

Resource Efficient Use of Mixed Wastes

Case study: Construction works in the preparation of the Olympics games in London 2012



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Key findings

Construction works in the preparation of the Olympics games in London 2012

Context

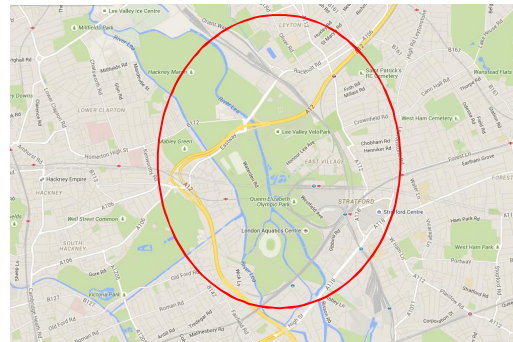
This case study represents the best practices implemented during London 2012 Olympic Park Construction for construction and demolition waste (CDW) management and resource efficiency.

When London won the right to host the London 2012 Olympic and Paralympic Games in July 2005, the bid team identified a 2.5 km² site in East London, as the site for the Olympic Park.

The Olympic Delivery Authority (ODA) pledged to hold the greenest Games of modern times and sustainability was built into all the activities, from the procurement to the operation of the Games.

An exemplar sustainable waste management objective was set during the design, demolition and construction phases of the Olympic Park, and sustainability targets, including an overall target of at least 90% by weight of demolition material to be reused or recycled were adopted.

In addition to the design and construction of London 2012 Olympic and Paralympic Games, the ODA also took into consideration the post Games legacy, which is managed by the London Legacy Development Corporation.



Queen Elizabeth Olympic Park
London E20 2ST

- Key figures
- 98.5% (427,531 tonnes) reuse and recycling rate was achieved
- 425,000 tonnes of waste were diverted from landfill;
- Over 20,000 lorry movements were saved
- Over 1.5 million cubic metres of soil was cleaned onsite and reused
- Approximately 170,000 tonnes, equivalent to nearly 22% of aggregates was from recycled and secondary sources
- 20,000 tonnes of new materials were saved

Objectives

The ODA set a number of CDW targets during the demolition, design and construction phases of the London 2012 Olympic Park, including:

- 90% re-used or recycled demolition waste **by weight**
- 90% re-used or recycled construction waste **by weight**
- 20% of materials to be from a re-used or recycled source by value
- 25% recycled aggregate by weight

This project is considered unique due to the need to design for the both the staging of the London 2012 Olympic and Paralympic Games and the post-Games legacy.



<p>Description</p> <ul style="list-style-type: none"> • In 2005, London submits its bid for the 2012 Olympic Games with sustainability included as a key commitment and subsequently won the rights to host the Games. • The site identified for the Games was in Stratford, East London, England, a previous industrial site. • The mission of the body set up to oversee the delivery, the Olympic Delivery Authority's (ODA) was to “deliver venues, facilities and infrastructure and transport on time and in a way that maximises the delivery of a sustainable legacy within the available budget”. • In 2007, the ODA published their Sustainable Development Strategy with set out how the ODA intended to deliver a sustainable legacy complementing its other objectives, including delivery on time and the achievement of value for money. • The ODA worked with the Delivery Partner (DP), which was a consortium of CH2M Hill, Laing O'Rourke and Mace (CLM) with Atkins as project manager. • Demonstrating exemplar sustainable waste management during the demolition, design and construction phases of the Park project presented a myriad of challenges for the ODA (for example, achieving a target for 90 per cent re-use, recycling or recovery waste segregation by contractors) • There were many stakeholders working together to achieve the project's waste targets. Clear processes, allocated responsibilities and communication were key factors in ensuring that these relationships were effective. 	<p>Key factors of success and potential for replicability</p> <p><i>Design out Waste (DoW)</i></p> <ul style="list-style-type: none"> • Setting out early on the whole project lifecycle for waste management; • Define targets and embedding in briefs, procurement documentation and contracts; • Improve DoW opportunities and provide guidance to design teams; • Designing future buildings for deconstruction is essential for facilitating higher levels of reclamation and re-use. <p><i>Demolition and remediation</i></p> <ul style="list-style-type: none"> • The approach of integrating pre-demolition audits with materials management planning. • A waste strategy was developed which resulted in 98.5% of Olympic Park demolition materials being diverted from landfill as well as cost savings through innovative solutions developed by the project teams. <p><i>Construction</i></p> <ul style="list-style-type: none"> • Working in partnership with the English Regulator, allowing the Park site to operate as a single site in terms of waste management. • A Waste Consolidation Centre (WCC) was set up on site to achieve economies of scale and minimise the effects of transporting waste. • Accurate forecasting of waste is important to ensure planning and resource efficiency. • Incentivisation of partner organisations via a share in savings and recognition through awards were key drivers for high levels of waste segregation.
<p>Conclusion</p> <p>Two of the most important lessons from the learning legacy were that many of the environmental sustainability benefits go hand in hand with cost savings, and that with the right approach to projects of this scale it is possible to drive innovation in areas such as design and materials specification.</p> <p>The ODA's overall objective of achieving exemplar sustainable waste management was achieved on a project of significant scale, with challenging and inflexible deadlines</p>	<p>Useful links</p> <p>http://learninglegacy.independent.gov.uk/index.php</p> <p>http://queenelizabetholympicpark.co.uk/</p> <p>https://www.london.gov.uk/sites/default/files/2901179_OlympicLegacy_acc.pdf</p> <p>https://www.gov.uk/government/publications/london-2012-legacy-sustainable-procurement-for-construction-projects</p> <p>http://www.constructionproducts.org.uk/?eID=dam_frontend_push&docID=1333&filename=Olympics_Legacy_single_pages_master_online.pdf</p> <p>http://assets.wwf.org.uk/downloads/towards_a_one_planet_olympics_revisited.pdf</p>

1. Introduction

1.1. Context of the initiative

When London won the right to host the 2012 Olympic and Paralympic Games in July 2005, the bid team identified a 2.5 km² site in the Lower Lea Valley, in Stratford, East London, as the site for the Olympic Park. The project was intended to catalyse regeneration in this area of East London.

The Olympic Delivery Authority (ODA) had to consider which of the existing buildings on the site could be used to minimize new construction, as well as which venues and infrastructures would be permanent or temporary. It was decided that only five permanent venues would be constructed on the Park site:

- Olympic Stadium
- Aquatics Centre
- Velodrome
- Handball Arena
- Eton Manor Sports Complex.

Other buildings included, the Athletes Village which became a residential quarter of Stratford City and the Olympic Press and Broadcast Centres were adapted to become office spaces.

In addition to the design and construction of the Games, the ODA had to take into consideration the post-Games legacy. The Olympic Park was named the 'The Queen Elizabeth Olympic Park' and in 2012, the London Legacy Development Corporation was given responsibility for the redevelopment of the Park, with the aim to create diversity and cultural vibrancy, economic growth and the city's newest, cleanest and most sustainable communities.

The post Games legacy intends to:

- Connect the United Kingdom's passion for sport to increase grass roots participation, particularly by young people – and to encourage the whole population to be more physically active.
- Exploit to the full the opportunities for economic growth offered by hosting the Games.
- Promote community engagement and achieving participation across all groups in society through the Games.
- Ensure that the Olympic Park can be developed after the Games as one of the principal drivers of regeneration in East London.

As part of the bidding process, the London 2012 bid team began by working with BioRegional and WWF to create a shared vision called "Towards a One Planet Olympics". This included an aspiration of 'zero waste' involving the development of closed resource loops, reducing the amount of waste produced, then reclaiming, recycling and recovery.

The ODA then developed the mission to "*deliver venues, facilities and infrastructure and transport on time and in a way that maximises the delivery of a sustainable legacy within the available budget*". To achieve this, the ODA undertook a number of actions including:

- Publication of the ODA's Sustainable Development Principles
- Development of the Sustainable Development Strategy in 2007, following on from the publication of the London 2012 Sustainability Policy. This Strategy had 12 objective areas; the objective for waste was: 'To optimise the opportunities to design out waste, and to maximise the reuse and recycling of material arising during demolition, remediation and construction'. The actions within this Strategy for waste were to:
 - operate within the ODA's waste hierarchy of eliminate, reduce, re-use, recycle, recover, dispose
 - at least 90 per cent, by weight, of the material arising through the demolition works will be reused or recycled.
- Permanent buildings would achieve a Building Research Establishment Environmental Assessment Method (BREEAM) 'excellent' rating, after the Games. To take this forward, it was necessary to develop a bespoke version of BREEAM that could be applied to both the sport venue and the park itself. For waste, credits were awarded by reducing wastage rates by 25% below standard industry practice.

- The ODA worked with the Delivery Partner (DP), CLM (a consortium of CH2M Hill International, Laing O'Rourke and Mace) with Atkins as the project manager to achieve these objectives.

Before the construction phase started, over 215 buildings had to be demolished, as well as a number of walls, bridges and roads. Contaminated land on site also had to be remediated and was a major part of the site's preparation. The site was highly contaminated as a result of pollution, non-regulated industries and unappropriated use of land in the past.

1.2.Objectives

The ODA ensured that responsibility for sustainability was taken very seriously by the project team. In setting objectives and targets for waste management, there was a commitment to deliver greater sustainability by working proactively with the supply chain. The objectives and targets established in relation to CDW and resource efficiency are presented below based on the project's phases.

Objectives

- Optimise the opportunities to design out waste, and to maximise the re-use and recycling of material arising during demolition, remediation and construction.
- Operate within the ODA's waste hierarchy of: eliminate, reduce, re-use, recycle, recover, and dispose.
- Minimise the amount of waste to be removed from the site and use sustainable transport methods where possible.

Design out Waste (DoW)

- The ODA is seeking to design out, as far as practical, the production of waste during construction and operation of the facilities. When designing venues, materials selection and structure will be kept under review to help minimise waste.
- At least 20% by value, of materials to be from a re-used or recycled source.
- At least 25% recycled aggregate, by weight, for the permanent venues and associated Park-wide infrastructure.
- Across all of the elements of the Park, care will be taken to optimise the provision of permanent elements for legacy and temporary elements for Games time.
- To minimise any waste during the conversion from Games to the legacy phase, all temporary venues and structures will be designed with re-use and recycling in mind.

Demolition and remediation

- At least 90%, by weight, of the material arising through the demolition works will be re-used or recycled.
- The topographical modelling and demolition waste strategy should minimise the export of material and minimise the import of clean material or secondary aggregate.

Construction

- At least 90%, by weight, of the material arising through construction to be re-used, recycled or recovered.
- Waste should be managed based on the proximity principle and source segregation.¹

The CDW objectives and targets defined for the project were included in the briefs, procurement documentation and contracts, to ensure project teams were aware of the requirements for all of the project's phases.

1.3.Results

The Sustainable Development Strategy was intended to act as a catalyst for the construction industry to deliver an improvement in the economic, social and environmental sustainability of development across the UK. The intention was for the lessons from London 2012 to be spread far and wide. Two of the most important lessons from the learning legacy are that many environmental sustainability benefits go hand in hand with cost savings,

¹Jo Carris and Dan Epstein (2011), The Olympic Park Waste Strategy: Development and Implementation

and that with the right approach to projects of this scale it is possible to drive innovation in areas such as design and materials specification.

To achieve high levels of diversion of CDW from landfill, manage it legally, efficiently and cost effectively, presented a challenge for all the actors involved, but remarkable performance levels were achieved in all the phases of the project. The results and achievements are summarised in turn for each phase.

Designing Out Waste

Designing out waste (DoW) principles were adopted by the project team and any savings were quantified in terms of tonnes of CDW and costs. These principles have been established by the Waste & Resources Action Programme (WRAP) and they should be considered for all stages of a project’s lifecycle, to systematically evaluate waste and resource use as part of the design development and review process. The most effective opportunities for DoW are at the early stages of design; in the latter stages the design becomes ‘locked down’ and interdependent so only incremental improvements rather than fundamental changes can be achieved without incurring significant cost and effort.

The DoW five basic principles are:

- Design for reuse and recovery – this includes reusing materials and/or components on site; using materials that have a high recycled content or recovered from other sites (e.g. recycled aggregates and salvaged items)
- Design for off-site construction – using offsite processes which leads to less waste, reduced risk to construction programmes and better quality.
- Design for materials optimisation – this can include using less material in the design and/or generating less waste. This can include simplification of the design, standardisation of materials and components and dimensional co-ordination.
- Design for waste efficient procurement- this involves working with contractors and subcontractors to reduce waste which could arise from design specifications, construction methods and sequencing of work.
- Design for deconstruction and flexibility – designers should consider how materials can be recovered during refurbishment and end of life and how the design can aid this.

The project team implemented waste minimisation initiatives identified at the design stage and continued to identify opportunities to design out waste during the construction, resulting in lower than forecasted waste arising across the site. Many examples were identified as savings resulting from different approaches to “regular design” using the DoW principles. Examples are shown in Table 1.

Designing Out Waste Principle (DoW)	Examples
Design for reuse and recovery	<ul style="list-style-type: none"> • On average, the structural concrete contained 30% recycled aggregate by weight of total aggregate and, depending on the class of concrete, between 25% and 40% by weight of pulverised fuel ash as a cement replacement • A solution was developed for the structural fill for two bridges which enabled 18,700 tonnes of recycled material from site to be used • 3,000 tonnes of recycled railway ballast was used instead of virgin aggregates in the vibro-stone columns for the Basketball Arena’s foundations. • 354 metres of existing cast-iron and steel fencing refurbished and reused instead of purchasing new park railings
Design for off-site construction	<ul style="list-style-type: none"> • The multi-storey car park serving the press centre was originally intended to be a cast in-situ structure, however this was changed to a prefabricated structure of steel and

Designing Out Waste Principle (DoW)	Examples
	<p>concrete which reduced the amount of materials required, the temporary works as well as reducing construction time.</p> <ul style="list-style-type: none"> • Toilet facilities for the International Broadcast Centre were designed to be manufactured off-site in a modular form and simply lifted into place.
Design for materials optimisation	<ul style="list-style-type: none"> • The design team for the Velodrome proposed a cable net roof which uses significantly less steel than more traditional options and enables other parts of the structure to be designed for reduced loads. • The foundations for the Stadium were largely pre-cast concrete piles and vibro-stone columns which minimised the amount of contaminated soil arising
Design for waste efficient procurement	<ul style="list-style-type: none"> • 2% wastage was achieved for 33,800m² of cladding by using coils of cladding which were cut and formed to size on site. • For the Velodrome site an on-site batching plant for mortar was used, enabling it to be used as required – this enabled the mortar waste to be reduced to around 5% (the industry norm is estimated to be around 20%) • Reusable packaging was agreed with the supplier of the 80,000 seats for the Stadium, instead of individual cardboard boxes
Design for deconstruction and flexibility	<ul style="list-style-type: none"> • The McDonalds restaurant onsite was a modular construction, enabling it to be dismantled for reuse following the games. Where items could not be reused, they were returned free of charge, to suppliers for recycling • The International Broadcast Centre was designed with a flexible internal layout to assist with a range of post-Games uses and was bolted connections were used for the steelwork to enable deconstruction/adaptation. The mechanical and electrical services were also easily accessible allowing them to be removed after the Games.

Table 2: Designing out Waste Principles (DoW) examples on the Olympics Games in London

Additionally, as a number of the venues were temporary, a set of temporary material guidelines were produced in collaboration with industry. These provided a framework for the project team on how to manage the sustainability impact of the materials used. One objective included zero waste to landfill. Reuse of materials was especially important with suppliers encouraged to take back their products and products and materials donated to community organisations. Suppliers had to ensure that items did not end up in landfill.

Demolition Waste Management

Key results

- 98.5 % (by weight) of demolition material was re-used or recycled, exceeding the original target of 90%, and above UK industry best practice at 95%. This rate is based on the quantities of material that were recorded on to BRE's SMARTWaste system² (an online tool to measure and monitor construction site impacts). This is equivalent to around 425,000 tonnes of demolition waste diverted from landfill.
- The majority of demolition materials were concrete, hardcore or masonry and all of this was processed and used on site, which saved over 20,000 lorry movements. This reduced the impact on the local community, as well as CO2 emissions.
- Nine steel portal framed buildings were deconstructed and were reclaimed for re-use. Other types of various materials were reclaimed and stored for re-use on the Park (660 tonnes of various brick types, 176 tonnes of paving material and 5,400 m of kerb).
- The ODA and the project team set up various ways to 'close the materials loop' between the use of materials from the demolition and new materials for construction. The use of demolition material as aggregates results in a save of 20,000 tonnes of new materials.
- For the site remediation, this was undertaken on site by creating "soil hospitals" that treated contaminated soil using techniques including bioremediation, soil washing, and chemical and geotechnical stabilization. Over 1.5 million m³ of soil was cleaned on site, resulting in the creation of more than 100 hectares of open space.

Construction Waste Management

Key results

- The ODA, DP and principal contractors worked together and collaborated with environmental regulators to set up the appropriate waste management processes to ensure that the best waste management was implemented. The Park operated as a single site for the purposes of waste management licensing and regulatory controls.
- The target of 90% reuse, recycling or recovery was achieved, with 98% being met. At the beginning of the construction, the recovery figures were low, at around 30% due to poor segregation, with the majority of waste being managed as mixed construction waste. This improved substantially, when the waste management contractor used a local material recovery facility that could segregate mixed construction waste with high recovery rates.
- The ODA defined that waste management should be undertaken as near to the Park as possible, to ensure a reduced impact on the local communities and related carbon savings. Vehicle movements related to waste management were reduced by approximately 90%. This was reached using barges to remove selected waste streams (by the River Lea and the extensive canal network) as well as with the installation of the Waste Consolidation Centre onsite. This Centre consolidated and compacted bulky waste and also enabled the crushing and reusing of concrete on-site
- Several contractors achieved segregation levels higher than 85%. Contractor's continually sought ways to improve their waste management practices. Examples of this include using waste materials for temporary works, and identifying materials suitable for reuse by others, as well as shared best practices and initiatives. Contractors worked together for the Main Stadium and the Aquatics Centre, to implement a take-back arrangement for timber pallets.

² For more information on SMARTWaste, go to www.smartwaste.co.uk

2. Implementation of the initiative

2.1. Planning of the initiative and actors involved

The ODA commitment to sustainability for the construction of London 2012 Olympic Park was encapsulated in the One Planet Olympics bid document *“We only have one planet; London 2012 will respect its ecological limits, its cultural diversity and create a legacy for sport, the environment and the local and global community”*³

A two-year planning period allowed for overarching, programme-wide objectives to be set prior to appointing contractors. Within the first year, a firm Sustainable Development Strategy was published by the ODA which was a framework for issues and objectives. The ODA worked with a wide range of stakeholders from government, non-governmental organisations (NGOs), the local community and others, prior to engaging the design teams, to develop this Strategy. This document reflected best practices in construction. The target for CDW was 90% of material, by weight, arising through demolition works to be reused or recycled and to follow the ODA’s waste hierarchy of eliminate, reduce, reuse, recycle, recover and dispose.

The ODA established the sustainability targets and the DP was responsible for meeting them, a consortium consisting of CH2M Hill International, Laing O’Rourke and Mace (CLM). This team was responsible for ensuring waste targets were met by providing technical advice and assurance. Investing in expert advice early in the project enabled investigative work to be carried out to inform key decisions.

The DP developed the Construction Waste Management Plan and was responsible for managing the Waste Management Contractor’s site services in line with best practice and legislation, and encouraging the use of sustainable transport for removing waste from site.

A Waste Management Contractor was responsible for collecting, consolidating and transporting waste legally and sustainably. In August 2008, Veolia Environmental Services was awarded the waste management contract for the Park for services until July 2011, and the ODA obliged its contractors to use Veolia.

Designers’ within the project teams were responsible for implementing the DoW principles and working together with the principal contractors they were responsible for minimising waste during detailed design and construction.

The Park itself was divided into the North and the South side with Morrison Construction and BAM Nuttall acting as the respective Tier 1 contractors for the Enabling Works.

There were many projects undertaken on the Park during construction each their own contractors and subcontractors. At the peak of construction, there it was estimated that there were 11,000 workers employed simultaneously at the London 2012 Olympic Park site and Athletes Village.

2.2. Implementation of the initiative

Designing Out Waste

The ODA Sustainable Development Strategy defined its headline objective for waste ‘to optimise the reduction of waste through design, maximise the reuse and recycling of material arising during demolition, remediation and construction, off-site construction and material optimisation’. This was a fundamental aspect to developing the permanent and temporary venues and infrastructure on the Park. Advice was provided by the ODA in relation to the DoW principles to the project teams including:

- The reuse of materials and components on site and the inclusion of the use of materials which contain a high percentage of recycled or reclaimed materials is the best way to achieve materials resource efficiency.

WWF and BioRegional (2005), Towards a One Planet Olympics Achieving the first sustainable Olympic Games and Paralympic Games

- Definition of off-site manufacture elements, such as prefabrication of steel frames and concrete elements, helps to minimize waste, and also reduced construction timescales and lower risks to programmes.
- The design of the venues and infrastructure should consider how they can use less material and/or produce less waste in the construction process
- Examples of optimisation techniques include the minimisation of excavation, simplification and standardisation of materials and component choices, and dimensional coordination.

It was a challenge for the designers to identify how design specifications, construction methods and the work program could generate waste, and they worked together with the contractors (Tier 1 and Tier 2) for finding ways to reduce this waste. To help manage risk, trials were set up for innovative products that designers might have been reluctant to specify due to concerns regarding performance. For example, different solutions were trialled on how to avoid the use of PVC and one supplier developed a PVC wrap with a non-phthalate plasticizer (they adopted a phthalate-free wrap on the venues).

It is increasingly important that when buildings are designed, the building's life cycle of construction, maintenance, refurbishment and deconstruction is considered in relation to resource efficiency. For this project, the legacy of the games and the future occupations and uses of the venues was paramount, by avoiding the use of materials or techniques that prevent future recycling or expansion.

Demolition Waste Management

In preparation for the demolition works, a Demolition and Site Clearance Materials Management Plan was produced (November 2006) setting out the strategy for recovering and recycling demolition materials. The Tier 1 contractors completed both a pre-demolition audit and a reclamation survey, as required in Demolition and Site Clearance Materials Management Plan, in order to identify the type of waste material on site, estimates quantities of each material and its recovery potential. The plan also included a recommended route for each of the demolition material categories (for example concrete, metals, and wood), prioritising options at the top of the waste hierarchy where feasible.

The ODA and DP worked with Hyder Consulting, BioRegional and Masco to undertake the following:

- pre-demolition audits
- reclamation surveys (non-invasive, visual inspections)
- embodied carbon and recovery potential report (for four work packages)
- key opportunities reports: proposals for reclaiming steel frames and bricks

These audits collected data that helped to improve the results of the waste recovery and recycling targets for each demolition site.

The Demolition and Site Clearance Materials Management Plan defined a hierarchy of recommendations for demolition/site clearance materials to be implemented:

1. Reclaim (re-use components in their existing form)
 - a Store and re-use locally on the (demolition) site
 - b Store in the central processing area or in an Olympics designated reclamation yard for re-use in the Park-wide construction works
 - c Off-site re-use (by other projects)
2. Recycle (including reprocessing, composting, on-site remediation)
 - a Recycle, store and use locally on the (demolition) site
 - b Recycle and store in the central processing area for use in the Park-wide construction works
 - c Off-site recycling (by other projects)
3. Incineration
 - a Off-site incineration for heat recovery
4. Landfill
 - a Off-site disposal to landfill⁴

Each of the Tier 1 contractors (20 in total) produced a Site Waste Management Plan (SWMP) which identified appropriate waste management options for waste types and quantities expected to arise. Six demolition contractors carried out all the demolition works over a period of 6 months. To maximize sustainability, 'deconstruction' was implemented instead of 'demolition' to enable the reuse of as many material and

⁴ Olympic Delivery Authority (2006), Demolition and Site Clearance Materials Management Plan

components as possible. Recycling was the next preferred option. Key points for the demolition waste management are summarised:

- Specialist subcontractors implemented methods to maximize materials recovery and minimize landfill such as deconstruction of some steel portal framed buildings, removal of furniture, lighting and electrics as well as the removal of asbestos prior to demolition was carried out.
- When buildings were being demolished, materials were segregated and stockpiled for future uses, including concrete, masonry, timber, metals and asphalts.
- The overall reuse and recycling rate achieved was 98.5% which exceeded the 90% target and industry best practices. This high percentage can be accredited to execution of the plans to manage the demolition material, and the dedication of those involved.
- Some of the demolition concrete was used as recycled concrete aggregate, rather than using it as a low value application such as general fill
- Materials were kept onsite to maximise reuse and recycling opportunities (in November 2007 an on-site storage was created)
- Although 98.5% of demolition materials were re-used or recycled, it was estimated that only 0.5% was re-used, which equated to 2,171 tonnes. Factors such as cost, time, space, market demand and health and safety influenced the reclamation potential.
- All the demolition and earthworks data was collected and reported due to a requirement within the Demolition and Site Clearance Materials Management Plan. A bespoke version of BRE's SMARTWaste tool was used to track type material, tonnage, source location, end destination and whether it was re-used/recycled, or landfilled.

The ODA aimed to 'close the materials loop' between the demolition of existing buildings and construction of new venues and infrastructure and established different targets embedded into briefs and contracts for design and construction teams. Several methods such as workshops, design team visits, a material database, etc., were implemented to raise designers' awareness to use recovered demolition materials.

Table 1 summarises the roles, responsibilities and the related financial incentives and benefits of those involved for the management of the demolition waste:

Agency	Project	Responsibilities	Related Financial Incentives and Benefits
Client	Recycling Focused	n/a	Incurred additional costs through compensation events where reuse occurred.
	Reuse Focused	n/a	Competitive tenders challenge contractors to meet reuse targets, ensuring best value to the client.
Tier 1 Contractors	Recycling Focused	Soft strip and site clearance. Consideration of reuse and reclamation as part of a waste management strategy.	Own items cleared as part of the soft strip (minimal value or present a disposal cost).
	Reuse Focused	Soft strip and site clearance. Contracted to consider reuse and reclamation in the soft strip and given time and contacts in the reuse and reclamation sectors. Contracted to deliver reuse and recycling targets which are passed on to Tier 2s.	Tier 1 reduces their disposal costs by facilitating reclamation and furniture reuse specialists to remove any remaining saleable furniture, white goods, lighting etc before the soft strip.
Tier 2 Contractors	Recycling Focused	Demolition of buildings to the floor slab. Obligation to contribute to 90% recycling target. No obligation to undertake reclamation.	Own building fabric and related arisings. Materials present a low cost when sent for recycling or an asset if contractor can recycle and sell materials themselves.
	Reuse Focused	Demolition of buildings to the floor slab. Obligation to deliver % by weight recycling target. Obligation to deliver % by value reuse target.	Own building fabric and related arisings. Financial penalties, bonuses or gain share in contracts ensure delivering on reuse is as profitable as recycling.
Specialist Subcontractors	Reuse Focused	Undertake initial reclamation audit following the pre-demolition audit. Subcontracted to undertake reclamation of specific structures.	Where subcontractors are employed, ownership of the structure passes to them. Charge for work can vary between the specialist paying for the building, to no charge or a charge for deconstruction and removal. On the Olympic Park the specialist subcontractors involved effectively paid to take down and reuse the building ³⁰ .

Table 1: Roles, responsibilities and benefits for those involved in the demolition waste management

Construction Waste Management

The construction site of the Olympic Park was the largest construction site in the UK and managing it was a challenge and multifaceted task led by the ODA and its DP. Without appropriate management processes, waste could have been a major issue.

The ODA was required to:

- meet legal Duty of Care requirements;
- comply with Site Waste Management Plan (SWMP) Regulations;
- reduce the number of vehicles on local roads;
- implement the waste hierarchy; and
- maximise reuse/recycling/recovery rates.

A business case was undertaken for construction waste management which analysed the different options available for managing waste, taking into account the ODA's environment and sustainability commitments and recommended a centralised waste management service an on-site Waste Consolidation Centre (WCC).⁵

Before construction phase started, a Construction Waste Management Plan (CWMP) was developed.

The ODA worked with the English Regulator to develop a solution that allowed the project to use one waste management contractor and the Park was considered as one site for the purposes of Environmental Permitting Regulations. This approach allowed a significant reduction of the number of vehicles on site and allowed the recording of the tonnage of waste arising, end destinations and recovery rates.

The WCC (fully operational by March 2009) was developed by the waste management contractor, Veolia Environmental Services and consisted of two large covered 'sheds' and a number of flexible external bays to accommodate different incoming waste streams. The waste management contractor developed a Material Usage Working Plan to demonstrate how the CWMP was implemented and to demonstrate confidence to the ODA and the English Regulators.

The process of the collecting and consolidating construction waste, excluding earthworks, involved the following steps:

Contractors segregate waste within site boundary.

Waste management contractor collected individual waste streams and transported the waste to the WCC.

Before entering the WCC, the waste collection vehicle drove over a weighbridge and a weighbridge ticket was produced.

In the WCC, construction waste was consolidated into bays of particular waste streams. Concrete was taken to the on-site crusher for use as aggregates.

When a suitable amount of waste was stockpiled, it was compacted into containers and either transported from site by road, or removal by barge.

Segregated waste was directly reprocessed at various facilities. Mixed construction waste was taken to a Materials Recovery Facility. Mixed office waste was taken to the waste management contractor's clean Materials Recovery Facility. Organic waste was composted

At the early phase of construction, only 30% of waste was being recovered. This resulted in more segregation of waste and the contractors employed a team, to segregate waste at source, which was cheaper than having loads charged at a mixed skip rate. On the Park, the contractors paid for their waste management, which incentivised them to reduce waste.

⁵ Richard Jackson, Christian Bonard, Noah Bold and Jo Carris (2011), Construction waste management on the Olympic Park

Transport of construction waste by barge was identified as a key opportunity and a wharf was constructed on-site. This minimised the vehicle movements and was key to the ODA's key sustainability objective of reducing the number of vehicles on the local roads and reducing carbon emissions.

A 90 % reuse, recycling or recovery of construction waste was a challenging target for a project of this scale, but was thought to be achievable. This target did not include the excavation waste due the high level of contamination present on the Park. The target did not incentivise the waste management contractor to reuse material, therefore the majority of waste was recycled. Though there was some donation of surplus materials for reuse.

2.3.Factors of success

The key factors of success included:

- setting out early as possible the whole project lifecycle for waste management;
- embedding targets in briefs, procurement documentation and contracts;
- developing site-wide waste management plans and guidance (using existing industry tools where appropriate);
- establishing processes for meeting legislative requirements and demonstrating progress against targets; and
- implementing means of improving standard practice across the site.⁶

The key targets and objectives were included in briefs, procurement information and contracts. All teams were aware of the requirements at all stages. This awareness was successful guaranteed by the DP's Sustainability team by providing clearly to the project teams the ODA's expectations and the responsibilities in respect to waste, so that the Park-wide targets could be achieved. As previous discussed, the ODA's waste objectives and targets required planning and guidance. Plans for managing demolition and construction waste were produced early on, agreed by the ODA and the English Regulator, and put into action. The development of these plans was supported by those whom has previous experience of working on demolition projects and other large projects.

DP's Sustainability team provide guidance on how to achieve the ODA's waste objectives and they also conducted workshops to communicate the requirements and provide technical advice. They considered best practices tools, standards and processes which were available and new processes were only developed where necessary. A bespoke reporting template had to be developed for recording waste minimisation actions taken by project teams, entitled the 'Waste Minimisation Actions Report', since a tool for this purpose had not been developed by industry at that stage.

Part of the success of the waste strategy was achieved by working close to English Regulator, which assisted with meeting legislative requirements and implementing best practice waste management.

An integrated Environment and Sustainability Management System, which was externally audited and certified to the international standard for environmental management systems – ISO 14001 was developed. This guaranteed all legal requirements would be respected. Before contractors started on site, Environmental Management Plans and SWMPs were reviewed to ensure compliance with legal requirements for waste. The DP also held all waste management licenses and permits centrally, and carried out audits on the Waste Management Contractor and Tier 1 and 2 contractors to ensure that duty of care requirements were being fulfilled.

To assure improvements above standard practice, the DP's Sustainability team carried out regular site inspections with contractors. This was to ensure that the environment was being protected and to encourage best practice. Best practices examples were shared every month through the DP's Sustainability team and Environment Managers' Forum, and improvements were significant, creating a healthy competition between the companies involved.

For the Athletes Village, a training programme called 'NoWaste Lean Construction' was adopted which resulted in a 13% decrease in waste produced over a 6 month period and £64,000 in costs. This programme was based in principles of lean manufacturing and best practice from the automotive sector.

⁶ Jo Carris and Dan Epstein (2011), The Olympic Park Waste Strategy: Development and Implementation

3. Lessons learned

London 2012 Olympic Park was delivered on time, on budget and with an exemplary sustainability performance. Whilst the 2012 Olympics Park was unique in its aims, size and governance there is much that could be taken forward to be replicated on other projects and to drive forward innovation for CDW management.

3.1. Preconditions for application of the initiative - replicability

The preconditions that helped achieve this high level of sustainability are summarised in turn:

- The involvement and action from the beginning of the project by the client, with the setup of a simple and a clear waste strategy, with quantitative targets was supportive to the design and construction teams. These teams had the opportunity to seek solutions and define strategies for improvement. The DoW occurred at the early stages in the design process and were systematically assessed and qualified in order to achieve the targets proposed, which is not typically current practice in projects.
- The client used the tendering and appointment process to require their design teams to DoW, and asked the teams to identify and prioritise the top DoW actions, for inclusion in a design-stage Site Waste Management Plan and the contractor's tender specification. During the design phase, the client should review and update waste forecasts, plan DoW actions and estimate savings at each design stage sign-off. This challenge was important for design teams to find ways to reduce waste in this project. Support by the client was important to the design team, especially when they don't have much experience of DoW.
- Future projects should use the DoW process, or similar, to plan, quantify and prioritise actions upfront as part of the design process and involve the contractor early, to help identify and incorporate technical solutions into the design to detailed specification and costing.
- Teams with specialist subcontractors can contribute to the reduction of waste, but this is only possible when the requirements and targets are clearly explained throughout the project's lifecycle stages (demolition, design, construction and deconstruction). The waste management strategy should consider the site-specific opportunities and restrictions and set targets and objectives that are challenging for the contractors.
- A process whereby regularly monitoring and reporting waste arising was important to allow the analysis of the performance and improvement.

Many of the initiatives that took place during the project are good examples of how the construction industry can improve waste management and derive associated benefits. Not disputing the achievements made, there were some lessons to be learnt that can help the industry in the future in projects similar to this, as well as best practices to apply during all life cycle of the buildings in other type of projects. These include:

- During demolition phase, the pre-demolition audits could have been more extensive, and these audit should have resulted in the preparation of a detailed Bill of Quantities. This didn't occur due to the size of the site and the tight deadlines available for audits. This means that tracking and recording of materials was more complicated.
- Further projects should aim to reach higher levels of reclamation and re-use of demolition and construction waste rather than focusing on diverting waste from landfill, targets should be defined to deliver at the highest levels of the waste hierarchy and optimise resource efficiency.
- Some of the markets, like reuse and recovery ones, need to become more established to incentivise the construction industry to expend resources on developing and implementing more waste strategies.
- At the end of the projects, the data collected should be disseminated to enable industry to learn and develop further⁶.

3.2. Innovation potential

A number of area which were innovative for the management of CDW and could have a high impact if replicated include:

- The design of certain buildings and subsequent construction to achieve high levels of deconstruction and reuse of materials; this was a key objective, especially in the design process of the temporary buildings and as such innovative solutions were identified;
- Considering the opportunity for designing out waste at every stage with associated processes. This commenced early in the design stage, allowing for systematic assessment and evaluation of options identified. This ensured a maintained focus by all those involved on waste prevention wherever possible.

- The contractual requirements for high levels of resource efficiency were embedded in all tender documentation and contracts. This ensured a firm commitment from all those involved, together with a shared understanding of the overall goal.
- Working in partnership with the English Regulator to ensure that waste could be handled as efficiently as possible, by ensuring that the Park operated as a single site for the purposes of waste management licensing and regulatory controls. This provided a common understanding of how waste could be reused on and off site and the necessary conditions.

4. References

Sources of documentation

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