within a London borough. At the same time, it offers some insight into the considerations that should be made when choosing a URS for a high density development.

B3.2 Strategy

Tower Hamlets council uses a number of underground waste containers as a means of reducing the amount of wheeled bins in the densely populated urban area (**Figure B 6**).

Poplar HARCA has 183 URSs in use and had a further 29 in development in 2014. The URSs were the first of their kind in the UK at the time of their installation – and the installations at Poplar HARCA still remain the largest URSs in the country.

The Iceberg Optima units come in three standard sizes - 3, 4 or 5m^3 containers. The 5m^3 can be found in Tower Hamlets, which is an ideal solution for the area's high density estates.

Figure B 6: Two-stream Iceberg Optima underground waste containers

B3.3 Lessons learned

A rise in the use of underground containers could be seen as a response to residents' complaints about wheeled bins.

An incident of significant reduction in the URS collection service was experienced within the borough of Tower Hamlets, resulting in a build-up of waste around the URS bins. This was due to problems with the council's collection vehicles, as there was only one vehicle in use at the time. This shows that in order for a successful scheme to work, waste generation, storage and collection should all be considered in close conjunction.

Customer figures showed that satisfaction with the quality of the estates rose from 69.2% in 2011 to 88% in 2014. This indicates that residents can value such waste management schemes, and this satisfaction may generate a positive feedback, encouraging residents to participate in the scheme more and in a better way.

B4 Case study: Hackney, London, UK

B4.1 Overview

This case study was produced based on publicly available information[86,87,88,89].

East London Community Recycling Partnership Limited (the Partnership) has been operating the East London Community Recycling Project (ELCRP) at the Nightingale Estate in Hackney, London since 2001. The company is a small, not-for-profit community organisation that is approved by both the Environment Agency and Defra.

The Partnership specialises in door-to-door services on estates, including the collection of recyclables and compostables. ELCRP was the first high-rise estate-based door-to-door food waste collection scheme and the first in-vessel community-based composting process to be approved by the Animal By-Products Regulations.

[86] Hackney Council (2004), *Inner City Estate Recycling*, Available at: apps.hackney.gov.uk/servapps/Reports/s_ViewRptDoc.aspx?id=2558 (Accessed 14 December 2016)
[87] Murphy, J (2007), *Governing Technology for Sustainability*, Available at: https://books.google.co.uk/books?id=cFsRHVKcKwsC&printsec=frontcover#v=onepage&q&f=false (Accessed 19 December 2016)
[88] UK Government (2016), *Companies House - East London Community Recycling Partnership Limited*, Available at: https://beta.companieshouse.gov.uk/company/04247971 (Accessed 14 December 2016).
[89] Due Dil (2016), *East London Community Recycling Partnership Limited*, Available at: https://www.duedil.com/company/04247971/east-london-community-recycling-partnership-limited/financials (Accessed 19 December 2016)

B4.2 Strategy

ELCRP serves six residential towers, comprising of 1,000 residential units. ELCRP provides the following services (**Figure B 7**):

- Dry recycling collection, including paper, glass and cans for the estates;
- Dry recycling including paper and cans for businesses;
- Food waste collection and composting; and
- Green waste collection and composting.

Separation of meat and fish from the rest of the organic waste is not required. The householders therefore, discard the food waste in the containers provided by the Partnership rather than down the waste chute.

Odour issues are not experienced because the system stops putrefaction, as well as, flies and maggots. In addition, it does not attract vermin and since the food waste is collected on a weekly basis, waste chutes and bins remain clean.

The food waste is placed in a “Rocket” in-vessel composter and shredded cardboard is added to make the nitrogen/carbon mix required for standard grade compost to be produced. Since the cardboard is also collected by the Partnership as part of the feedstock, the waste chutes cannot be easily blocked are greatly reduced and estate maintenance costs are consequently reduced.

If higher grade compost is required ELCRP can place the composted material in Wormeries to produce a high quality fertiliser.

ELCRP runs regular workshops covering all aspects of inner city estates recycling and they visit estates to speak to residents, landlords and other community groups, as well as, local authority representatives.

Figure B 7: Overview of the ELCRP system

According to the Partnership's balance sheet of 2013, it had a deficit of tens of thousand pounds on each of its assets, with the highest one being £55,708. Cash at bank was only available for two of their assets, each sum being less than £10,000. Overall, its net assets are currently declining at a 15.69% rate.

In June 2016, a voluntary strike-off and a subsequent dissolution of the Partnership was filed. However, this was suspended in July 2016, although the strike-off proposal is still active. The Partnership currently has two directors, however, it has changed 21 directors over its 15 years of activity.

B4.3 Lessons learned

ELCRP is a demonstration of the long-term viability of high-rise community recycling schemes, including both mixed dry recyclables and food waste, as the Partnership has been operational since 2001. However, it is also a good example of how ineffective management can lead to a failing business with minimal profits.

B5 Case study: Bournbrook, Birmingham, UK

B5.1 Overview

This case study was produced based on publicly available information[90,91].

Birmingham City Council decided to update its recycling collection scheme in the residential (mainly student dominated) area of Bournbrook. The previous system used individual recycling boxes left on the street which was considered to be inefficient, but also visually unattractive.

Taylor Street Recycling centres, provided by Taylor® were installed in Bournbrook to create communal recycling areas.

The Bournbrook case study is included in this RWMS as it is a successful example of communal recycling points in a densely populated, busy residential area.

B5.2 Strategy

The Taylor Street™ units are container housings that are designed to blend into their surrounding while providing clear communication and easy access to the container for collection. Each unit consists of 1,100 litre bins, making it ideal for residential and commercial areas.

One of the units is for the collection of glass and cans while the other one was designed for the collection of paper and cardboard (**Figure B 8**).

[90] Taylor Street (2010), *Technical Information*, Available at: http://taylorbins.co.uk/wp-content/uploads/2014/12/Taylor-Street-Tech-Sheet.pdf (Accessed 10 December 2016).
[91] Taylor (2011), *Birmingham City Council Chooses Taylor Street to Improve Recycling Rates*, Available at: http://taylorbins.com/wp-content/uploads/2016/10/Taylor-Birmingham_City_Council-Case_Study.pdf (Accessed 10 December 2016).

Figure B 8: Bournbrook communal recycling bins in Bournbrook

B5.3 Lessons learned

The bins proved to be so popular that Birmingham council had to arrange for weekly collections to prevent the bins from overflowing. This shows that for the success of a recycling scheme, waste collection should match the waste generation in an area and the relevant arrangements need to be made in time.

B6 Case study: Milan, Italy

B6.1 Overview

This case study was produced based on publicly available information[92,93].

The city of Milan, Italy, which is also Italy's most important economic centre, produces approximately 665,000 tonnes/annum of waste, of which 285,000 tonnes is organic waste (i.e. food and green waste).

Organic waste collected from Milan is taken to the Montello Biogas & Composting plant (**Figure B 9**), where 86% of the waste is captured.

The biogas that is produced is used in the generation of energy via a power plant with an 11MW power generation capacity. The compost that is also produced is meets the appropriate quality standards and thus, it is certified.

[92] Consorzio Italiano Compostatori (2014), *Food waste collection in metropolitan areas: Milan (Italy)*, Available at: http://www.compost.it/ (Accessed 19 December 2016)
[93] Amsa (2016), *Food and organic waste collection*, Available at: http://www.amsa.it/gruppo/cms/amsa/multilingua/en/raccoltaumido/ (Accessed 19 December 2016)

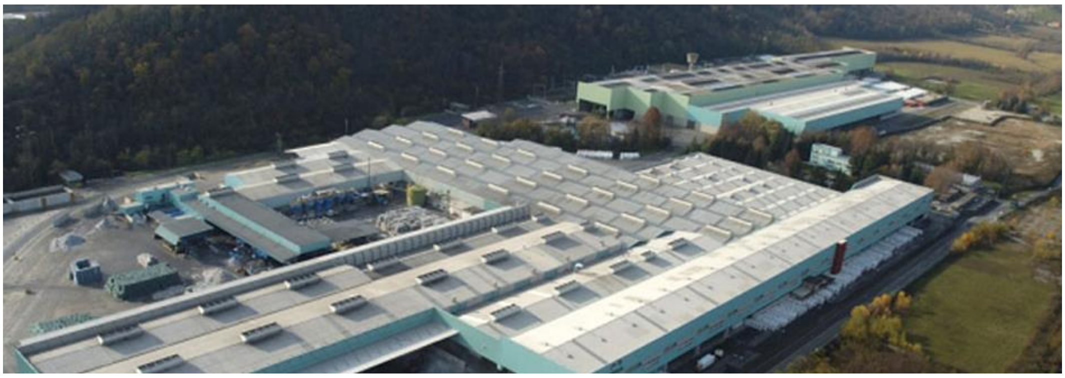

Figure B 9: The Montello Biogas & Composting plant

B6.2 Strategy

The food waste recycling rate of Milan in 2012 was 34.5%. However, food collection occurred only within the Horeca sector (i.e. from hotels, restaurants and cafés). This is equivalent to 23kg/capita/annum.

A stepwise introduction of separate food waste collections was introduced between November 2012 and June 2014, in order to include household food waste collections throughout Milan. The introduction occurred at different times for Milan’s four districts.

Within each district, the introduction of the new collection system occurred in three steps:

5. Baseline survey/Investigation;
6. Distribution of collection containers; and
7. Public engagement and awareness campaigns.

The baseline survey and investigation step included the verification of available spaces for bio-bins inside private properties, the creation of preliminary contacts with building-managers, the mapping of refuse chutes and the mapping of critical areas.

The container distribution included the provision of 10-litre caddy bins and 25 bio-bags to be used for lining the caddy bins for each household, together with information leaflets on how to participate in the new collection system. Brown wheeled bins were also provided for the outdoors storage of food waste, from which the actual collections occur. For blocks of flats, the distribution involved an appropriate number of wheeled bins according to the dimension of each block (**Figure B 10**).

Figure B 10: The types of containers provided to all households

The food waste collection scheme is operated by Amsa, which is a publicly-owned company and is responsible for the overall municipal solid waste management in Milan.

Household collections occur bi-weekly, while Horeca sector and school collections occur six times a week.

Most vehicles used are non-compacting. Vehicles run on methane or biodiesel. They transfer the food waste to one of two transfer stations. From there, waste loaders (mainly rear loaders), transport the food waste to the Montello Biogas & Composting plant.

The introduction of household food waste collections, resulted in the collection of 91kg/capita/annum of food waste, which translates to 86% diversion of food waste from residual waste. During the 2014/2015 period, it was estimated that 260,000 tonnes/annum of food waste was recycled.

B6.3 Lessons learned

Following a survey that included 800 inhabitants, it was shown that customer satisfaction with the food waste collection system is significantly high. Of the surveyed residents, 79% said that they think that the collection service is either very efficient or efficient. In addition, it was shown that the use of vented kitchen caddy bins with bio-bag liners resulted in higher acceptance and participation rates by the residents. Since the levels of contamination are low (<5%), the AD and composting processes can occur efficiently. Overall, Milan's food waste recycling scheme is a good indication that food waste collection can also be effective in metropolitan areas.

B7 Case study: Yuhua, Singapore

B7.1 Overview

This case study was produced based on publicly available information[94,95].

Yuhua is a precinct located at Jurong, Singapore. The area's Housing Development and Board (HDB) retrofitted an AWCS into 38 residential blocks of flats in Yuhua, consisting of 3,200 households (**Figure B 11**) through a project that started in 2015 and ended in 2016. The technology provider is ST Environment Services & Technologies Ltd (STE&T).

The retrofitting was facilitated by the existing waste chutes, which were already installed in all of the high-rise blocks of flats in the development.

The Yuhua case study is included in this RWMS as it is a good example of how waste chutes can be combined with an AWCS to improve the waste collection within a large housing estate.

These efforts have been part of HDB's Greenprint scheme in Yuhua which aims to create more sustainable homes. Yuhua is the first HDB estate to be part of this scheme.

B7.2 Strategy

Residents can dispose of their residual waste through the waste chutes, which lead to the centralised bin centre, which is also located on site. Residents can recycle their items at 24 outdoor disposal inlets which are located throughout the estate. These outdoor recycling inlets are available only for dry, mixed recycling.

The two-stream source segregation strategy is compliant with Singapore’s national waste collection strategy, which includes also includes the same two streams; dry mixed recyclables and residual waste.

The system has an automatic air flushing and drying mechanism which works by forcing air at a higher speed through the pipes, thereby cleaning and drying them at the same time with each waste stream.

STE&T claims that its system's collection pipeline design - of pipe elbows and bends - allows better conveyance of glass and metal waste. This is an important advantage of this system, as the operators of many other AWCSs (e.g. Wembley), do not allow the disposal of glass through the system, due to its potential detrimental effects on the pipes.

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[94] London Waste and Recycling Board (2014), *Waste Management Planning Advice For Flatted Properties – Case Studies*, Available at: http://www.lwarb.gov.uk/wp-content/uploads/2015/05/Waste-management-planning-advice-for-flatted-properties-case-studies.pdf (Accessed 9 December 2016).

[95] Housing & Development Board (2016), *Waste Management Pneumatic Waste Conveyance System*, Available at: http://www.hdb.gov.sg/cs/infoweb/about-us/our-role/smart-and-sustainable-living/hdb-greenprint/waste-management (Accessed 9 December 2016).

In the context of public awareness, HDB staff are visiting residents to explain how the system should be used. Residents are advised to avoid heavy, bulky, long items, as well as foam packaging, plastic wraps and large carton boxes.

B7.3 Lessons learned

The retrofit of an AWCS in building blocks shows how odour associated with the presence of waste chutes without an AWCS can be eliminated. Subsequently, it demonstrates how two beneficial waste collection arrangements can be combined to achieve greater benefits;

Although retrofitting is facilitated through certain existing conditions (i.e. the waste chutes in this case), it is potentially more difficult to install an AWCS with indoors source-segregation on every floor. It is still a positive outcome that residents have the chance to recycle at outdoors inlet points, but it is more difficult to engage people to recycle at desirable levels in this way.

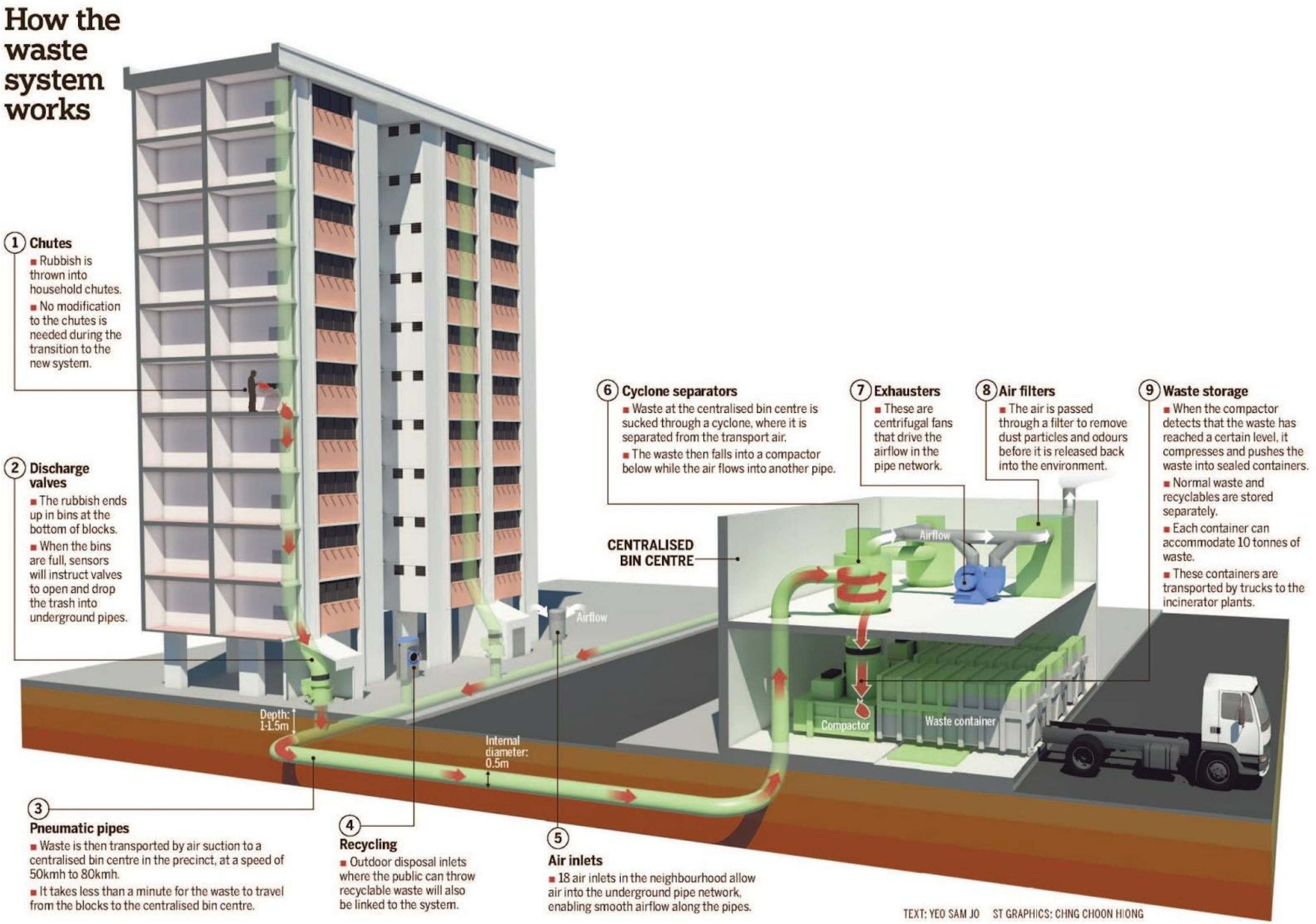

Figure B 11: The AWCS in Yuhua

B8 Case study: Msheireb Downtown, Doha, Qatar

B8.1 Overview

This case study was produced based on a technical note produced by Arup in July 2016.

The AWCS in Doha, Qatar, is being developed as part of the Msheireb – Heart of Doha project, which began in 2011 and it is planned to finish by 2017 (**Figure B 12**).

The Msheireb Doha case study is included in this RWMS as it is a good example of a three-stream waste source-segregation strategy servicing both residential and commercial land uses.

Msheireb is aiming to be the world's first sustainable downtown regeneration project. It has been designed to revive the old commercial district in a sustainable manner, adhering to green building standards.

Figure B 12: Installation of the AWCS pipes at the Mshreib development

B8.2 Strategy

The AWCS consists of a horizontal vacuum system, provided by Envac, which will start serving a residential area and a shopping centre and has a capacity of 25 tonnes/day. More specifically, the system will serve an area of 760,000m^2, with 16,621 fixed users and approximately 50,000 daily visitors. It includes the following specification:

8. Residential area

9. Shopping Centre
10. Number of inlets: 263
11. Total pipe network length: 6,000
12. Number of Waste fractions: 3
13. Waste fraction types: food waste, dry mixed recyclables (glass, plastic, metal, paper, card) and residual waste.

The three vertical chutes for organic waste, dry waste and mixed recyclables are installed in every residential building, with three waste inlets located on each floor.

The inlet doors are equipped with a weighing mechanism, which weighs and disposes the waste, and it also records' all users and waste disposal transactions, which is possible due to the use of access card readers.

The waste is air-transported from the inlets to the central waste collection terminal, whose maximum distance from an inlet is 3km.

As recycling habits are not well incorporated into the local culture, the scheme will also include education programmes, such as site visits to the central collection system, to observe how waste is collected and segregated.

The installation cost Msheireb Properties 180 million Swedish Krona.

B8.3 Lessons learned

As recycling and waste reduction awareness is not well-embedded in Qatar's culture, Envac will hold workshops for the AWCS users to make sure that they understand how to use the system in the best possible way. This is a good lesson even for more environmentally-aware regions, like the UK, to show that with the introduction of any new system, residents have to be well-engaged and should understand the importance of participating in new waste management schemes.

B9 Case Study: Songpa, Seoul, South Korea

B9.1 Overview

This case study was produced based on publicly available information [96,97].

The Songpa district developed a zero waste park, which acts as a food waste treatment centre in Janjidong. The Songpa Food Waste Treatment Centre is situated within a residential area (**Figure B 13**). It was established in 2010 and it

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[96] Legislative Council of the Hong Kong Special Administrative Region - Delegation of the Panel on Environmental Affairs (2013), *Report on the Duty Visit to the Republic of Korea to Study its Experience on Waste Management*, Available at:http://www.legco.gov.hk/yr13-14/english/panels/ea/papers/ea1125cb1-377-1-e.pdf (Accessed 11 December 2016).
[97] Ho, Kang (2013), *South Korea Country Report*, Available at: http://www.biogas.cn/UpLoadEditor/file/20140116/20140116162010_2457.pdf (Accessed 11 December 2016).

is a privately-run plant. The Recycling Centre recycles food waste using AD technology.

South Korea aims to achieve 100% food waste recycling by 2017, using the food waste in the production of biogas. In general, South Korea aims to reach a 75% recycling rate by 2017, to be the highest recycler in the world.

The Songpa case study is included in this RWMS as it is an important demonstration of the fact that food waste recycling can be both feasible and beneficial within dense residential developments, if managed correctly.

Figure B 13: The AD facility in Songpa

B9.2 Strategy

Two garbage workers inspect, scan and collect food waste containers in Seoul's Songpa District **Figure B 14**). Each container has a barcode unique to every household. The residents pay a monthly collection fee based on the amount of food waste discarded.

Figure B 14: Inspection, scanning and collection of food waste containers in Songpa

To minimise the nuisance to nearby residents, collected food waste is unloaded in the underground area of the Recycling Centre.

The facility has a capacity of 450 tonnes/day, but its average throughput is 300 tonnes/day. The hydraulic retention time is 15 days.

The biogas that is generated from the process, is used to produce heat. In 2011, 653,800m^3 of biogas were produced at the facility.

After the necessary processing and treatment in the recycling facility, food waste is turned into different resources, including animal feed, bones, biodiesel and metal items (**Figure B 15**).

Figure B 15: Food waste undergoing the AD process (top) and its resulting products from left to right - animal feed, bones, steel utensils, biodiesel, recyclables, and wooden chips (bottom)

B9.3 Lessons learned

The strict and well-targeted waste policies of South Korea, have resulted in the implementation of successful waste reduction and recycling schemes.

Food waste processing is feasible within a residential area if it can be managed underground and in general if measures are put in place to ensure that the waste is contained in such a way that odour and other health and safety issues are avoided.

Implementing a PAYT scheme together with a recycling scheme in a residential area, can have positive synergistic effects, as there is a focus on the waste hierarchy, as people are taught to reduce their waste generation rates rather than simply rely on recycling.

Appendix C

Waste forecast assumptions

Table C 1: Summary of assumptions used in the waste forecast

Assumption	Value	Units	Comment	Source
Demolition schedule				
1A demolition area	45,211	m^2	Buildings to be demolished: Portal West Business Centre, The Portal, Ramada Encore Hotel and two other buildings. Assume all steel frame.	OPDC Demolition Schedule
1B demolition area	4,465	m^2	Buildings to be demolished: Newly built, not yet occupied. Assume all structural concrete.	
2 demolition area	40,155	m^2	Buildings to be demolished: Perfume factory and Victoria Industrial Estate. Assume all structural concrete.	
3 demolition area	770	m^2	Buildings to be demolished: Esso station and two other buildings. Assume all masonry.	
4 demolition area	0	m^2	-	
5 demolition area	37,507	m^2	Buildings to be demolished: Westway Estate and Brunel House. Assume all masonry.	
6 demolition area	105,939	m^2	Buildings to be demolished: Torpedo Factory, Chandos Park Industrial Estate, Europa Studios, Boden House, Waitrose, Lewis House, HR Owen, Acton Business Centre, Hedley Humpers, Bestway Cstering, Jack Wills, Braitrim House and other buildings. Assume all steel frame.	
7 demolition area	20,403	m^2	Buildings to be demolished: Chandelier Building, Pentacostal City Mission Inc, Willesden Diesel Locomotive Depot and two other buildings. Assume all steel frame.	

Assumption	Value	Units	Comment	Source
8 demolition area	103,421	m^2	Buildings to be demolished: Apex Industrial Estate, Gateway Trading Estate, Hyrthe Road Industrial Estate and Regents House. Assume all steel frame.	
9 demolition area	12,442	m^2	Assume all steel frame.	
10 demolition area	11,579	m^2	Assume all steel frame.	
11A demolition area	4,468	m^2	Buildings to be demolished: Triangle Business Park. Assume all steel frame.	
11B demolition area	1,751	m^2	Assume all masonry.	
12 demolition area	2,629	m^2	Assume all steel frame.	
13 demolition area	9,452	m^2	Buildings to be demolished: Powerday Recycling Centre. Assume all steel frame.	
14 demolition area	6,879	m^2	Assume all steel frame.	
15A demolition area	8,933	m^2	Buildings to be demolished: Railyard. Assume all steel frame.	
15B demolition area	8,933	m^2	Buildings to be demolished: Railyard. Assume all steel frame.	
16 demolition area	32,377	m^2	Buildings to be demolished: Railyard. Assume all steel frame.	
17 demolition area	0	m^2		
18 demolition area	19,478	m^2	Assume all steel frame.	
19 demolition area	10,487	m^2	Assume all steel frame.	
Average floor height				

Assumption	Value	Units	Comment	Source
Average floor height	3	m	Assumption used to determine volume of buildings to be demolished.	
Demolition waste generation rates				
Steel frame building	0.470	tonnes/m^3		WRAP Net Waste Tool - Demolition Bill of Quantities Estimator
Structural concrete building	0.480	tonnes/m^3		
Masonry building	0.540	tonnes/m^3		
Construction area schedule				
Additional residential units	26,804	households	Total housing provision from 'Design and Technical Study Input' column (26,247 households) plus hotel and student accommodation provided (26,804 households)	OPDC - Phasing Trajectory v5
Residential usable space	94	m^2	In 2014, homes had an average usable floor space of 94 square metres	Department for Communities and Local Government (2016). *English Housing Survey Housing Stock Report 2014-15*.
Residential development area	2,519,548	m^2	Estimated floor space	-
Office development area	660,360	m^2	Total office floor space provision from 'Design and Technical Study Input' column	OPDC - Phasing Trajectory v5
Retail development area	44,018	m^2	Total retail and leisure floor space provision from 'Design and Technical Study Input' column. OPDC Retail and Leisure Needs study suggests potential retail floor space is 3 times more than potential leisure space	

Assumption	**Value**	**Units**	**Comment**	**Source**
Leisure development area	14,673	m^2	Total retail and leisure floor space provision from 'Design and Technical Study Input' column. OPDC Retail and Leisure Needs study suggests potential retail floor space is 3 times more than potential leisure space	
Industrial development area	57,400	m^2	Represents designated industrial development areas (i.e. Strategic Industrial Locations), which reflects existing industrial uses rather than replacing non-industrial uses - as described by Peter Farnham, OPDC Principal Planning Officer. Therefore, construction waste related to industrial development not included in waste forecast.	OPDC (2016). *Draft Local Plan*.
Construction waste generation rates				
Commercial residential	0.168	tonnes/m^2		Building Research Establishment (2012). *Waste Benchmark Data*.
Commercial office	0.238	tonnes/m^2		
Commercial retail	0.275	tonnes/m^2		
Commercial leisure	0.216	tonnes/m^2		
Commercial industrial	0.126	tonnes/m^2		
Development period				
Development period	32	years	Construction period assumed from 2017 to 2049 seeing as residential units are planned to come online in 2018 with the last residential units planned to come online in 2049. This development period is used to annualise demolition and construction waste forecasts.	OPDC - Phasing Trajectory v5

Assumption	**Value**	**Units**	**Comment**	**Source**
Household population				
Existing residential units	2,800	households		OPDC (2016). *Draft Local Plan*.
Additional residential units	26,804	households	Total housing provision from OPDC 'Design and Technical Study Input' column (26,247 households) plus hotel and student accommodation provided (26,804 households)	OPDC - Phasing Trajectory v5
Total residential units	29,604	households	Calculated value	-
Residential unit density - Brent	2.684	capita/household	Average between 2011 and 2036 value	Greater London Authority and SLR Consulting (2014), *Waste Arisings Model: Further Alterations to the London Plan*.
Residential unit density - Ealing	2.642	capita/household	Average between 2011 and 2036 value	
Residential unit density - Hammersmith & Fulham	2.280	capita/household	Average between 2011 and 2036 value	
Residential unit density - Average	2.535	capita/household	Calculated average	-
Total household population	75,053	capita	Calculated value	-
Household waste generation rate				
Household waste generation rate - Brent	0.301	tonnes/capita/annum	Calculated value	Greater London Authority and SLR Consulting (2014), *Waste Arisings Model: Further Alterations to the London Plan*.
Household waste generation rate - Ealing	0.293	tonnes/capita/annum	From 2016-2036	
Household waste generation	0.316	tonnes/capita/annum	From 2016-2036	

Assumption	**Value**	**Units**	**Comment**	**Source**
rate - H&F				
Household waste generation rate - Average	0.303	tonnes/capita/annum	Calculated average	-
Household waste composition				
Organic waste composition	40%	%		Department of Environment, Food & Rural Affairs (2013). *EV0801 National Compositional Estimates for Local Authority Collected Waste and Recycling in England 2010/11*.
Paper & cardboard waste composition	22%	%		
Plastics waste composition	11%	%		
Glass waste composition	7%	%		
Metals waste composition	3%	%		
Wood waste composition	1%	%		
Textiles waste composition	3%	%		
Inerts waste composition	4%	%		
Residual waste composition	7%	%		
WEEE waste composition	1%	%		
Hazardous waste composition	1%	%		
Total waste composition	100%	%		
Employee population				
Existing employee population	36,000	employees		OPDC (2016). *Draft Local Plan*.
Additional employee	59,000	employees	3,108 new retail jobs / 56,000 new office jobs	OPDC (2016). *Development*

Assumption	Value	Units	Comment	Source
population - Old Oak				*Capacity Study*.
Additional employee population - Park Royal	12,100	employees	300 new retail jobs / 11,800 new industrial jobs	
Additional employee population - Total	71,100	employees		
Total employee population	107,100	employees	Calculated value	-
Commercial and industrial waste generation rate				
Commercial and industrial waste generation rate	0.969	tonnes/employee/annum	2016 value	Greater London Authority and SLR Consulting (2014), *Waste Arisings Model: Further Alterations to the London Plan*.
Commercial and industrial waste generation rate	0.937	tonnes/employee/annum	2021 value	
Commercial and industrial waste generation rate	0.905	tonnes/employee/annum	2026 value	
Commercial and industrial waste generation rate	0.875	tonnes/employee/annum	2031 value	
Commercial and industrial waste generation rate	0.845	tonnes/employee/annum	2036 value	
Commercial and industrial waste generation rate - average	0.906	tonnes/employee/annum	Calculated average	-
Commercial and industrial waste composition				
Animal & vegetable waste composition	16%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	Department of Environment, Food & Rural Affairs (2010). *Survey of*

Assumption	Value	Units	Comment	Source
Chemical waste composition	8%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	*Commercial and Industrial Waste Arisings - Report tables 2009*.
Common sludges composition	0%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	
Discarded equipment composition	4%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	
Healthcare waste composition	6%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	
Metallic waste composition	6%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	
Mineral waste composition	3%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	
Non-metallic waste composition	58%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	
Non-waste composition	0%	%	Average C&I waste generation in LB Brent, Ealing and Hammersmith & Fulham	