



WEST OXFORDSHIRE
DISTRICT COUNCIL

CLIMATE ACTION for West Oxfordshire

Research Paper:

Underground Refuse Systems in the Oxfordshire Cotswolds Garden Village

Author	Alfred Tolley
Reviewer	Ness Scott
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Purpose	Research paper assessing the financial and environmental benefits of using advanced waste collection technologies (underground refuse systems) within the Oxfordshire Cotswolds Garden Village.

EXECUTIVE SUMMARY

The utilisation of subsurface space is a key issue towards attaining an environmentally friendly and sustainable development, especially within new build urban and sub-urban areas. This research paper assesses the potential benefits of using underground refuse systems (URS) within the Oxfordshire Cotswolds Garden Village. The information presented in this paper may be used by Officers to inform the waste collection strategy for the Garden Village.

Currently, the management of municipal waste within the District relies on traditional collection and disposal activities, mainly associated with kerbside collection. This system is highly flexible; however, it has several drawbacks giving rise to important financial and environmental impacts.

URS provide a modern and advanced alternative to traditional waste collection methods and may allow for considerable resource savings. A key ethos of the Oxfordshire Cotswolds Garden Village is to explore exemplar methods of urban development through creating sustainable infrastructures. URS have the potential to provide an alternative to the traditional kerbside waste collection strategy. Although capital costs for URS are currently high, they may offer large operational savings by making service delivery cheaper. In addition to this, as URS units have a very large storage capacity and are only emptied when required (due to sensor technologies), URS may provide a more environmentally sustainable option of collecting municipal waste for the Garden Village by minimising waste vehicle mileage.

It is recommended that URS be considered in the design and development of the Oxfordshire Cotswolds Garden Village. There are clear benefits to the Council in terms of minimising the rise in carbon emissions as a result of a 'business as usual' waste collection service being implemented for the c.2,200 new homes within the development area.

In light of the Council's commitment to become carbon-neutral by 2030, any innovative approach which can reduce and mitigate a rise in the Council's carbon emissions, should be given full consideration and implemented as a priority. By using the Garden Village as a flagship project for these advanced waste collection systems, the Council may begin to assess the potential for URS to be used (or retrofitted) within other areas of the District. This may prove a key aspect in allowing the Council to promote sustainable growth through modern urban design.

I. INTRODUCTION

- 1.1. In January 2017 the government announced its support for 14 new garden villages, one of which is the Oxfordshire Cotswolds Garden Village. The new, freestanding settlement will be located on land to the north of the A40 near Eynsham and will house c.2,200 dwellings, a campus style science/technology park and a new park and ride station.
- 1.2. The preferred option consultation paper published in July 2019 as part of the preparation of the Area Action Plan (AAP) says that the development should identify key opportunities to “make use of emerging technologies ... in order to help with transport and movement in and around the site” and that “good quality design is an integral part of sustainable development”. URS provide a technologically advanced system which is in accordance with these statements¹.
- 1.3. Making use of subsurface space is a key issue towards attaining an environmentally friendly and sustainable development, especially within newly constructed urban and sub-urban areas². Infrastructures that are difficult, environmentally undesirable or even less profitable to be installed above ground can be relocated underground, thus releasing valuable surface space for other uses. In a global community where consumerism has created the need for waste collection from each house and neighbourhood, URS can provide a more sustainable method to collect municipal waste within the Oxfordshire Cotswolds Garden Village.

2. ENVIRONMENTAL POLICY

- 2.1. The Waste Regulations (England and Wales) 2011, requires local authorities to manage waste according to the waste hierarchy (Reduce, Reuse, Recycle, Recover and Dispose). West Oxfordshire District Council is responsible for the collection of waste and recycling from domestic properties as the Waste Collection Authority (WCA). West Oxfordshire District Council is also responsible for all street cleansing services, including the provision of litter and Fido (dog waste) bins. Oxfordshire County Council (OCC) is the Waste Disposal Authority (WDA) and is responsible for disposing of the waste that is collected by the District Councils, as well as having a duty to provide facilities for residents to deposit their household waste. OCC also determines planning applications for waste developments.
- 2.2. The national policy ‘Our Waste, Our Resources: A Strategy For England’³ notes that the “government supports comprehensive and frequent waste collections and is determined to help local authorities and waste management companies act in the most sustainable and resource-efficient way possible”. This supports the adoption of technologically advanced waste collection methods. As summarised in Chapter 7, “In some areas where we are seeking transformative change, our knowledge, data or technology has yet to match the breadth of our ambitions. Innovation here is vital – both to developing novel solutions and improving the efficiency, cost and/or effectiveness of existing technologies. As Government, we support industry and academia to stimulate innovation”³.

3. BACKGROUND TO UNDERGROUND REFUSE SYSTEMS

- 3.1. URS are fixed waste collection points, with sub-surface storage units which can be used for the collection of waste from residential, commercial and on-street bins. URS can either operate as stand-alone collection points (see figure 1), in which waste is entered through an above surface inlet and stored below ground; or can incorporate automated vacuum collection schemes (AVAC) where waste is pneumatically transported to a central location for compaction and collection.

¹ Nakou *et al.* (2014) Assessing the financial and environmental performance of underground automated vacuum waste collection systems.

² ISWA Report Underground Solutions (2013) Underground Solutions for Urban Waste Management: Status and Perspectives, Task Force Globalisation.

³ Our Waste, Our Resources: A Strategy for England; DEFRA Waste and Resources Department (2018).

- 3.2. At the surface, URS units often appear as stylish waste inlets which complement modern urban designs. The surface units typically have closed hopper style hatches which prevent users from placing bulky waste into the URS. The below-surface unit is composed of a concrete casing unit and a removable steel container in which the waste is collected. When full, the unit is removed via a hydraulic platform, or a specialised waste collection vehicle fitted with a mechanical lifting arm. All URS units are fitted with ventilation devices to prevent the build-up of harmful/flammable gases (typically methane) which may be emitted from decomposing waste.
- 3.3. The principles of underground refuse collection are not new; United States patent documents from the early 1970s include designs for the installation and operation of ‘underground trash containers’⁴. Technological advancements in the 21st century (particularly with regards to sensor technologies) have allowed waste solution manufacturers to develop advanced URS which have a high operational efficiency and a proven reliability.



Figure 1: Diagram indicating the components of a stand-alone underground iceberg style refuse system provided by SULO Ltd. Although mechanical composition can vary, this design is typical of most suppliers.

- 3.4. Underground refuse systems have many benefits in comparison to the traditional method of kerbside waste collection. These include:
- Larger containment capacity of units (up to 15,000l greater) for the same above surface space of standard waste containers⁵. This may release surface space for community needs or additional development.

⁴ Weaver, H. (1974) Underground trash and garbage container, U.S. Patent 3,800,973.

⁵ <https://www.apse.org.uk/apse/index.cfm/news/2016/going-underground-could-underground-waste-storage-systems-be-the-way-forward>.

- Communal waste bins means that there is no need for multiple containers at each domestic property, reducing space demand within the individual design of each new home.
- The large storage capacity means that the containers need to be open less frequently. This reduces the number of waste collection trips which are required each month.
- A significant reduction with issues associated with vermin and odour.
- Enhanced safety for collection workers (increased hygiene and minimisation of physical strain/accidents)
- A flexible system with the ability to cope with change.
- Minimized noise and aesthetic pollution within the urban cityscape.
- Significantly longer life cycle of waste containers in comparison to kerbside bins.

3.5. The latest URS designs from all major providers include sensor technologies which are used to indicate to the WCA when the unit is close to being full. As a result of this, the Council would only need to send waste collection vehicles to the Oxfordshire Cotswolds Garden Village when required which would optimise both fuel usage for the waste collection fleet and the time spent collecting waste. The sensor technology also allows for route optimisation (the best route for waste vehicles to take to reach each unit) so that noise disturbances and traffic congestion can be avoided in urban areas. These resource efficiencies are post construction and post occupation, which is when the environmental impacts associated with a waste collection service become the responsibility of the Council.

3.6. Although designs vary, the most common URS units are emptied either by a rising hydraulic platform, or by a specialised refuse vehicle which is fitted with a mechanical lifting arm (Figure 2). This allows for single-person operation, and therefore does not require a team of waste collection operatives. In addition, the nature of waste collection from URS minimises the physical strain which waste collection operatives experience. Traditional kerbside collections are both time consuming and physically demanding, often leaving operatives with minor physical injuries. URS provide a safer and quicker method to collect municipal waste, which benefits both the WCA and employees.



Figure 2: Waste collection operative emptying a URS unit using a hydraulic mechanical lifting arm. The process can be completed by one individual and provides a safer/less physically demanding approach for waste collection.

- 3.7. URS can also be fitted with RFID fob key systems (with an individual user codes) so that residents must register the need to open waste inlets before disposing of their waste. By including fob entry in the design, the WCA can attribute any changes in volume/contamination of waste streams to individual residents which have used the URS. By having this data feed and targeting actions to tackle incorrect use of the units, the Council can minimise contamination rates and reduce any additional on costs which are typically incurred from the disposal of contaminated waste.
- 3.8. URS units can be used to collect waste from all property types within the urban environment. Table I outlines the benefits of using URS for each building type and location.

Table I – Benefits of using URS for each property type and location.

	Typologies	Benefits of using URS
Domestic properties	Flats	Communal waste containers are often the norm for flats. A URS would provide a similar waste collection method, but would provide a much greater storage capacity. In addition as the container is below surface, problems associated with littering and vermin/odour production will be minimised which additionally benefits the Council.
	Terraced housing	A URS would be a design benefit; removing bin storage infrastructure from individual dwellings. In addition, URS would eliminate issues with the bins stored on pavements or narrower streets on collection day. If properties are designed to have narrower property frontages the maximum number of properties within an acceptable walking distance of the waste inlet can be increased.
	Semi-detached and detached houses	These properties often accommodate waste containers within purpose designed bin housing areas. URS would eliminate the need for these aesthetically poor housing areas to be included within the architectural design of new builds.
Commercial properties	Terraced commercial properties	These commercial properties typically have limited on plot storage space and therefore often do not have the capacity to accommodate individual waste containers large enough to capture each waste stream. 1,100l communal waste containers are therefore commonly used by these businesses and are often placed in areas of public inconvenience. URS can provide a form of communal collection which will reduce service costs and provide a more operationally efficient means to collect waste from multiple businesses.
	Campus style/business park commercial properties	Communal collections are already common for high-density commercial areas; an underground refuse would reduce the area needed for surface bin compounds within campus style parks. Larger sized URS units will reduce the need for frequent collection and therefore minimise inconvenience of waste collection for businesses.
Public	Litter and Fido bins	As URS provide a large waste storage capacity, they can be used for on-street bins within public areas. Separate waste inlets can be installed to collect litter and dog foul separately if required. The distribution of URS units can match the current distribution of on street bins but have a much greater storage capacity to meet periods of heavy demand.

- 3.9. Both a URS manufacturer (Contenur Ltd.) and the 'Sustainable resource and waste management strategy addendum assessment report' for North-west Cambridge⁶ suggest that the maximum distance that domestic/commercial occupants will travel to reach a URS point is a 30m radius of the refuse inlet. This refers to the property boundary of a site and not the main entrance of a property. APSE recommends that a URS within the capacity range of 5,000 – 15,000l has the ability to collect waste from a maximum of 21 domestic properties.
- 3.10. In order to ensure that URS units do not experience mechanical malfunctions, manufacturer Sulo Ltd. recommend that URS units are serviced annually by a trained engineer. As with most mechanical devices, maintenance usually takes the shape of replacing damaged/corroding elements, lubrication of moving parts and degreasing/deep cleaning of the above and sub-surface units. Without proper annual maintenance, Sulo Ltd. suggest that URS units will have a considerably shorter life-span as major damage can result from weathering and long-term deterioration. The costing estimates provided within Section 6 therefore include an annual maintenance fee to consider any ongoing operational costs associated with URS units.

4. EXISTING EXAMPLES OF URS IN THE UK

- 4.1. URS are common across the mainland Europe, but are less commonly used to collect waste in the UK. Many local authorities are now learning from the WCAs which currently operate URS, and the business case for adopting these advanced technologies is becoming stronger.

Peterborough City Council

- 4.2. Peterborough City Council installed a total of 60 URS units (24 for refuse, 29 for recycling and 7 for glass) within 19 separate medium and high density residential sites during a series of regeneration projects starting in 2004. The URS units were procured from multiple different manufacturers (which included Sulo Ltd.) and collect both refuse and commingled DMR. The units have a capacity of 5m³ (or 5,000l) and one unit is used to serve approximately 40 high-density properties for each waste stream. This exceeds the 21-property guidance that manufacturers recommend, but the containers are emptied weekly as opposed to fortnightly to prevent overfilling. The current collection strategy uses two crane assisted 26t open-back trucks to empty the units. The purpose of this high frequency of collection is also to minimise the risk of container overfilling as the units are not fitted with fill level sensors. These URS do not allow for the source separation of recyclable materials, nor do they serve trade waste collection.
- 4.3. The major barrier faced by the WCA when installing these systems was associated with accessing infrastructural funding in order to cover the CAPEX of the units. Failure for regional planning documents to include reference to alternative waste collection strategies made achieving this infrastructural funding difficult. Despite this, funding was eventually sourced from the developer but also had to be part-funded by the local authority. This highlights the need for alternative waste collection strategies to be considered within the infrastructural delivery report and environmental plan for the Garden Village.
- 4.4. Recent assessments⁷ indicate that resident engagement with URS in Peterborough is high, and that contaminations rates across all waste streams remained largely unchanged despite URS installation. This is possibly due to the fact that URS were largely used to replace above ground communal

⁶Sustainable Resource and Waste Management Strategy Addendum: North West Cambridge (2012).

⁷ Perscomms (Glen Vincent - Waste Policy & Performance Coordinator, Peterborough Council), teleconference interview (2019).

containers and not to replace property individual containers. Considerable aesthetic gains have resulted from the installation of URS as bin housing areas are now fitted with more discrete waste inlets. A marked reduction in vermin presence was also observed due to the installation of this sub-surface infrastructure. Due to the social and operational benefits gained from URS installation, the WCA has adopted this waste collection method as a 'preferred strategy' for all new developments where appropriate, and is promoting URS use over standard bin compounds within planning development reports.



Figure 3: Left; image of two retrofitted URS with a low rise flat residential area in Peterborough City. Right; a crane operated waste truck pictured emptying of a 5,000l URS unit. A single waste collection worker is capable of operating the system.

The London Borough of Tower Hamlets

- 4.5. The London Borough of Tower hamlets have 115 operational URS units which were retrofitted within medium and high density estates as part of a £250 million regeneration which started in 2013. URS have also been installed within the new purpose built developments in order to utilise sub-surface space so waste containers do not occupy sparse (and high premium) above surface ground. The URS units were procured from multiple suppliers (including Sulo Ltd.) and range in volumetric capacity; the largest container size in operation is currently 5,000l. The units are used to separately collect municipal refuse and commingled DMR. Currently, trade waste collection is not provided within the borough via URS.
- 4.6. Due to the premium price of above and below surface space within the borough, alongside complex sub-surface infrastructure (e.g. gas and electric service lines), capital expenditure for these URS units was high due to high installation and trenching costs. Funding for the URS units was covered in part by the registered social landlords (RSLs) during the regeneration process but also the developers of the regenerated properties.
- 4.7. The LB of Tower Hamlets waste collection department did not procure a maintenance license for the URS units from suppliers, however a hygiene/cleanliness servicing of the units is provided by the RSLs within each estate. Despite not paying for this service, few mechanical failures (unit malfunctions) have occurred since their installation. The main way that the WCA attempts to mitigate container damage is through using two designated crews to collect waste for the refuse and

DMR units. As a result of their specialised training and familiarity with the collection procedure, damage to the physical infrastructure of the URS is minimised.

- 4.8. Contamination rates of DMR and refuse have remained high within the district despite the installation of URS. The WCA is attempting to combat this issue through ongoing communications campaigns and engagement with the RSLs. It is important to note however that the WCA identifies that contamination rates have not increased as a direct result of URS installation⁸ as these units were largely used to replace above-ground waste containers. As a result, the WDA has not suffered increased gate fee costs within reprocessing facilities.
- 4.9. The major issue posed to the WCA associated with the URS is that there are frequent failures for residents to breakdown large recyclable materials in order for them to fit into the closed-hopper style waste inlets. As a consequence, large refuse and recyclable items are often left on the kerbside next to the URS inlets which then requires an additional street cleansing service.

Princes Street Gardens, Edinburgh

- 4.10. The Princes Street Gardens in Edinburgh provide one UK example of how over 200 communal litter bins have been replaced by 16 larger underground 'Silo-bins' within a public area. Edinburgh City Council adopted the use of on-street subsurface waste containers in order to maximise the operational efficiency of waste collection and to minimise the cost of service delivery within the park. The underground units (supplied by Silobin Ltd.) have a 2,500l capacity which means during peak periods, the waste containers have the ability to store over two and a half weeks' worth of waste. This has reduced the risk of bin overflowing and therefore public littering⁹.



Figure 4: Underground silo bins in Princess Street Park (left) and Harrison Park (Right), Edinburgh. 16 underground bins were used to replace over 200 on-street litter bins. In addition to environmental and financial benefits, the large waste storage capacity reduces the chance overflowing and therefore keeps the collection area tidy despite heavy footfall.

⁸ Perscomms (Neil Crump - Contracts Development Manager, Tower Hamlets Council), teleconference interview (2019)

⁹ <http://silobin.co.uk/>

5. KEY CONSIDERATIONS FOR URS IN THE OXFORDSHIRE COTSWOLDS GARDEN VILLAGE

5.1. COMMINGLED RECYCLING VS SOURCE SEPERATED RECYCLING

- 5.1.1. Methods of communal waste collection, such as URS present a valuable opportunity to source separate recyclable materials from both domestic and commercial properties. Source separation can be achieved by installing additional units (and above ground inlets) in order to encourage residents to separate out what would normally be commingled DMR. This deviates from the current (hereafter referred to as the baseline) collection method which is currently in operation across the district.
- 5.1.2. Using a strategy which source separates DMR will result in a significantly higher capital expenditure due to the additional number of URS units which will be required to cover the site (c.525 units with source-separation as opposed to c.105 units without). However, source separation of recycling should be considered so that the waste collection system is future-proofed if national legislation changes and does not allow the Council to transport waste to Mixed Recycling Facility (MRF) in the future.
- 5.1.3. By installing enough URS units to allow for source separating DMR, waste disposal has the potential to be significantly more environmentally friendly as material will no longer need to be sent to the SUEZ MRF facility. Additionally, if an appropriate communications strategy is implemented alongside the URS, an improvement to current contamination rates may be seen. If source separation reduces the contamination rate of recyclable material, WODC may also gain more recycling credits per annum from OCC and in turn, minimise the operational cost of service delivery.
- 5.1.4. Currently, no other council in the UK uses a URS framework which source separates recyclable materials. As a consequence, if source separated URS are considered for the Garden Village, the high level of innovation may make accessing various forms of central government funding (such as green infrastructure budgets) easier to achieve.

5.2. WASTE STREAMS NOT COLLECTED BY URS

- 5.2.1. It is important to note that at present, stand-alone URS do not facilitate the collection of the following:
 - Garden waste
 - Food waste and cooking oil
 - Bulky waste

Nor would it be appropriate for the following streams due to the low volumes collected:

- Small electrical items
- Textiles and shoes
- Car batteries
- Household batteries
- Engine oil
- Clinical waste

- 5.2.2. Based on the April 2018 to March 2019 WODC waste tonnage data, if these items are not collected by the proposed URS, 30.6% of total waste tonnage from the Garden Village would require an alternative collection method.
- 5.2.3. Although URS do not currently allow for the collection of food and garden waste, technological advancements being made by URS manufacturers are likely to provide units which can collect these waste streams in the future. By example, Sulo Ltd. have recently installed a series of food waste URS units within Barcelona, Europe and suggest that similar systems are likely to be available within the next two years in the UK. These advancements may also be driven by national legislative change as manufacturers attempt to design products which allow for collection of all waste streams.
- 5.2.4. Whilst uncertainty remains over the capacity for URS to collect organic waste, alternative methods to kerbside collections for organic waste may need to be assessed for the Garden Village. For example, domestic properties could be fitted with solar green cone food digesters (an innovative system which utilises a sub-surface unit to encourage bacterial decomposition of household organic matter; see Figure 4). These systems cause the breakdown of 90% of food waste into water which is then absorbed by the surrounding soil. One of these units has the capacity to serve an average domestic household which would eliminate the need for food waste collection from domestic properties.
- 5.2.5. In conjunction, communal composting schemes may be used to collect garden waste from the domestic properties within the Garden Village so that WODC does not have to provide a container collection service. Multi-property composting units (see figure 4) have the capacity to collect large volumes of green waste and convert organic matter into a re-useable mineral rich soil. Units such as these may eliminate the need for a garden waste collection service. It is important to note however, that as garden waste collection is currently a paid service provided by WODC, divergence from the baseline method may result in financial loss.



Figure 5: Examples of alternative methods for organic waste disposal. Left; green cone solar food digesters are an innovative food waste disposal method which can process domestic food waste (one cone can serve a whole domestic property annually). Right; community compost bins have a large storage capacity and can take all types of garden waste. After a period of time, the decomposed organic matter can be used as nutrient-rich soil.

5.3. ASSISTED COLLECTIONS AND CLINICAL WASTE COLLECTION

- 5.3.1. Assisted collections are offered by the Council to residents who do not have the ability to place refuse containers at their designated site of collection. This typically involves a waste operative entering a private plot, and collecting the bin from close to the home's entrance. Clinical waste

refers to any infectious material produced by a domestic property, and is currently collected on a separate delivery to avoid contamination with other municipal waste streams.

- 5.3.2. As URS are a form of communal waste collection, this method does not facilitate assisted collections for vulnerable residents. Using the current percentage of properties that require assisted collection as an indicative model for the Garden Village, it can be estimated that 35 residential properties may require assisted collection out of the 2,200 domestic properties set to be constructed. For these properties, an alternative form of municipal waste collection may need to be considered.
- 5.3.3. The baseline WODC waste strategy also allows for the collection of clinical waste from domestic properties across the District. Clinical waste refers to any form of infectious material which by waste regulation law cannot enter the refuse waste stream from domestic properties. Currently, the clinical collection service provided by WODC operates by registered properties being issued with specialised waste sacks which are then placed kerbside on collection day. Waste collection operatives (protected with PPE) then collect clinical waste sacks in a different waste vehicle.
- 5.3.4. If a similar clinical to non-clinical ratio percentage is used to estimate the number of properties that are likely to require clinical waste collection within 2,200 properties, it can be estimated that only one property will require clinical waste collection within the new development site. Under this circumstance, it may be most appropriate to use the baseline collection method for clinical waste (issue of labelled waste sacks and property specific collection) in order allow for the collection of this infectious materials.

5.4. INFRASTRUCTURAL CONSIDERATIONS

- 5.4.1. In order for URS to be emptied, a 26t waste collection lorry must have adequate room on a tarmacked surface to access the location of the waste container. When the architectural designs for the Garden Village are developed in conjunction with the statutory AAP, the capacity for collection vehicles to access the installed URS must be considered. This infrastructural requirement may align with needing to grant access for emergency vehicles within the domestic and commercial areas of the development.
- 5.4.2. Similarly, if URS are adopted, the architectural design of the site should consider the capacity for the baseline solution of waste collection to be rolled out across properties as part of a contingency plan if the URS experience operational failure. Although the ethos of the Garden Village is to engage with experimental green infrastructures, from an operational perspective, the architectural design of the site must have the capacity to facilitate the roll out of the baseline collection method if the experimental waste collection infrastructure is insufficient to provide a viable waste collection method.
- 5.4.3. In conjunction with this, domestic properties should be designed to include the internal space (e.g. within kitchen cabinets) to allow for multiple waste containers. WRAP suggest that if residents are encouraged to source separate out recyclable materials in their home, there is a greater chance that they will place the correct waste into each communal bin¹⁰. This may be an important consideration to ensure that contamination rates are minimised for the Garden Village.

¹⁰ <http://www.wrap.org.uk/content/sme-food-waste/4b-right-things-in-the-right-bins>.

5.4.4. If c.2,200 domestic properties are constructed in the Garden Village, approximately 525 URS units will be required to collect source-separated municipal waste in the Garden Village. In addition to this (and in-line with WRAP guidance), approximately 45 on-street and 35 Fido bins will need to be installed on the site to match this number of properties. If it is assumed that 10,000l domestic URS are installed, this will equate to c.5,250m³ of subsurface space that will need to be set aside for the URS units. For on-street and Fido bins, a further 800m³ of sub-surface space will be required. Above surface, the closed hopper units only occupy a c.2m² area; however, as Figure 1 displays the closed hopper units are surrounded by a raising metal platform which is used to empty the sub-surface container. Depending on the design of the URS, this can range in size between 2m² and 5m². Using these approximate figures for the above surface area of the units, between 1,210m² and 3,025m² of above surface area will be occupied by the URS if enough units are installed to allow for the source separation of recyclable material. As an alternative, if only 2 URS units are installed for domestic municipal waste (e.g. one for DMR and one for refuse) an estimated 2,900m³ of subsurface space and 580m² of above-surface space will be required. These estimations are purely indicative, and do not consider the needs for trade waste disposal from the campus style science/technology park referenced within the AAP. Future investigations should consider the use of URS to collect waste stream from these facilities as an environmentally friendly and cost-effective method.

6. FINANCIAL COSTS OF INSTALLING AND OPERATING URS

- 6.1. The financial costs of providing a waste collection service are largely divided into two categories – capital expenditure and operational expenditure. In this context, capital expenditure refers to any cost associated with the procurement and distribution of new waste containers for residents to use. Operational expenditure refers to the cost of delivering the waste collection service (on an annual basis). This includes staffing expenditures, vehicle procurement, vehicle fuel costs, waste reprocessing/disposal costs, transportation costs and vehicle maintenance costs.
- 6.2. Table 2 provides an indicative cost comparison between the baseline waste collection method vs. a proposed collection method using URS to collect domestic and on-street waste. The capital costs have been estimated from waste container/URS price and installation/delivery costs. If c.2,200 domestic properties are constructed, approximately 525 URS units will be required to collect source-separated municipal waste in the Garden Village. Operational expenditures have been estimated from the average price to collect waste for new build properties. Further details on these estimations are outlined in Appendix I. These costings do not anticipate changes in market prices, nor do they anticipate a rate of national inflation greater than 2% per annum. Also these costings do not consider using URS to collect waste from the science/technology park referenced in the AAP.
- 6.3. These costings are calculated to provide 2,200 domestic properties with access to 5 URS waste containers, and are multiplied to cover a twenty year operational period. The capital costings for URS are based from manufacturers' indicative quotes (Sulo Ltd. and Contenur Ltd); as are the average maintenance costs. The 'cost of service delivery' for each collection method is estimated from the current waste contract held with Ubico for the 2019/20 financial period. For the proposed URS collection method, the cost of service delivery is estimated using the research from The Sustainable Resource and Waste Management Strategy Addendum for North West Cambridgeshire. URS waste collection has been modelled a circa 50% reduction in service delivery. If on street waste bins are also collected by URS, an additional 5% reduction in service delivery cost can be expected.

The annual staffing expenditures included within the assessment are estimated from 2018/19 budget held with Ubico.

Table 2 – Indicative costings for the implementation of the baseline (business as usual) waste collection method vs. the proposed (using URS) waste collection method.

Capital expenditure (CAPEX) (£)	Baseline (business as usual method)	Proposed collection (using URS)
Container cost	£152,214	£2,999,000
Trenching/installation cost	£0	£1,160,000
Feasibility assessment cost	£0	£20,000
Delivery cost	£47,320	£240,750
CAPEX total for 20 years	£199,534	£4,419,750
Operational expenditure over a 20 –year period (OPEX) (£)		
*i Cost of service delivery	£4,444,120	£1,999,860
*ii Waste vehicle procurement	£1,117,200	£558,600
Maintenance/replacement of waste containers	£307,740	£340,000
Maintenance of waste vehicles	£318,000	£106,000
Total OPEX over 20 years	£6,187,060	£3,004,460
Operational staffing expenditure over a 20-year period (OPSEX) (£)		
Staff hiring costs	£16,000	£4,000
Staff training costs	£6,783	£1,923
Staff wages (net)	£3,680,000	£920,000
Staff welfare expenditure (injury/sick pay)	£2,727	£681
Total OPSEX over 20 years	£3,705,510	£926,604
Total OPEX/OPSEX over 20 years	£9,892,570	£3,931,064

*i This includes fuel consumption, gate and reprocessing fees for refuse and recycling, recycling credits, street cleansing.

*ii This has been estimated on the basis that a waste collection vehicle lasts for an operational lifespan of seven years.

6.4. This financial assessment (Table 2) indicates that although the capital costs of procuring and installing URS is estimated to be £4,220,216 greater than the baseline waste collection method, it may be possible to make large operational savings by using URS within the Garden Village (Table 3). These savings are largely the result of waste collection vehicles not having to make as many rounds per fortnight to empty waste containers. Additionally staffing expenditures are considerably lower when using URS due to the advanced methods of emptying the waste containers. Projected estimates (Table 3) suggest that a c.60% cost reduction per annum (c.£298,076) in operational and staffing expenditure may be achieved by using URS. When projected over a 20-year period (the minimum predicted lifespan of a URS unit), this operational saving would equate to an estimated c.£5,961,520. These estimates suggest that the capital expenditure required to install URS will have a payback period of c.15 years and an ROI of c.7% (Appendix 3). This payback period is shorter than the expected life span of URS units, meaning that the URS units are likely to result in a real-world operational saving over their lifetime if installed in the Oxfordshire Cotswolds Garden Village.

Table 3 – Estimated difference in operational and staffing expenditures between the baseline (business as usual) waste collection method vs. the proposed collection method (using URS).

	Baseline (business as usual method)	Proposed collection (using URS)
Annual operational and staffing expenditure	£494,629	£196,553
Annual difference in operational and staffing expenditure	£0	- £298,076 (60%)
Projected difference in operational and staffing expenditure over 20 year period	£0	- £5,961,520

6.5. To facilitate the baseline waste collection method for a site the size of the Garden Village, the Council would need to procure a minimum of two 26tn waste collection vehicles (for refuse and DMR) and a 15tn waste collection vehicle for food waste. These costs are captured in the operational expenditure in Table 2. However, if URS are adopted, the large storage capacity of these units would mean that waste containers would not have to be emptied as frequently. Because of this, only one 26tn specialised collection vehicle would therefore need to be procured in order to collect waste from the Garden Village if URS are used. This will reduce both Capital and maintenance costs incurred from the waste collection fleet.

6.6. With the correct maintenance, manufacturers guarantee that the life-span of URS units can exceed 20 years; In contrast, the average kerbside collection container has a life-span of 1.5 years. If the URS units are adequately maintained in the Garden Village, the Council will incur a considerably lower annual cost associated with fixing/replacing damaged waste containers.

6.7. Trade waste collections are currently a paid service operated by the Council to companies and businesses which purchase a contract. A similar approach may be taken if URS are used in the science/technology park within the Garden Village, in which registered (and paying) companies are provided with an RFID fob for a series of centrally located URS units so that they are able to dispose of commercial waste. Further costing estimates would need to be calculated in order to assess the viability of this option for the Garden Village.

7. ENVIRONMENTAL BENEFITS OF USING URS IN THE GARDEN VILLAGE

- 7.1. As previously discussed, the major benefit of using URS to collect waste is that the units have a considerably larger storage capacity (meaning they do not have to be emptied as frequently) and each unit is fitted with a sensor technology which indicates when the container is full. The baseline waste collection method sees the deployment of the waste collection fleet to residential properties on a routinely (fortnight) basis. The major issue with this collection system is that residents will present waste containers at the kerbside on collection that are not full, thereby slowing down the process of waste collection and reducing the efficiency of the service (i.e. reducing the tonnes of waste collected per litre of fuel used by the fleet of collection vehicles).
- 7.2. If URS fitted with sensors are installed, waste vehicles will only be deployed when required (and not on a rota basis) meaning that vehicle mileage is much reduced in comparison to the baseline collection method. In addition, when the waste vehicles are sent to the Garden Village, they will be able to collect the maximum amount of waste (tonnage) before returning to the depot to tip. The result of these efficiency savings will not only be economic, but the significant reduction in fuel consumption will minimise carbon emissions and other atmospheric pollutants from the waste collection fleet.
- 7.3. Using the exhaust emission factors for diesel fuel EURO 10 Garbage trucks (Table 4) and a spatial model (based on total travel distance travelled for waste collection vehicles), the difference in kilograms of exhaust emissions from waste collection of 2,200 properties has been calculated. In order to minimise the complexity of the model, the difference in exhaust emissions have been calculated for individual 'blocks' of 21 domestic properties. The model therefore does not consider the capacity for multiple URS to be emptied by a 26tn truck in one go. In reality, the annual emissions savings may therefore be greater than the values estimated as a 26t vehicle may have the capacity to empty 8 – 10 URS units before returning to the depot. The model also considers the different emissions produced when vehicles are in motion (highway emissions) and not in motion (downtown emissions, e.g. when waste is being loaded into the vehicle).
- 7.4. Table 5 displays the modelled difference in annual exhaust emissions from using the baseline waste collection method, and by using 10,000l URS units to collect waste from 2,200 domestic properties. The model estimates that approximately 33,607 kg of carbon dioxide may be saved by using URS to collect municipal waste from the Garden Village in comparison to the traditional method of waste collection.
- 7.5. As the Council has an obligation to collect municipal waste from domestic properties within the District, the construction of the Garden Village will result in additional carbon emissions to be emitted from the service delivery of waste collection. As the Council takes the necessary measures to reach its target of carbon neutrality by 2030, there will be a subsequent financial cost to the Council to offset the additional carbon emissions linked with a new waste collection service operating at the GV. This report does not seek to assign a cost to these additional costs, but acknowledges that this should be considered in the design of any new development in West Ox.

Table 4 - EURO 10 Garbage trucks exhaust emissions factors according to the GEMIS Data Base based on the TREMOD model.

Pollutant type	Down town emissions (kg/km)	Highway emissions (kg/km)
SO ₂	6.36480E-04	4.82561E-04
NO _x	8.8205E-03	4.45739E-03
Particulates	1.83263E-04	6.99335E-05
CO	2.33491E-03	1.00690E-03
NM VOC	7.48348E-04	3.50802E-04
CO ₂	1.05350	7.66033E-01
CH ₄	1.84020E-05	8.6269E-06
N ₂ O	9.74496E-06	6.09591E-06

Table 5 - Modelled annual exhaust pollutants under the alternative waste collection scenarios. See Appendix 2 for details regarding model framework and assumptions.

Pollutant	Emissions from baseline collection method (kg per annum)	Emissions using URS collection method (kg per annum)	Difference between methods (kg per annum)
SO ₂	26.16	5.86	20.30
NO _x	362.80	81.22	281.62
Particulates	7.53	1.69	5.85
CO	95.9	21.48	74.49
NM VOC	30.7	6.88	23.87
CO ₂	43,299.69	9691.94	33,607.75
CH ₄	0.76	0.17	0.59
N ₂ O	0.40	0.09	0.31

7.6. In addition to minimising CO₂ emissions, the model also indicates that this alternative method of waste collection may result in significant of other exhaust pollutants. Particulates, Nitric oxide (NO_x) and sulphur dioxide (SO₂) are the pollutants recognised by the World Health Organisation to cause asthma, bronchial symptoms, lung inflammation and reduced lung function. Poor air quality is currently recognised the largest environmental risk to public health in the UK¹¹. Using URS to collect waste will assist in reducing these vehicle pollutants will be reduced, and will play a role in promoting good air quality within the District.

7.7. The modelled emissions savings presented in Table 5 apply only to 'blocks' of 21 domestic properties. The model does not consider the collection of on-street waste containers or trade waste containers. If these waste streams were also collected using URS units, further emissions savings could be made in order to reduce the carbon footprint of waste collection for the entire

¹¹ <https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution>

Garden Village site. Ant future assessments should aim to model the emissions savings that can be made from collection trade/on-street waste with URS within the Garden Village development.

8. CONCLUSIONS

- 8.1. The development of new approaches for the management of municipal waste is becoming a mandatory requirement for modern urban and sub-urban developments. Innovative systems are expected to dominate the field of municipal waste collection in the forthcoming years, especially in cases of densely populated urban areas or in urban expansion projects where the infrastructures can be developed with ease, right from the beginning of the project. New schemes which take advantage of both technological developments and the utilization of the subsurface space may have the capacity to tackle the significant drawbacks which arise from the traditional methods of waste collection and management.
- 8.2. The ethos of the Oxfordshire Cotswolds Garden Village is to explore exemplar methods of urban development through creating sustainable infrastructure. This presents the opportunity to explore the use of an innovative waste collection method in order to maximise operational benefits whilst minimising longer-term environmental and social impacts.
- 8.3. This research paper had the purpose of assessing the potential benefits of using URS to collect municipal waste within the Oxfordshire Cotswolds Garden Village as part of a new waste collection strategy. Financial assessments indicate that due to the advanced technologies present within URS, the capital costs to procure and install c.525 units within the Garden Village will far exceed the capital costs of implementing the baseline waste collection method (estimated to £4,220,216 greater, Table 2). Despite this, the economic and environmental benefits of using URS come from the operational savings that can be made. This paper identifies that URS provide a waste collection method which is approximately c.60% cheaper to operate, and produces significantly less atmospheric pollutants in comparison to kerbside collections.
- 8.4. This paper also recommends that multiple URS should be installed in the Garden Village to allow for the source separation of DMR. Although this will result in a higher capital cost for installation, DMR will no longer have to be processed at a MRF (a carbon intensive process) which will greatly reduce the downstream environmental footprint of the recycling stream leaving the District. The uncertainty over potential National Legislation changes also ensures that by source separating DMR, the waste collection method is future-proofed. Additionally, as no other UK local authority currently uses highly innovative systems to achieve source separated recyclable material, there may be greater potential to achieve various forms of green infrastructural funding to part cover the capital costs of this waste collection method. Although not considered within this paper, it is also recommended that trade waste from the campus style science/technology park should be collected using URS as a more environmentally-friendly and cost effective alternative.
- 8.5. The Garden Village presents the perfect opportunity to explore the capacity for URS to form part of West Oxfordshire's waste collection strategy. By using the Garden Village as a flagship project for these advanced waste collection systems, the Council is able to assess the potential for URS to be used (or retrofitted) more widely in other areas of the District. This may prove a key aspect in allowing the Council promote sustainable growth through modern urban design.

APPENDIX I - ASSUMPTIONS MADE WITHIN THE INDICATIVE COSTINGS OF WASTE COLLECTION METHODS

(The capital costings included within this section have been estimated based from quotes provided by URS manufacturers Sulo Ltd. and Contenur Ltd. and other waste container manufacturers. Operational costings have been modelled based upon the technical expertise of Ubico Ltd. and the Environmental Services department)

I. CAPITAL EXPENDITURE COSTING ESTIMATES:

I.1. Baseline waste collection method

I.1.1. This capital expenditure refers to the cost of procuring the following containers to each domestic property within the Garden Village: 180l refuse container, 240l mixed recycling container, 240l garden waste container (upon procurement of a license), 44l glass recycling container, 23 external food caddy, 7l internal food caddy. This cost also includes the procurement of two new 26t waste collection vehicles and a 15t waste collection vehicle to serve refuse, DMR and food waste collection across the site.

I.1.2. This capital expenditure also includes the cost for procurement, delivery and installation of 45 on-street metal waste containers and 35 on-street metal Fido (dog waste) bins.

I.2. Waste collection using URS

I.2.1. This capital expenditure cost works on the assumption that 1 URS unit can serve 21 properties for each waste stream. Therefore, 5 URS container units are required for each cluster of 21 properties in order to capture each waste stream. This cost also includes the procurement and installation of URS to collect on-street waste streams and the procurement and installation of 25 URS units (5 locations which collect each source separated waste stream) to serve municipal trade waste. The cost of URS delivery and associated feasibility assessments (such as groundwork tests) are also included.

I.2.2. This CAPEX also includes the procurement of 1 new 26t waste collection vehicle to empty the URS units at the site.

2. OPERATIONAL EXPENDITURE COSTING ESTIMATES

2.1. Baseline waste collection method

2.1.1. The majority of the operational expenditure associated with the baseline solution refers to the cost of service delivery (fuel costs, waste reprocessing costs, gate fees and recycling credit offsets). The cost for the Garden Village development has been calculated from the average cost per annum to collect waste from the West Oxfordshire District, multiplied by 2,200 properties.

2.1.2. In addition to this, an annual 10% replacement rate of the waste containers issued to each household is included. This is representative of the bin replacement rate for the 2018/19 financial period. An average annual cost to maintain two 26t and one 15t waste collection truck is included within this estimate (these maintenance costs refer to the servicing, insurance and cleaning of vehicles).

2.2. Waste collection using URS

2.2.1. Due to limited data availability, the comparative model included within the Sustainable Resource and Waste Management Strategy Addendum for North West Cambridgeshire has seen used to estimate the reduction in cost of service delivery by using URS. The model has been developed based on information from Sotkon, and in collaboration with the waste officers from Cambridge City Council. Based from projected annual service costs, the model assumes a 10% saving in time by using the URS units, a reduction from 3 to 1 waste collection operatives and a circa 40% saving in total fuel consumption. This estimate therefore suggests that service delivery using URS will be c.50% cheaper than the baseline collection method.

2.2.2. The maintenance cost for waste containers is provided based from an estimate by Sulo Ltd. of £75 for cleaning and spare parts for the URS units. Although Sulo Ltd. recommends that this service should occur annually, a maintenance service is only required every three years to prevent severe damage to the URS units. A three year maintenance service is therefore included within the OPEX to reflect these additional costs.

3. **STAFFING EXPENDITURE ESTIMATES**

3.1. Baseline waste collection method

3.1.1. The estimated staffing expenditure refers to staff hiring and training costs (number of individuals per annum) and the annual average staff wage for 9 waste collection operatives (three for each collection truck). In addition to this, an estimate for welfare expenditure is also provided, which refers to the number of days leave loading operatives may take due to muscular skeletal injury.

3.2. Waste collection using URS

3.2.1. The staffing expenditure applies to a single operative (as one SPOV will have the capacity to serve URS collection across the whole site), this minimises the total annual staffing costs. Training costs for the operation of the crane assisted waste collection vehicle are assumed to be the same as training a waste collection operative for the baseline solution. Welfare expenditure is assumed to be zero as the risk of muscular skeletal injury during URS emptying is extremely minimal.

APPENDIX 2 – EMISSIONS MODEL DETAILS

- I.1. This appendix outlines the methodology which has been used to calculate the total exhaust emissions produced per annum from the waste collection vehicles which collect waste from 21 properties for both the baseline solution and a collection method which uses URS.
- I.2. The following Figure indicates the calculation method used to produce the exhaust emissions estimates.

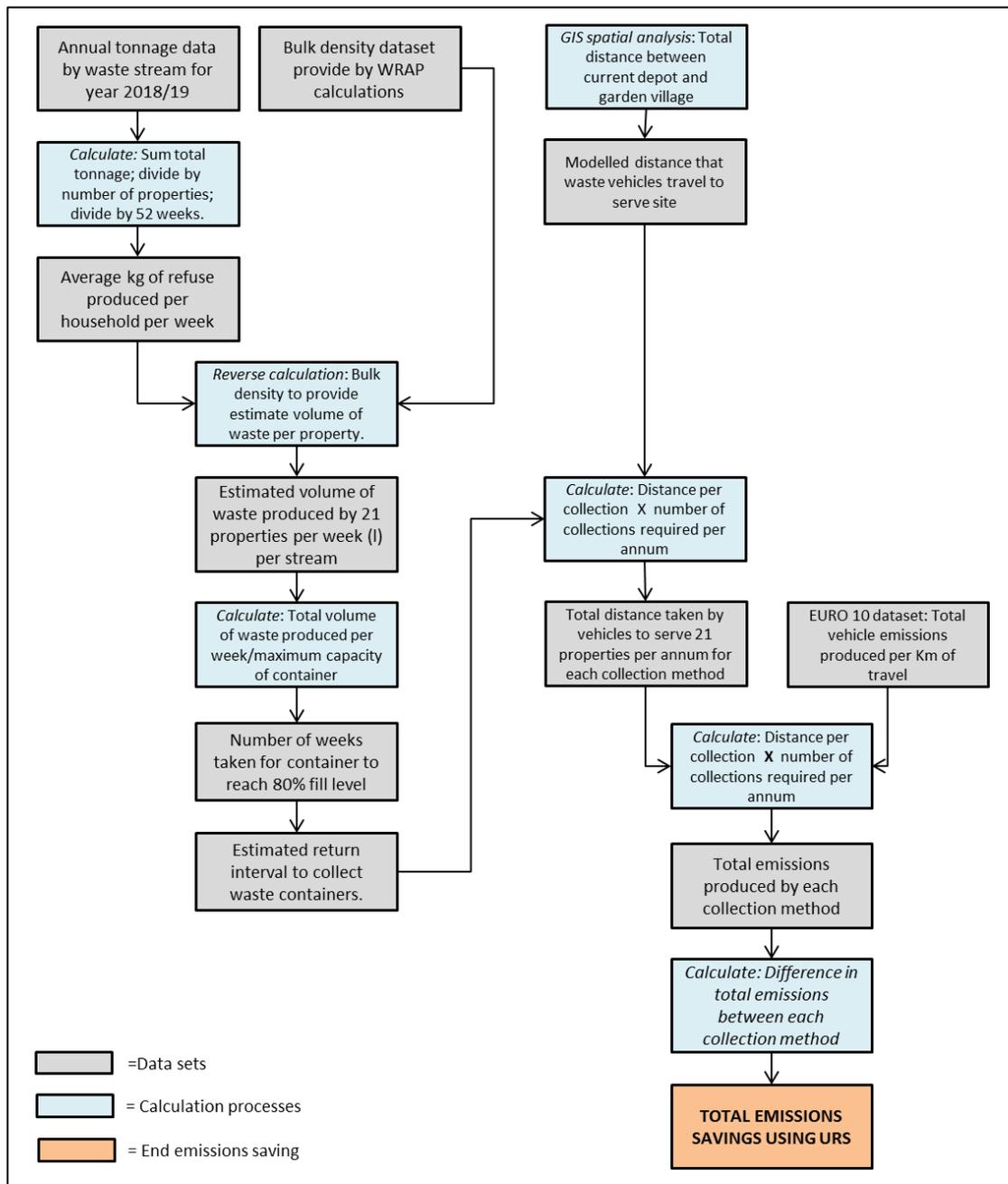


Figure 6: Framework outlining the reduced complexity emissions model used to estimate the total exhaust emissions produced for both the baseline solution and a collection method which uses URS. The figure indicates the datasets used and calculations made.

1.3. Table 6 details all of the assumptions made within the emissions model:

Table 6 – Key assumptions made within the emissions model

	Assumption	Notes
Model framework	Number of properties served	To eliminate complexities associated with vehicles completing multiple collections per round, the model estimates the emissions produced from waste collection for 21 properties alone. In reality, if a waste collection vehicle serves multiple URS before tipping and returning to the site then total exhaust emissions may be further reduced.
	Domestic waste collection only	Although business option three within this report assesses the potential for trade and on-street waste to be collected using URS, this model only estimates the reduction in exhaust emissions if URS were used to collect domestic waste only. This increases the simplicity of the model with regard to calculating total distances travelled by waste vehicles.
	Waste collection vehicles are identical	The assumption that the same waste collection vehicle cab(s) will be used if the baseline solution or URS collection method are adopted is included within the model.
Calculation assumptions	Average mass of waste produced per household	The average mass of waste produced per household is calculated from the sum total of each waste stream produced across the district divided by the total number of properties in the district. In reality, 20 properties may produce a disparate mass of waste per annum to this averaged estimate.
	Average bulk density of refuse per waste stream (WRAP data)	The WRAP bulk density data set provides an estimate mass: volume ratio of the waste streams assessed within the model. In reality, the exact volume of waste per kg may be different. In turn, this will affect the rate at which URS containers reach the 80% fill volume.
	Distance travelled by waste collection vehicles	For the purpose of the model, the distance which waste collections must travel to serve the site is calculated from the WODC Depot, Supergass Industrial Estate, Downs Rd and Eynsham village via the A40 highway. In the future, procurement of different waste processing depots may alter the total distance travelled by waste vehicles.
	Emissions dataset for waste collection vehicles	Due to the limited availability of datasets detailing the total emissions produced by 26t waste collection vehicles, the emissions data provided for exhaust emissions factors from the IFEU (2012) emissions model for Euro 10 vehicles has been used. Net emissions produced may vary considerably dependent upon which 26t waste vehicles are procured/used to serve the site.

APPENDIX 3 – CALCULATIONS USED TO CALCULATE THE RETRUN OVER INVESTMENT ON CAPITAL EXPENDITURE FOR URS.

I. RETURN OVER INVESTMENT

- 1.1. Return over investment refers to the ratio between net profit and cost of investment. If capital costs of urban infrastructure are high, in order to make the investment viable, they need to either significantly minimise operational expenditure as of year one; or have a long life-span over which they reduce operational costs.

2. PAYBACK PERIOD FOR URS WITHIN THE GARDEN VILLAGE

- 2.1. The following calculation has been used to estimate the number of years it will take for a return over investment for the URS units in the Garden Village.

$$\textit{Return over investment period (years)} = \frac{\textit{Operational savings per annum} - \textit{Cost of inestment}}{\textit{Capital expenditure}}$$

- 2.2. Using this calculation, and the capital/operational expenditure estimates included within Table 2, it can be estimated that the return over investment is c. 15 years. This estimation is dependent upon future market changes in cost of service delivery and the performance gap between predicted and real-world life-span of URS units. Future assessments may wish to consider these factors when validating financial estimates of project delivery.