Summary report

Submitted to
Transport for London

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Road safety standards for construction, supply and waste sites

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Contents

List of Appendices

List of Tables

List of Figures

List of Acronyms

CLOCS	Construction Logistics and Cyclist Safety
FORS	Fleet Operator Recognition Scheme
HGV	Heavy Goods Vehicle
LEC	Low Entry Cab
N3	A vehicle designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes
N3G	A vehicle designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes with off-road capabilities

Executive Summary

This report details research undertaken for Transport for London by AECOM, as part of the Construction Logistics and Cyclist Safety (CLOCS) research programme. The aim of the study is to identify the minimum standards for site accessibility and develop a framework to quantify the criteria to rate construction, supply and waste sites, and create a directory of sites. Recent research demonstrates the requirement for a single specific standard linking site operational conditions to vehicle specifications[1] to reduce the number of incidents involving heavy goods vehicles (HGV) and vulnerable road users, specifically cyclists, on London's road network.

Studies[2] have shown that HGVs are proportionately overrepresented in fatal collisions with cyclists, with 53% of pedal cyclist fatalities between 2008 and 2012 involving direct conflict with a HGV, though they make up just 4% of traffic. HGVs used in the construction, supply and waste industry, commonly known as tipper trucks, account for the highest number of fatalities to cyclists within London. In 2011, seven of the sixteen cyclist fatalities resulted from direct conflict with tipper trucks[3].

Tipper trucks in operation within London have a maximum mass exceeding 12 tonnes and are therefore category N3. This category also has variants of the standard N3 tipper truck named; Low Entry Cab (LEC) and N3G (off-road capable). LEC vehicles, like standard N3 vehicles, are not considered off-road capable, despite having a degree of off-road capability, and are fitted with under-run protection reducing ground clearance capability of the vehicles. N3G vehicles are off-road capable and are exempt from under-run protection as the operation of equipment may be compromised by its presence. Off-road capable vehicles also have blind spots associated with the elevated cab height, resulting in poor visibility; in combination these factors increase the likelihood and severity of incidents with vulnerable road users.

Despite the safety limitations associated with N3G, these vehicles are commonly procured to cope with the variable conditions encountered on material supply, construction and waste sites. Therefore, the development and implementation of minimum standards will help to improve site conditions and facilitate procurement of the safer LEC and N3 vehicles within the industry. The adoption of LEC and N3 tipper trucks would provide safer conditions for workers as well as a safer traveling environment for vulnerable road users.

The purpose of this document is to summarise; the development of the standards and framework to evaluate construction, supply and waste sites, the creation of a directory to identify sites that are located in the South East, the assessment methodology and associated provisional site ratings of identified sites, and provide guidance to improve sites. This document is accompanied by a site assessment handbook and GIS directory of provisionally rated sites.

The site assessment handbook has been developed for site personnel to evaluate their sites based on four categories; approach angles, materials, rutting and water. These four criteria were seen as the most important factors in deciding which vehicle types can access sites. Each category has five ratings; CLOCS 5 (LEC), CLOCS 4 (N3 or LEC weather permitting), CLOCS 3 (N3), CLOCS 2 (N3G or N3 weather permitting) and CLOCS 1 (Site plant only or N3G weather permitting). The overall site rating is based on the lowest rated criterion.

A directory of sites including landfills, waste treatment, waste transfer, cement works, concrete works, asphalt plants, aggregate served railheads and wharfs that service the South East and East was developed. The 1,848 sites identified were provisionally assessed utilising the criteria in the assessment handbook. Of these sites 1,190 are rated as a CLOCS 5. This means that 64% of sites currently in operation are LEC vehicle accessible in all weather conditions. Of the CLOCS 5 rated sites, 949 are waste transfer or waste treatment sites which are required to have a hardstanding tipping area due to environmental legislation. A further 459 sites are rated as CLOCS 4 and 114 as CLOCS 3 meaning 95% of sites, from the provisional assessment, are accessible with LEC or N3 vehicles. Of the CLOCS 2 sites, 75% are landfills, where N3G vehicles would be required. These findings show that in order to reduce the number of N3G vehicles on the network, it is important to improve site conditions on landfills where the majority of construction waste will ultimately end.

[1] AECOM: Operational Conditions Research Project For Construction Off-road Vehicles, 2015
[2] Transport for London: Safer Lorry Scheme, The Way Forward, 2014
[3] Transport Research Laboratory: Construction Logistics and Cyclist Safety, 2013

1 Introduction

This report details research undertaken for Transport for London by AECOM, as part of the Construction Logistics and Cyclist Safety (CLOCS) research programme. The aim of the study is to identify the minimum standards for site accessibility and develop a framework to quantify the criteria to rate construction, supply and waste sites, and create a directory of rated sites. Recent research[4] demonstrates the requirement for a single specific standard linking site operational conditions to vehicle specifications to reduce the number of incidents involving heavy goods vehicles (HGV) and vulnerable road users, specifically cyclists, on London's road network

1.1 Research Rational

Studies[5] have shown that HGVs are proportionately overrepresented in fatal collisions with cyclists, with 53% of pedal cyclist fatalities between 2008 and 2012 involving direct conflict with a HGV, though they make up just 4% of traffic. HGVs used in the construction, supply and waste industry, commonly known as tipper trucks, account for the highest number of fatalities to cyclists within London. In 2011, seven of the sixteen cyclist fatalities resulted from direct conflict with tipper trucks[6].

The increase in fatal collisions associated with cyclists and tipper trucks can be attributed to two factors. Firstly, the construction industry within London has seen strong post-recession growth since 2010, with a number of major projects, such as Crossrail, providing the catalyst for work. Continued growth is anticipated, with Greater London expected to see a construction output growth rate of 4.2% between 2015 and 2019[7]. The increase in construction activity has resulted in greater demand on suppliers, waste away operations and ultimately fleet operators. Furthermore, cyclists traveling within London have also seen a significant increase. In 2014 there were 645,000 cycle journey stages in London per-day, which is a 10% increase from 2013 and a 70% increase from 2004[8]. In order to understand the correlation between tipper truck collisions with cyclists, this report considers the variations of tipper trucks available and currently used within the industry, and how practice and/or behaviour could change in order to improve on-road safety for cyclists and drivers.

At present the predominant tipper truck type used within London are off-road capable, allowing them to traverse rough terrain that may be encountered on sites such as landfills and quarries. The off-road characteristics of these vehicles do not allow provision for safety features, such as under-run protection, and an increased axle height and elevated cab creates greater blind spot areas. As a consequence these off-road variants pose a greater hazard to cyclists in comparison to their non-off-road counterparts.

Transport for London and the industry have been examining ways to further incorporate the tipper truck variants with safety features including front, rear and side under-run protection and improved visibility. If ground conditions could be guaranteed on-site, and the minimum standards required for each vehicle type defined, greater adoption of on-road tipper trucks could be achieved providing safer conditions for workers and a safer traveling environment for vulnerable road users in London. Therefore, the purpose of this document is to provide the standards and framework to evaluate construction, supply and waste sites and provide guidance to improve, thus reducing the requirement for off-road capable tipper trucks. This document details the findings of an investigation to establish:

1. The current understanding of existing construction, supply and waste site standards and why industry expectation relies on a need for off-road capable vehicles.
2. Comparison between construction, supply and waste industry site practice with that of other sectors and other countries that have removed the need for off-road capable vehicles.
3. Site assessment criteria and minimum standards rating system.
4. What good (and not so good) construction, supply and waste sites look like with regards to site conditions, vehicle capability and road safety.
5. Optimum site standards and a selection of exemplar sites.

[4] AECOM: Operational Conditions Research Project For Construction Off-road Vehicles, 2015
[5] Transport for London: Safer Lorry Scheme, The Way Forward, 2014
[6] Transport Research Laboratory: Construction Logistics and Cyclist Safety, 2013
[7] CITB: Industry Insights, Blueprint For Construction 2015 - 2019
[8] Transport for London: Travel in London, Report 8, 2015

1.2 Research Methodology

In order to achieve the requirements of this research, the methodology was developed to include both desk and site based study. Site visits to landfills, waste transfer and supply sites were conducted on a regular basis throughout the study period, in order to capture current conditions encountered on-site and to inform the development of a site assessment handbook. The site assessment handbook is designed to allow site management to determine the types of vehicles that can operate on their sites and apply a CLOCS site rating (Sections 3 and 4). Therefore, the site assessment handbook is designed to provide clear guidance and images to reduce ambiguity and inconsistency when rating sites.

The desk based study involved the development of a directory for construction, supply and waste sites. The directory identifies all sites in operation within London, the South East and East allowing for spatial mapping and a remote evaluation using the site assessment handbook. This remote, provisional assessment is designed to give an indication of which sites require off-road capable vehicles and those that can accept the safer tipper truck variants. Directory details, GIS mapping, provisional ratings and site information can be found in Section 5. The desk based study also involved capture of global best practice and innovative solutions for improving ground conditions detailed in Section 6.

The reporting stage of the study collated the findings, conclusions and recommendations, which are detailed within this report. Throughout the entire study period, continual stakeholder engagement helped define the site assessment handbook and facilitated for sites visits. Figure 1-1 shows the order in which each stage of the project was undertaken.

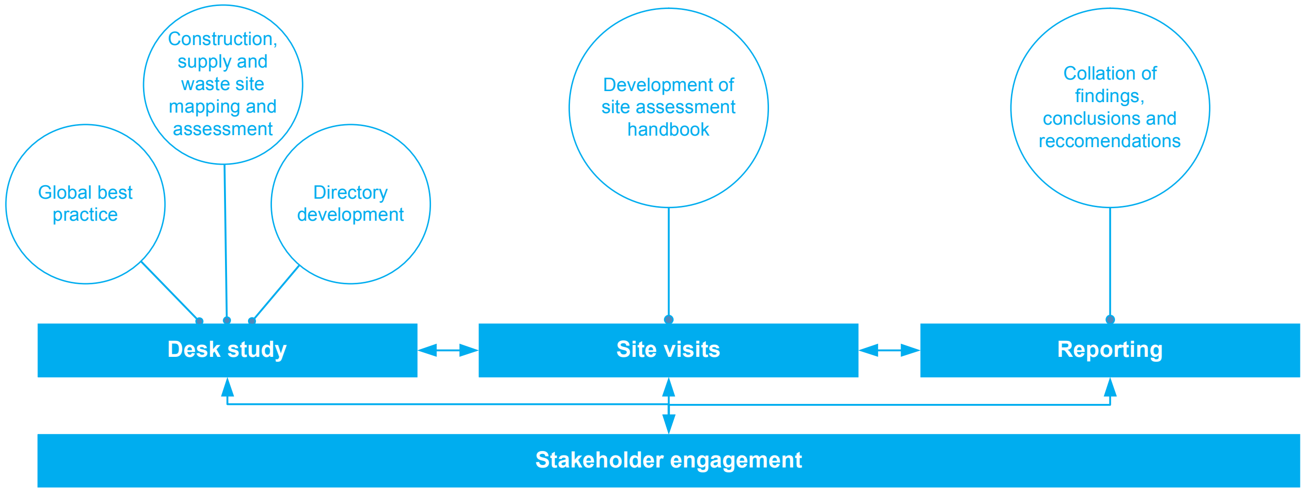

Figure 1-1 Research methodology and structure

2 Tipper Truck Variants

Vehicles used on roadways in the United Kingdom are designated categories relating to their type and usage. These categories align with the following structure:

- Category M: Motor vehicles with at least four wheels designed and constructed for the carriage of passengers.

- Category N: Motor vehicles with at least four wheels designed and constructed for the carriage of goods.

This study focuses on tipper trucks which are designed and constructed for the carriage of goods. Therefore tipper trucks fall within category N. This category is further broken down into three sub-categories:

- Category N1: Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes.

- Category N2: Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes.

- Category N3: Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes.

Tipper trucks in operation within London have a maximum mass exceeding 12 tonnes and are therefore category N3. This category also has variants of the standard N3 tipper truck named; Low Entry Cab (LEC) and N3G (off-road capable). LEC vehicles, like standard N3 vehicles, are not considered off-road capable, despite having a degree of off-road capability, and are fitted with under-run protection reducing ground clearance of the vehicles. N3G vehicles are off-road capable and are exempt from under-run protection as the operation of equipment may be compromised by its presence. Therefore these vehicles are commonly procured to cope with the rough terrain anticipated at many sites. Off-road capable vehicles have blind spots associated with the elevated cab height, resulting in poor visibility; in combination with the lack of under-run protection the use of these vehicles increases the likelihood and severity of incidents with vulnerable road users. The following sections provide an overview of the features associated with N3, LEC and N3G vehicles.

2.1 Standard (N3)

The ground clearance capability of an N3 vehicle will be dictated either by; the size of the wheels and tyres, the type of suspension fitted and/or the type and configuration of axles. Standard N3 vehicles are not classed as off-road capable, although they do have some off-road capability, and certain vehicles can be equipped with air suspension increasing ground clearance by up to 200mm when required.

2.2 Low Entry Cab (LEC)

A variant of category N3, LEC vehicles have reduced ground clearance capability compared with the other variants. LEC vehicles have been in use for 16 years mainly serving the refuse and recycling industry. LEC models can differ significantly by manufacturer; however each can be configured for specific uses. The vehicle has enhanced safety features including large panoramic windscreens, cross cab vision and provision for external cameras and sensors. Like standard N3 vehicles, air suspension can be fitted on selected models increasing ground clearance by up to 200mm. Built specifically for use in urban environments; LEC vehicles represent the standard for safe and environmentally responsible urban construction, supply and waste away operations.

2.3 Off- road capable (N3G)

In order for an N3 vehicle to be considered off-road capable and thereafter referred to as N3G, a number of conditions have to be met. These include the ability to climb 25° gradients with a maximum payload, at least half of the wheels being driven, at least one differential locking mechanism or at least one mechanism having a similar effect. Front, rear and side under-run protection is often omitted from N3G vehicles as this reduces their approach, breakover and departure angles. These types of protection also reduce the vehicle's operational capability to traverse severe off-road terrain.

2.4 Vehicle Design Data

In relation to vulnerable road user safety, a Loughborough University report[9] detailed the variations between each vehicle type over a range of manufacturers. It was demonstrated that although each vehicle variation had blind spots, LEC designs demonstrated real benefits in terms of reducing direct and indirect vision blind spots. It was also demonstrated that the height of the cab above the ground is the key vehicle factor which affects the size and direction of indirect vision blind spots. LEC vehicles have the lowest driving position of each of the variants, the N3 sits in the middle and the N3G has the highest driving position. Figure 2-1 illustrates the differences in axle height between each vehicle type.

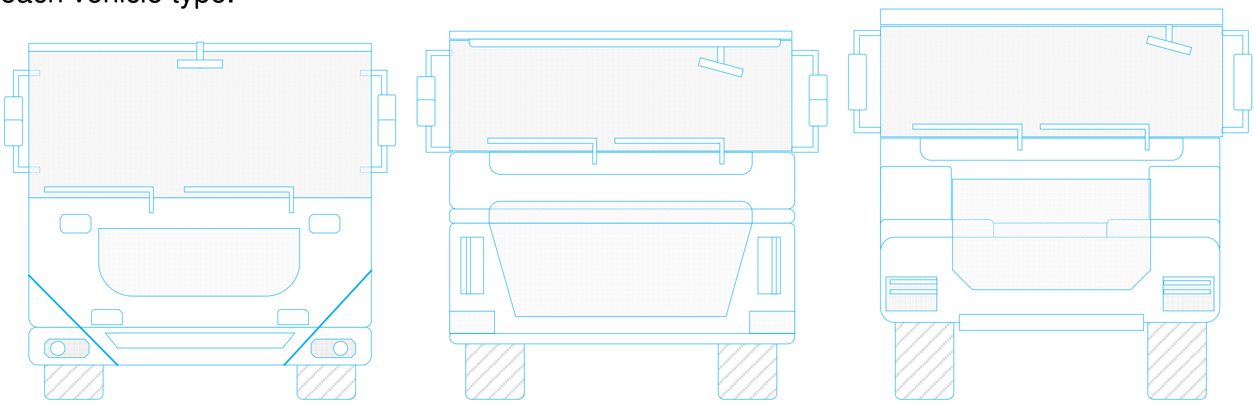

Figure 2-1 Variation in axle height between LEC, N3 and N3G vehicle types

There are two types of suspension that can be fitted to tipper trucks; air and steel. As previously mentioned, air suspension has the ability to increase ground clearance by up to 200mm. Steel suspension is typically fitted to N3G types which require more robust components for traveling off-road. Table 2-1 details the variation in approach angle, breakover angle and ground clearance between the different vehicle types and different suspension types.

Vehicle Type	Approach angle (°)	Breakover angle (°)	Ground clearance
LEC	0 -10		115 - 269
N3 with under-run	11 - 16		151 - 285
N3 Air (low)	13 – 18	13 – 22	215 – 369
N3 Air (high)	18 – 21	22 – 29	375 – 469
N3 (steel)	14 – 27	17 – 28	251 – 385
N3G (steel)	22 – 27	24 – 26	222 - 435

Table 2-1 LEC, N3 and N3G vehicle variant capabilities

The reported categories in Table 2-1 represent the minimum requirements for each vehicle and therefore takes into consideration laden vehicle ground clearance, which can reduce axle height by up to 100mm. Certain models of category N3 vehicles with air suspension have the potential to exceed the maximum ground clearance capabilities of some N3G off-road variants, although the rubber bellows incorporated in air suspension systems have been found to be more prone to failure in off-road conditions.

The major difference between the vehicles is the approach angle capabilities, with N3G vehicles designed to traverse sudden and steep gradients. The approach angle and ground clearance are

[9] Loughborough University: Understanding direct and indirect driver vision from heavy goods vehicles, 2015

perceived barriers to the adoption of N3 and LEC vehicles, even though these vehicles do possess a degree of off-road capability.

Previous research[10], commissioned by Transport for London, reported that tipper vehicles spend the majority of their time in an urban environment and never or hardly ever encounter off-road conditions. It also found that a significant number of fleet operators were unaware of the terms LEC, N3 or N3G, and were therefore not aware of the capabilities of each vehicle. However, there is a prevalent perception that off-road capable vehicles are required for the majority of sites visited and these vehicles are commonly procured even if off-road capability is not specified.

During our site visits N3 vehicles were often seen on landfill and supply sites where conditions were considered to be off-road. LEC vehicles have also been trialled on these sites, and whilst there have been some instances of LEC vehicles grounding on off-road terrain, a marginal improvement in ground conditions would mitigate this. Therefore, small improvements on-site could lead to further adoption of LEC vehicles by the industry.

[10] AECOM: Operational Conditions Research Report For Construction Off-Road Vehicles, 2015

3 Ground Conditions

Ground conditions can vary significantly depending on the type of site, phase of construction and prevailing weather conditions. Confined inner city construction sites are typically paved and tipper vehicles only have to travel a short distance from any main road, whereas landfill sites may require vehicles to traverse long sections of unpaved, off-road, terrain. Previous research[11] found that loss of traction and vehicles becoming grounded are rarely encountered on inner city construction sites. However, reports from some sites suggest that gradients are now becoming an issue at some inner city construction sites, with vehicles required to travel further below ground level, resulting in steep and sharp gradients. Despite this, LEC or N3 variants are suitable for the majority of construction sites, in operation at the time of assessment, within London.

The main issue and primary focus of this study is to assess conditions on supply and waste sites, establish where vehicles are less likely to encounter off-road conditions and to identify where LEC vehicles can be used. Ground conditions encountered on some sites can vary from day to day, with weather significantly impacting the quality of surfaces. To establish the range of conditions that can be encountered, numerous site visits were conducted to capture the effect pf traffic and weather. Through collaboration with project stakeholders, site visits to waste and supply sites were conducted at 13 locations (Figure 3-1).

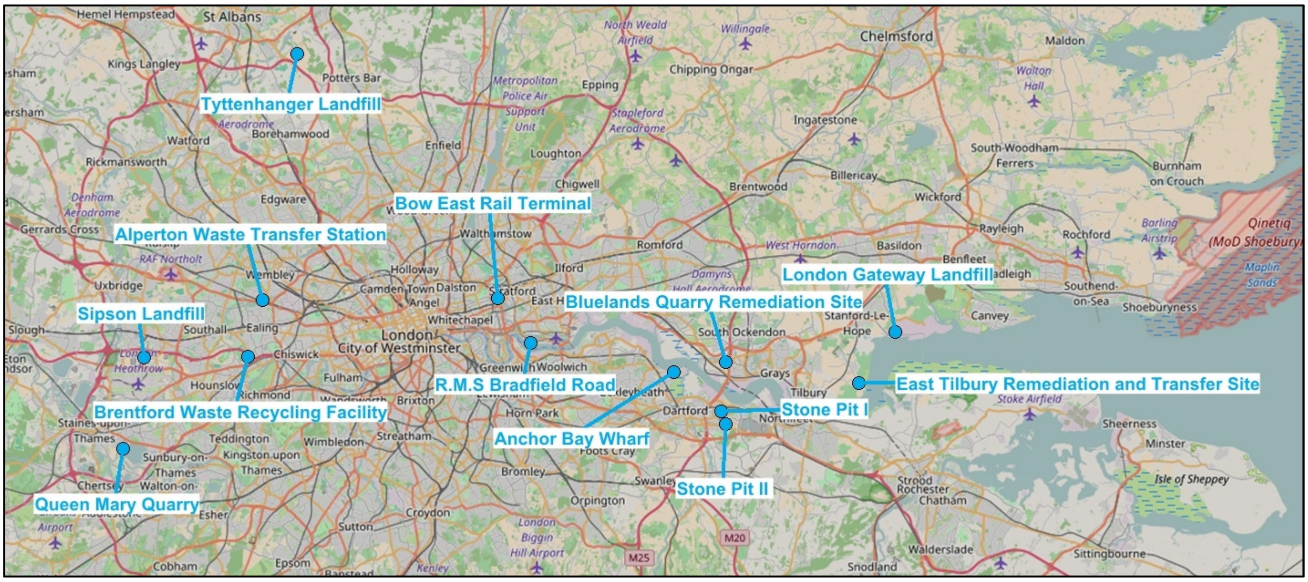

Figure 3-1 Site visit locations

A range of ground conditions was encountered on-site throughout the study period from off-road conditions to paved roads. The variation in ground conditions encountered highlighted the need for a standardised site assessment framework which encompasses a range of variables. The following sections provide an overview of ground conditions encountered during site visits. At each location a site assessment form was completed in order to record and rate the sites, and also inform the development of the site assessment handbook (case studies for each site visited can be found in Appendix A).

[11] AECOM: Operational Conditions Research Report For Construction Off-Road Vehicles, 2015

3.1 Paved

All waste transfer and waste treatment sites are required to provide a level of environmental protection to prevent contaminated substances entering the surrounding environment, dependant on their permit type. Therefore, waste transfer sites are paved throughout and swept on a regular basis. Environmental legislation states “all waste should be stored in a building or within a secure container; all waste shall be stored and treated on an impermeable surface with selected drainage system; specified waste shall be stored and treated on hard standing or on an impermeable surface with sealed drainage system” (Standard rules; household, commercial and industrial waste transfer stations, 2010[12]). LEC vehicles are able to operate on waste treatment and waste transfer sites in all weather conditions without a loss of traction due to the required paved surfaces.

The majority of ingress and egress routes into landfill and aggregate supply sites are paved, providing passage to weigh bridges or wheel washes. These areas are swept on a regular basis in order to prevent material being tracked onto the highway. Provision of a paved tipping apron (Figure 3-2) from which site plant transports material onto the landfill site allows LEC and N3 vehicles to operate in all weather conditions. However, many landfill sites require the vehicles to leave these paved areas to transport the material onto the landfill tipping site.

The majority of paved areas encountered on-site were well maintained with no evidence of pot holes and were also well drained. Where pot holes and surface water were present they were not deep enough to warrant the use of an N3G vehicle.

Figure 3-2 Paved tipping apron at entrance to landfill/remediation facility

12 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/479540/LIT_10277.pdf

3.2 Unpaved

The majority of landfills and supply sites visited were unpaved past the weigh bridge and wheel wash, and a variety of ground conditions were encountered after this point, with weather affecting conditions significantly. The majority of landfills visited within Greater London possessed some areas of off-road conditions, where tipping vehicles would be required to travel. Material was often tipped in a designated area to be transported by site plant a few metres to its final destination. Ruts to a depth of 150mm on trafficked surfaces were frequently encountered; however, the ability for a vehicle to traverse these areas was subject to the composition of material underneath the surface layer. Where clay was present significant flexing of the surface structure and a loss of traction for N3G vehicles was witnessed. Loss of traction was exaggerated after vehicles had completed a tip as the unladen weight was insufficient to maintain traction with the surface material.

Tyttenhanger landfill had installed a mechanically stabilised haul road up to the tipping area which created much improved ground conditions. Crushed concrete was mixed into the subsurface and subsequently reinforced with geotextiles on a particular area of the site which was prone to loss of traction in adverse weather conditions. The surface condition was much improved compared to the majority of landfills visited, where this level of maintenance had not been undertaken. N3 vehicles were able to traverse the reinforced haul road on this particular site in all weather conditions. This investment has led to additional business for the site, where vehicles that cannot otherwise access competitor sites in poor weather conditions, can come to complete their run. Figure 3-3 shows a comparison between the mechanically stabilised haul road to the left and unbound material to the right.

Figure 3-3 Mechanically stabilised soil (left of cones) and unbound soil (right of cones)

The stakeholders consulted during this project described instances where even N3G vehicles had become stuck in unpaved material on landfill and supply sites; however, this was not witnessed during site visits. All site visits were conducted from February to July and only sunny and dry conditions were encountered. The majority of sites would be suitable for N3 vehicles in all but extreme weather conditions and/or where high traffic volumes result in deteriorating ground conditions for unpaved surfaces.

3.3 Materials

The materials encountered on-site were dependant on the nature of the site and if any maintenance had been carried out. Landfills visited mainly consisted of cohesive material, particularly near the final tipping destination. Loss of traction and reduced ride quality was witnessed in these areas. Site plant was used to regularly grade haul roads although conditions deteriorated after one or two tipper truck movements, where vehicles follow in the wheel path of previous vehicles (see 3.4 Rutting). Figure 3-4 shows cohesive material present at a tipping area where significant flexing of the surface and loss of traction were witnessed. N3 or N3G vehicles would be required in such areas due to the risk of grounding LEC vehicles.

Figure 3-4 Cohesive material present at tipping area of landfill

Supply sites visited mainly consisted of hardstanding of crushed material and fines. This provided good access to most parts of the site and into bays where tipping vehicles are loaded with material. Project stakeholders provided anecdotal evidence of where vehicles have become stuck on cohesive materials, although site visits to confirm this were not realised within the project timescale.

3.4 Rutting

Rutting was an issue on unpaved sites where continuous vehicle movements led to poor ground conditions. The depths of ruts were generally shallow, particularly on sites that had invested in reinforced haul roads. Ruts where an N3G vehicle would be required were rarely encountered. The most severe instance of rutting, as shown in Figure 3-5, proved difficult for even N3Gs to operate on. The other sites visited would be able to operate LEC or N3 vehicles equipped with air suspension, which can be activated if required. Generally, on paved areas of sites, rutting was not encountered at a significant depth to cause damage to any vehicle.

Figure 3-5 Ruts with the potential to cause damage to vehicles at tipping area

Driver behaviour also dictated the size of ruts present on-site. Drivers were actively encouraged to drive outside of wheel tracks to discourage further rutting, however this was not always put into practice. Similarly the speed of the vehicle would determine if vehicles ground out on ruts. Site speed limits were often not adhered to, resulting in site management to intentionally leave the site unmaintained to discourage speeding. Sites which provided hardstanding haul roads had witnessed driver speeds in excess of 30mph as the nature of the surface encouraged faster driving.

3.5 Approach Angles

The approach angle is the maximum angle of a ramp onto which a vehicle can climb from a horizontal plane without interference. It is defined as the angle between the ground and the line drawn between the front tyre and the lowest-hanging part of the vehicle at the front overhang. The general opinion of site operatives is that the major barrier to adopting LEC and N3 vehicles is the range of change in gradients that can be encountered on-site. Trials of LEC vehicles on certain sites have resulted in front bumpers to be sheared off. However, operatives of the vehicles may not have been aware of the air suspension capabilities of the LEC or N3, or approached the hazard too quickly.

Change in gradients encountered during site visits did not generally exceed the approach angle capabilities of an N3 vehicle, although reports of construction sites within London possessing sharp gradients have caused concern. Figure 3-6 shows an approach angle on a vehicle providing sufficient clearance over the railhead on which an LEC vehicle lost its front bumper. This railhead is present at the bottom of a slope which exacerbates the problem when fully laden. Many of the issues documented, such as in Figure 3-6, could be resolved with small earthworks to allow for the use of LECs.

Figure 3-6 Vehicle approach angle sufficient to clear railhead

3.6 Loose Material & Debris

Loose material is common on construction, supply and waste sites where the movement of material often leads to spillages either onto the haul road surface or to the edge. Loose material has the potential to damage vehicles and cause injury to site personnel if not managed and maintained on a regular basis. The amount of loose material present on-site will not necessarily affect the type of vehicle able to operate on it, but should be considered within the overall condition of the site.

Management personnel at landfills with cohesive material often put down loose aggregate as a means of improving traction for vehicles. This loose material has the potential to flick up and damage vehicles or become lodged between wheels and can be difficult and dangerous to remove, with injuries sustained as a result of material removed from the wheels under high pressure.

Loose material spilt whilst loading tipper trucks was common place on aggregate supply sites where material is held in designated bays and subsequently loaded for transport. The waste transfer station visited did not allow road vehicles into the area where waste is sorted, only allowing dedicated site vehicles and plant to transport the waste to the designated storage areas.

Loose material was also present at the edge of most sites where material is swept or graded. Whilst not in the haul road, this material has the potential to damage vehicles that stray from the defined road due to careless driving or on sites where there are no passing places. Figure 3-7 shows loose aggregate and metal present at the edge of an aggregate supply site.

Figure 3-7 Loose material, including metal bar, present at edge of haul road

The sites visited over the course of the study were regularly graded and swept throughout the day to minimise the potential of damage to vehicles and personnel. Regular monitoring of loose material should take place at a frequency appropriate to the site and traffic flow. Additional inspections are recommended after heavy rainfall where material could be washed onto the haul road or exposed as a result of erosion or trafficking.

3.7 Water

Ponding of water on-site will determine the types of vehicles that can be used. The depth of water is often hard to judge without measurement and therefore there is a risk of vehicles exceeding their wading depth or grounding, when fording ponded water. Where significant surface ponding is present, N3G vehicle will be required whereas if the site is well drained N3 or LEC may be able to operate.

The level of water present on-site is dependent on the levels of precipitation, so the site visits conducted were a snap shot in time. However, many of the sites did possess the required drainage or had areas which allowed ponding of water where vehicles do not travel. Vehicles were seldom witnessed traveling through significant levels of water that have the potential to hide features that may cause damage. Figure 3-8 shows surface water present on an aggregate supply site. The use of an N3G in this situation was required due to the depth of the water, the underlying material and the inability to accurately judge the depth of water. Ponding of water will also influence the performance of the underlying materials, which will often turn to slurry, affecting traction.

Figure 3-8 Ponding of surface water at an aggregate supply site

3.7.1 **Wheel Washes**

The siting of a wheel wash, provision of suitable drainage and cleanliness of water used in a wheel wash are also important. Wheel washes on-site often use recycled water which can contain suspended aggregate, this has the potential to damage sensitive equipment, particularly safety cameras and sensors.

4 CLOCS Site Assessment Handbook

The site assessment handbook is an auditing tool to enable site personnel to review their site in order to achieve a CLOCS rating. The rating is based around the types of vehicle able to operate on the assessed site, including LEC, N3 and N3G vehicles. The evaluation is self-assessed to encourage user participation. Sites suitable for the use of LEC vehicles will achieve the best rating and sites not achieving a desirable standard will be encouraged to improve. Clients that want to improve safety and use LEC vehicles will prefer to do business with sites that accept their vehicles. In addition, the use of safer vehicles and suitable sites may be specified in new contracts for Major Projects. Over time, managers of sites with poor standards will see both the safety and financial benefits of improving site conditions, which will cater for a sustainable, industry-wide adoption of safer construction, supply and waste vehicles.

The site assessment handbook is formed of a series of criteria, relating to conditions, which are frequently encountered on-site. Each criterion is quantified in a way whereby site operatives will be able to assess a site with limited background experience. In developing the tool it was evident that weather impacted site conditions considerably, altering the outcome of the rating. The structure of the tool is such that multiple evaluations can take place over different weather conditions, meaning the system is dynamic and should be reviewed regularly to ensure standards are maintained. Table 4-1 depicts the assessment criteria in order of how they are rated in the assessment handbook.

Materials				
Concrete or asphalt	Unbound hardstanding	Granular material with fines	Fine material with some granular	Predominantly fine material (cohesive)
				
Rutting and bumps				
No ruts or bumps	Ruts and bumps less than 50mm	Ruts and bumps between 51 – 100mm	Ruts and bumps between 101 – 150mm	Ruts and bumps in excess of 150mm
				
Approach angles				
<10°	11 - 16°	17 - 21°	22 - 25°	>25°
				
Water				
No surface water	Shallow puddles	Water ponding	Water ponding on firm to soft material	Surface liquified
				

Table 4-1 Assessment criteria

The assessment will result in a CLOCS site rating from one to five. The assessment rating has been designed in a way so it is easy to establish what sites are suitable for LEC, N3, N3G or site plant only. Site management will be encouraged to display their site condition rating much in the same way as Fleet Operator Recognition Scheme[13] (FORS) and CLOCS accreditation. The rating categories (Table 4-2) are as follows:

LEC accessible all weather	N3 and LEC weather permitting	N3	N3G	Site plant and N3G weather permitting
5 CLOCS	4 CLOCS	3 CLOCS	2 CLOCS	1 CLOCS

Table 4-2 Site assessment ratings

4.1 CLOCS 5

A CLOCS 5 rated site is classed as an exemplar site and is typically paved throughout. Gradients should be gentle so vehicles with minimal approach angles, of up to 10°, could be used on-site. There will be no measurable ruts or pot holes on-site and loss of traction should not be encountered, even in wet conditions. There will be little to no loose material on-site with the potential to cause damage to site personnel or vehicles. This site will be appropriate for LEC vehicles, N3G vehicles should not be required on any part of a CLOCS 5 site.

4.2 CLOCS 4

A CLOCS 4 rated site can be achieved if the site is paved or hardstanding throughout. Sites that are hardstanding should consist of graded granular and fines. Vehicles with approach angles of 16° are appropriate. Shallow ruts and pot holes may be present on-site, with ground penetration not exceeding 50mm. Shallow puddles may be present but adequate drainage should be in place to disperse water shortly after rainfall. Loss of traction should be non-existent in dry conditions and minimal in wet conditions. Vehicles should be able to pass on-site with care and there may be areas where loose material is present but not substantial enough to cause damage. N3 vehicles will be able to operate on CLOCS 4 sites and LEC vehicles weather permitting. N3G vehicles should not be required.

4.3 CLOCS 3

A CLOCS 3 site will have unpaved sections with surface materials consisting of granular material and fines. Change in gradients may be steep so approach angles up to 21° are recommended. Rutting and pot holes will be encountered with ruts up to 100mm. Loss of traction will become increasingly likely in wet conditions and high traffic. Localised ponding of water may be present on-site in the trafficked area. It is highly likely that loose material will be encountered that has the potential to cause damage. The predominant vehicle on-site should be category N3; it is unlikely that LEC vehicles would be suitable for a CLOCS 3 site. Category N3G vehicles should not be required.

4.4 CLOCS 2

A CLOCS 2 site will have unpaved sections, with cohesive material present in the main trafficked areas. Change in gradients is likely to be steep so approach angles up to 25° are recommended. Rutting and pot holes will be present; with ruts up to 150mm. Loss of traction will be encountered in wet conditions, and may be problematic for N3 and unladen vehicles. Loose material will be present on-site with the potential to cause damage. Surface ponding of water will be present creating a

[13] https://www.fors-online.org.uk/cms/

potential hazard to moving vehicles in the trafficked area. Such sites will not be suitable for LEC or N3 vehicles and N3Gs vehicles would be required in order to operate safely all year round.

4.5 CLOCS 1

A CLOCS 1 site will have unpaved sections with cohesive surface materials and will soften to slurry with an increase in water content. Change in gradients will be steep so approach angles in excess of 25° are recommended. Ruts and pot holes will be present with ground penetration in excess of 150mm. Significant ponding of water may be witnessed in the trafficked area where the surface may be liquefied. A significant amount of loose aggregate and material will be present which has the potential to cause damage. A CLOCS 1 rated site would not be suitable for LEC or N3 vehicles. The site will only be suitable for site plant or N3G vehicles weather permitting.

5 Construction, Supply and Waste Site Mapping and Assessment

To establish the location and nature of construction, supply and waste sites that regularly service the London area, a directory was developed containing information on construction sites, waste treatment sites, waste transfer stations, landfill sites, cement works, concrete batching plants, asphalt plants, aggregate served railheads and aggregate served wharfs.

In total there were 90 construction sites identified within Greater London (including individual Crossrail sites). These construction sites were identified on 13th January 2016. Due to the dynamic nature of construction phases, the number of projects at any one time is likely to fluctuate significantly, therefore the number of construction sites identified is intended to be a snap shot in time. There were also eight landfill sites, 109 waste transfer stations and 50 waste treatment sites identified within the Greater London area.

The search was expanded for waste and supply sites to the East and South East of England. This search identified:

- 106 landfills (including the eight identified within London);
- 723 waste transfer stations (including the 109 located within London);
- 553 waste treatment sites (including the 50 located within London);
- 6 cement works;
- 195 concrete batching plants;
- 56 asphalt plants;
- 75 aggregate served railheads; and,
- 44 aggregate served wharfs.

In order to display the directory of sites, GIS was used to map the location and relative distribution of each of the identified sites. Each site identified within the directory and subsequently mapped has been given a provisional CLOCS rating. A virtual assessment was conducted using satellite imagery to assess the sites using the site assessment handbook. The ratings given to each site are intended to provide an indication as to what the rating may be if the assessment was to be conducted on-site. The provisional ratings also provide an indication as to how many sites are currently suitable for LEC, N3 or N3G vehicles. The CLOCS ratings are displayed on the mapped sites using the following key:

CLOCS 5 CLOCS 4 CLOCS 3 CLOCS 2 CLOCS 1

During the virtual assessments, some sites were either unavailable to view on satellite imagery or the conditions were not clear enough in order to make an accurate assessment. These sites have been categorised as unassessed but are not part of the CLOCS rating, and are displayed as follows:

Unassessed

For mapping and assessment of sites located solely within a London borough, see Appendix B.

5.1 Construction Sites

The location and names of construction sites within Greater London were extracted from the London Development Database[14]. The identified sites only include started projects. Omissions from the list include minor residential developments that are unlikely to require HGVs. All identified construction projects were cross-referenced using web resources, including Google Maps, to ensure they are still current. Crossrail construction site locations were identified directly through the Crossrail website[15]. The majority of work consisted of redevelopment, demolition and construction in the residential, office and leisure space. Construction sites are continually evolving and as such the construction sites captured in this report, with the search concluding on 13/01/15, are a snap shot in time and will not necessarily reflect current construction activity.

Figure 5-1 shows the spatial distribution of construction sites within Greater London. The highest concentration of construction sites is found within the City of London, with 16 major projects taking place within a 3.14km^2 area. Furthermore the City of Westminster has 9 major projects, with construction activity generally decreasing with distance from the city centre.

Of the 90 construction sites assessed, 60 were provisionally rated as CLOCS 5 and 18 as CLOCS 4. The remaining 12 sites were either complete or not available to view through satellite imagery. This virtual assessment indicates typical construction sites in an inner city environment should meet the requirements to operate LEC vehicles.

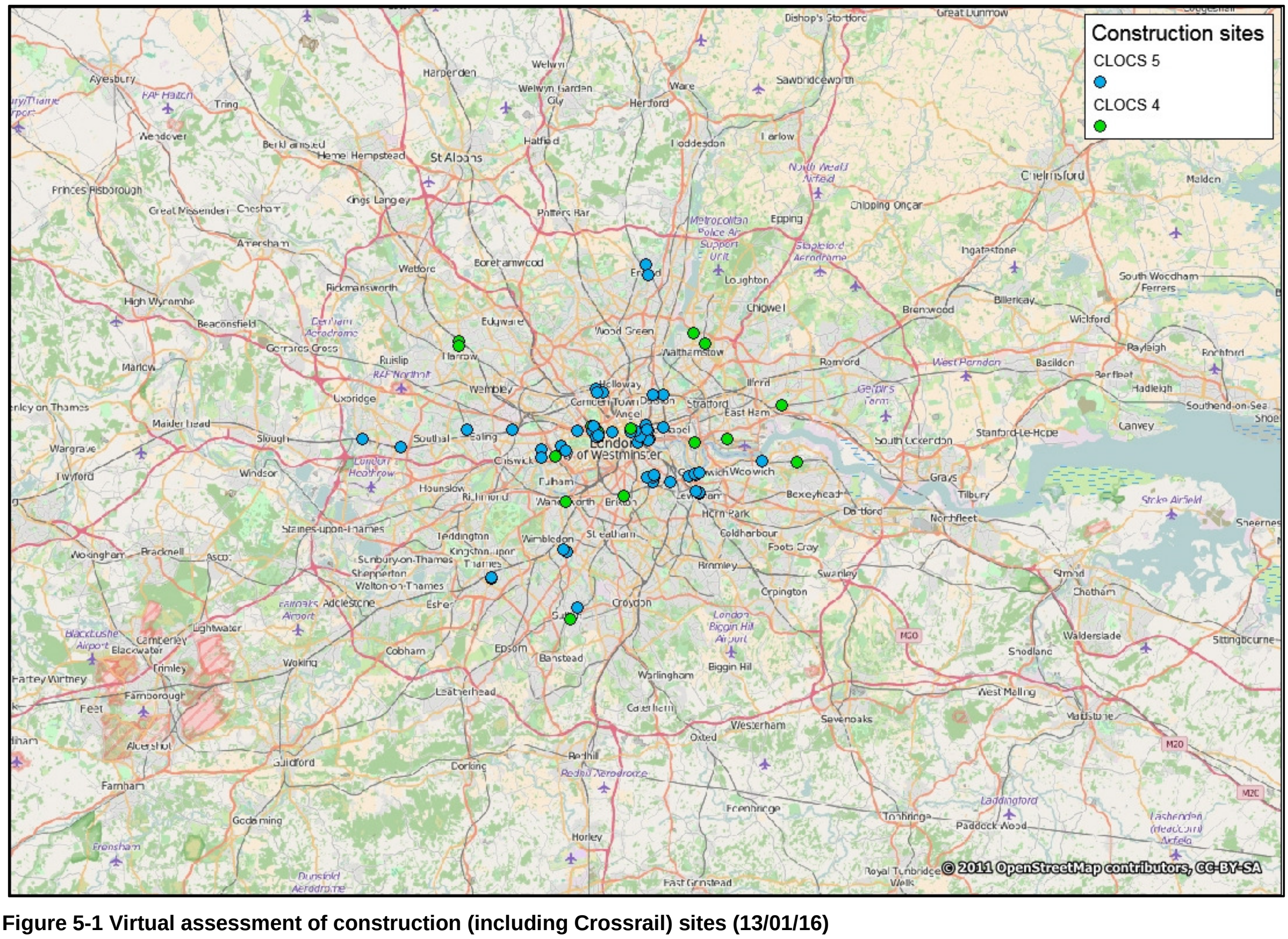

Figure 5-1 Virtual assessment of construction (including Crossrail) sites (13/01/16)

14 http://www.london.gov.uk/webmaps/ldd/
15 http://www.crossrail.co.uk/construction/

5.2 Waste Sites

To obtain landfill, waste treatment and waste transfer site information, the Environment Agency Waste Interrogator tool 2014 was utilised. The Waste Data Interrogator is a database of information about the types and quantities of waste taken to transfer, treatment or disposal to sites permitted by the Environment Agency in England. Datasets for the previous year are made available in October, therefore the dataset for 2015 was not available during reporting of this study. The Environment Agency registered landfill and waste sites map[16] was also utilised to cross reference results from the interrogator tool. Additionally individual site operator websites were accessed, again to ensure the correct sites were being mapped.

5.2.1 **Landfills**

Figure 5-2 shows the location and rating of landfills that received waste from a London borough in 2014. A total of 50 landfills were identified, with six located within a London borough. In addition to the 50 landfills that accept waste from a London borough, a further 56 were identified within the South East and East. Rainham landfill, located to the east of the city centre, received 42% of all waste from a London borough in 2014. All mapped and assessed landfills can be found in Appendix C, Figure C 1.

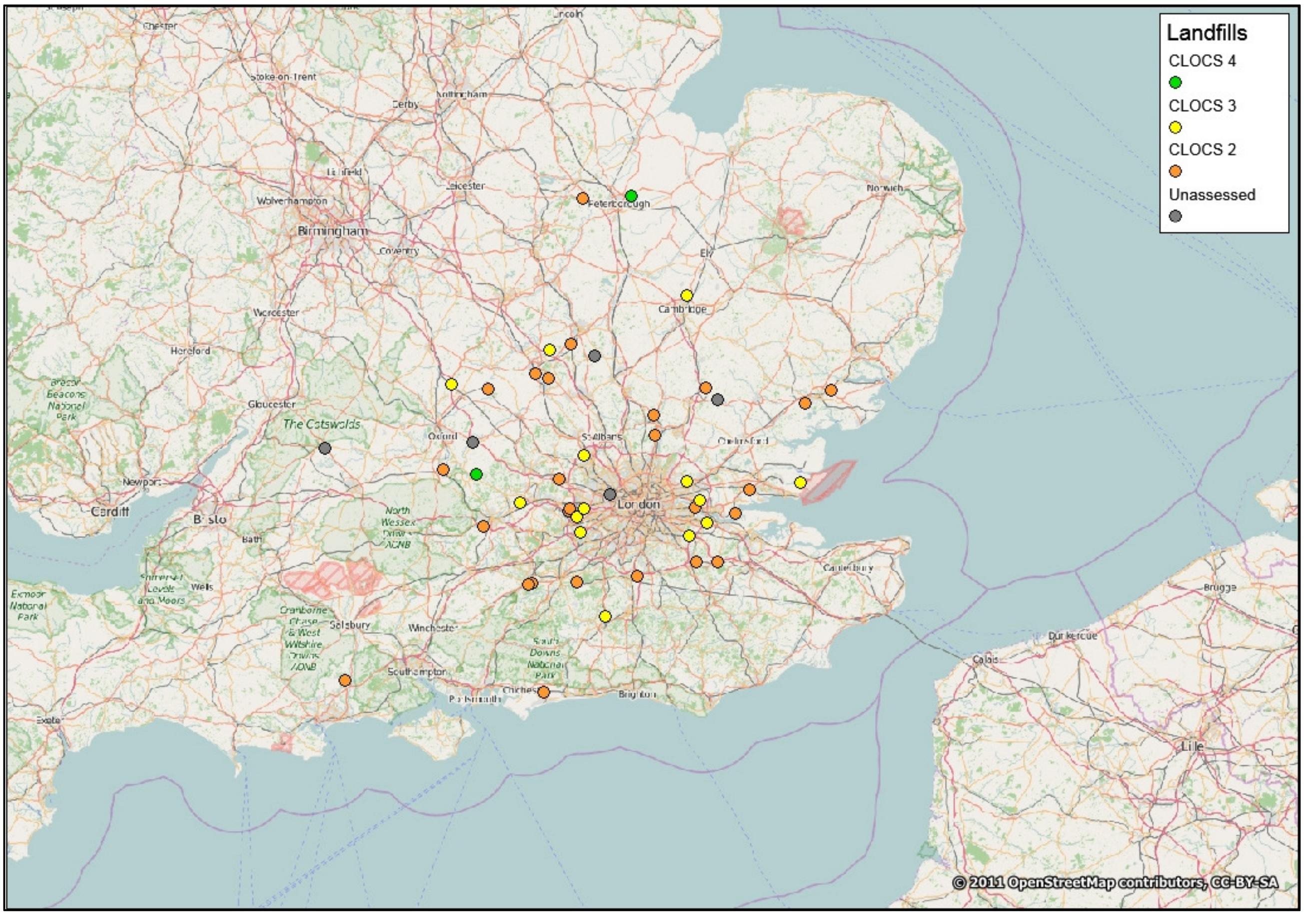

Figure 5-2 Virtual assessment of landfill sites

Of the landfills assessed (Figure 5-2), three sites were provisionally rated as CLOCS 4, where well maintained haul roads were visible and surface water was not present on the trafficked areas of the site. A further 15 were identified as CLOCS 3 sites where N3 vehicles can operate and 27 sites were rated as CLOCS 2 as dirt tracks were apparent from satellite imagery. Five were not assessed as the satellite imagery was either not available or clear.

The ever changing nature of landfills does not make it economically viable to install paved roads throughout, as the tipping area will change periodically. Therefore it is not anticipated for landfill

[16] http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=357683.0&y=355134.0&scale=1&layerGroups=default&ep=map&textonly=off&lang=_e&topic=waste

sites to achieve a CLOCS 3 rating or higher unless tipping aprons are introduced so that tipper vehicles do not have to leave paved areas.

5.2.2 Waste Transfer Sites

There were 205 waste transfer sites that accepted waste from London in 2014 (Figure 5-3). In addition to the 205 waste transfer stations identified as having received waste from London, a further 518 were identified in the South East and East. All assessed and mapped waste transfer sites can be found in Appendix C, Figure C 2.

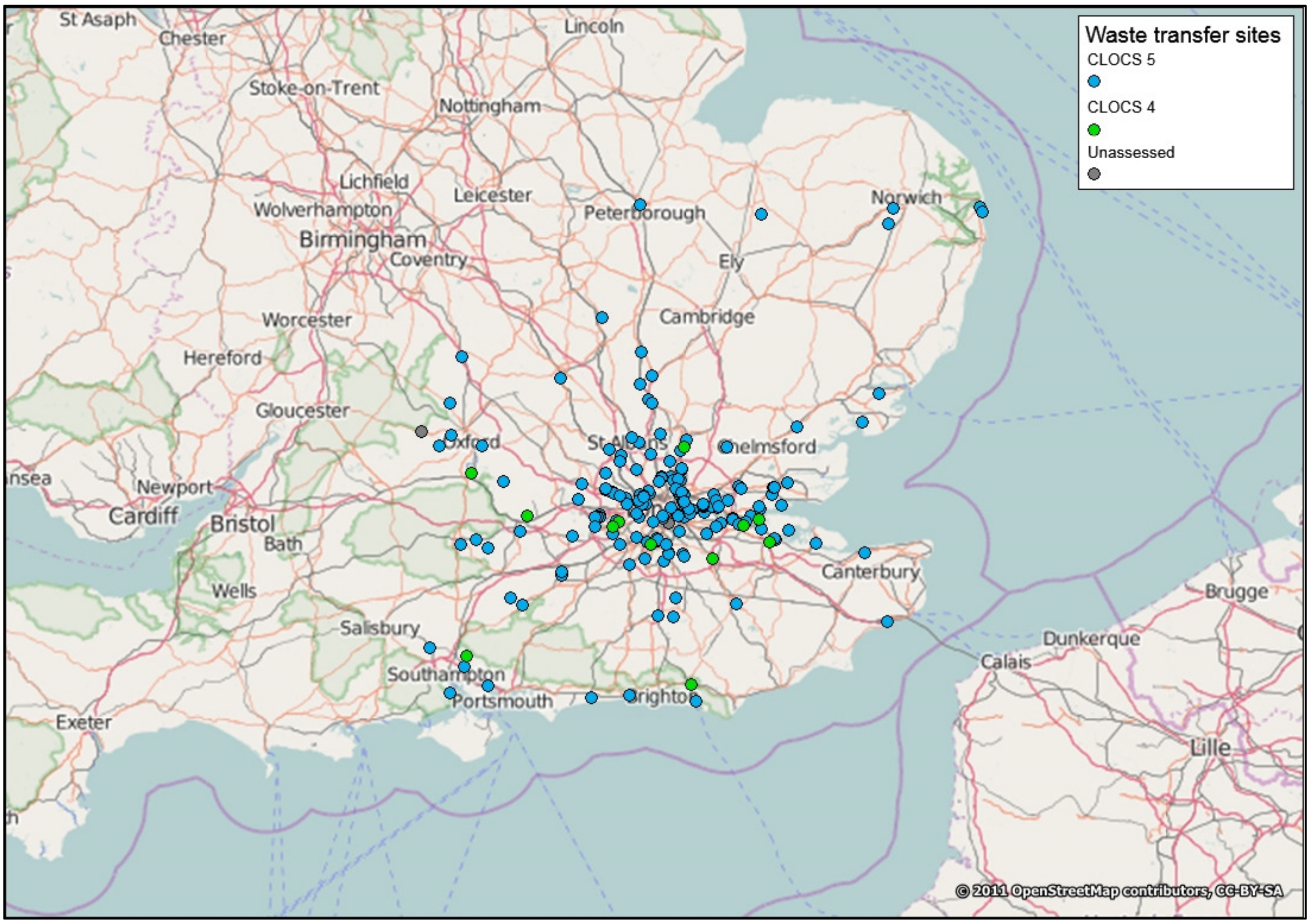

Figure 5-3 Virtual assessment of waste transfer sites

Of the 205 waste treatment stations identified that accept waste from London, 189 were provisionally rated as CLOCS 5 where an LEC vehicle would be able to operate. A further 14 were rated as CLOCS 4 and two were unassessed. The high percentage of CLOCS 5 rated waste transfer sites is to be expected due to the environmental legislation that dictates the types of surface material that can be used.

5.2.3 **Waste Treatment Sites**

There were 192 waste treatment sites that accepted waste from London in 2014, which are displayed in Figure 5-4. Of the assessed sites, 143 have been provisionally rated as CLOCS 5, a further 41 as CLOCS 4, 5 as CLOCS 3 and three were unassessed. All assessed and mapped waste treatment sites can be found in Appendix C, Figure C 3.

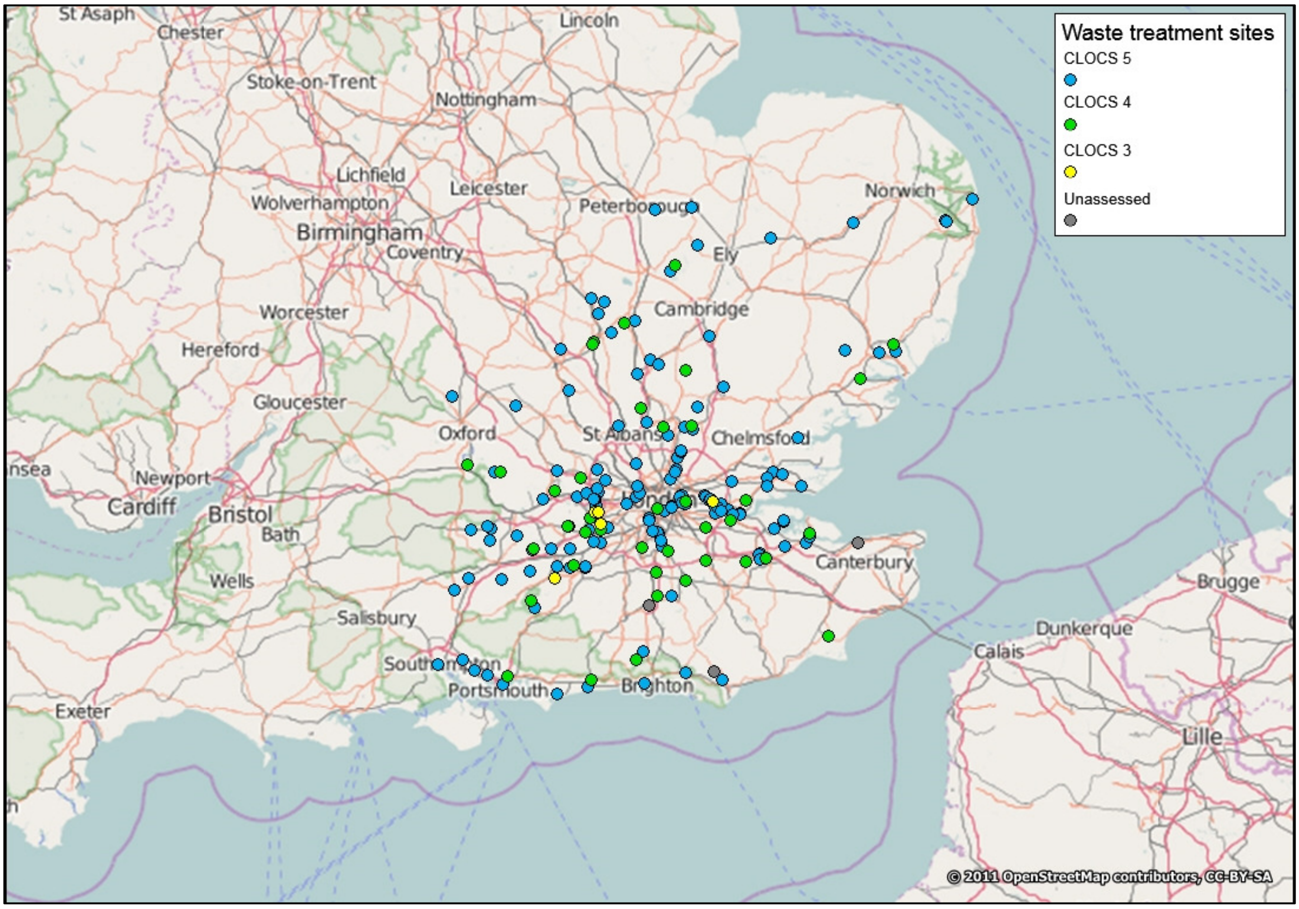

Figure 5-4 Virtual assessment of waste treatment sites

Similar to waste transfer sites, waste treatment sites are required to provide hardstanding areas which act as containment, preventing contaminants from leaching into the environment. As such it was expected that the majority of sites would fall into the CLOCS 5 and CLOCS 4 ratings.

5.3 Cement Works

Six cement works were identified within the South East and East (Figure 5-5). Three of these sites were assessed and provisionally rated as CLOCS 5 sites, two as CLOCS 4 and one as CLOCS 2.

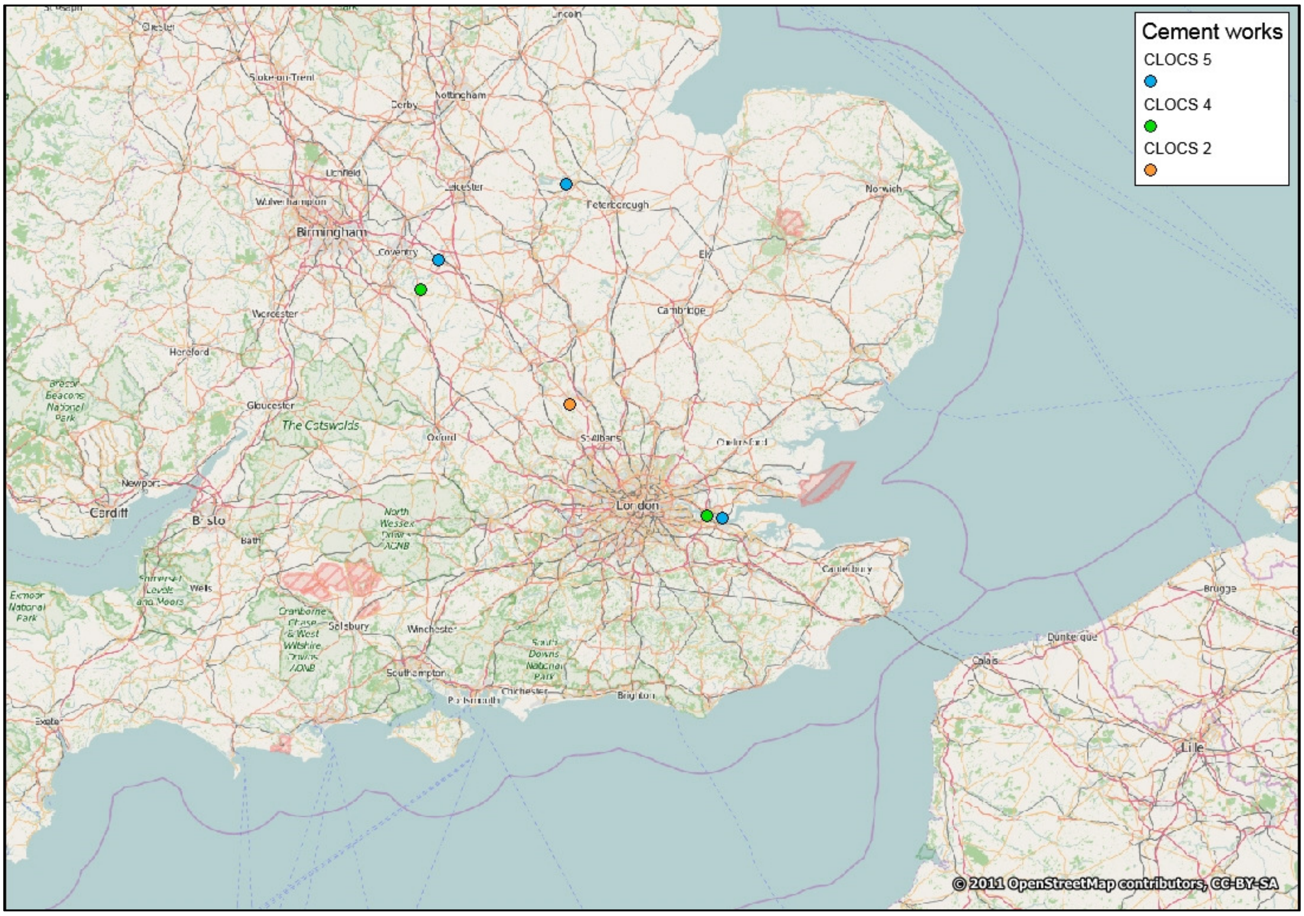

Figure 5-5 Virtual assessment of cement works

Table 5-1 displays the location and operator of the cement works currently in operation in the UK. Three main cement works service the London area; located to the East of Greater London is the Tilbury and West Thurrock works, and to the North is the Kensworth works.

Operator	Location
Hanson	Ketton
Cemex	Rugby
Cemex	Southam
Cemex	Kensworth
Euromix	West Thurrock
Cemex	Tilbury

Table 5-1 Cement work operators and locations in the South East, East and East Midlands

5.4 Concrete Batching Plants

There are 195 concrete batching plants within the South East and East (Figure 5-6). Of these, 119 were provisionally rated as CLOCS 5, 53 as CLOCS 4, 19 as CLOCS 3 and four as CLOCS 2.

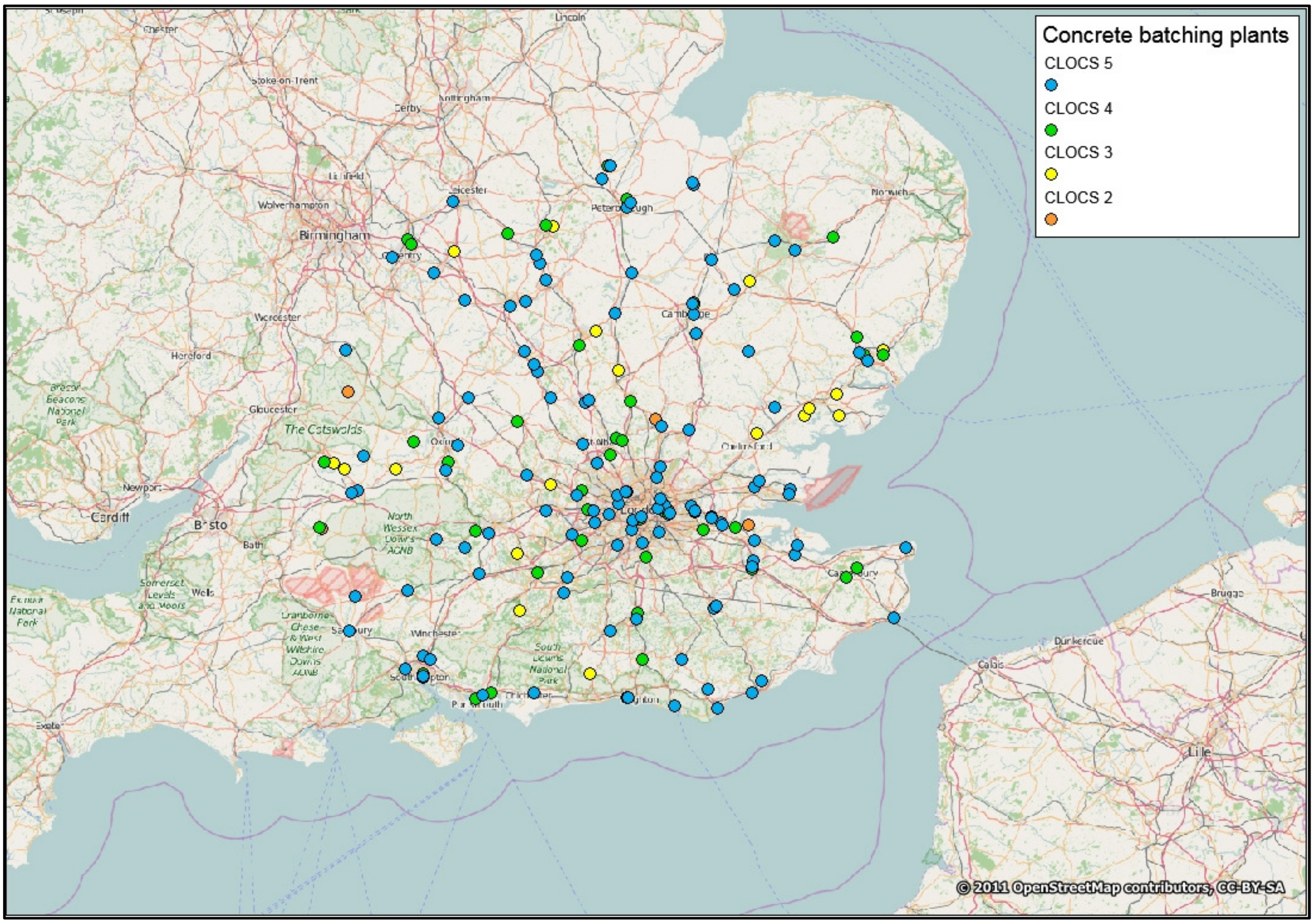

Figure 5-6 Virtual assessment of concrete batching plants

Of the 195 sites identified, the majority (60) are operated by Cemex. A further 52 are operated by Hanson with Hope Construction and Tarmac operating 25 and 21 sites respectively. Within the Greater London area, Cemex operate 11 sites, Hanson 9, Tarmac 6, Aggregate Industries 4, Hope Construction 3 and Brett 2. Table 5-2 shows where each of the concrete batching plants within Greater London is located, and who operates them.

Operator	Location
Hanson	Dagenham, Denham, Edmonton, Erith, Silvertown, Victoria Deep, Wandsworth, West Drayton and Wimbledon
Cemex	Croydon, Sydenham, Chiswick, Fulham, Battersea, Angerstein, Canning Town, Stepney, Edmonton & North London, Hendon and Wembley
Tarmac	Battersea, Hayes (Pump Lane), Mulberry Wharf Depot, Murphy's Wharf, Park Royal and Silvertown (Trad Wharf)
Aggregate Industries	Bow, Greenwich, Purley and Tolworth
Hope Construction	Feltham, Cricklewood and Enfield
Brett	Bow and Croydon

Table 5-2 Concrete batching plant operators and locations in Greater London

There are 13 concrete batching plants located along the banks of the Thames estuary providing access for boats to either ship material to location, or provide the raw materials for production.

5.5 Asphalt Plants

There are 56 asphalt plants within the South East and East (Figure 5-7). Of the 56 sites, 27 were provisionally rated as CLOCS 5, 24 as CLOCS 4 and five as CLOCS 3.

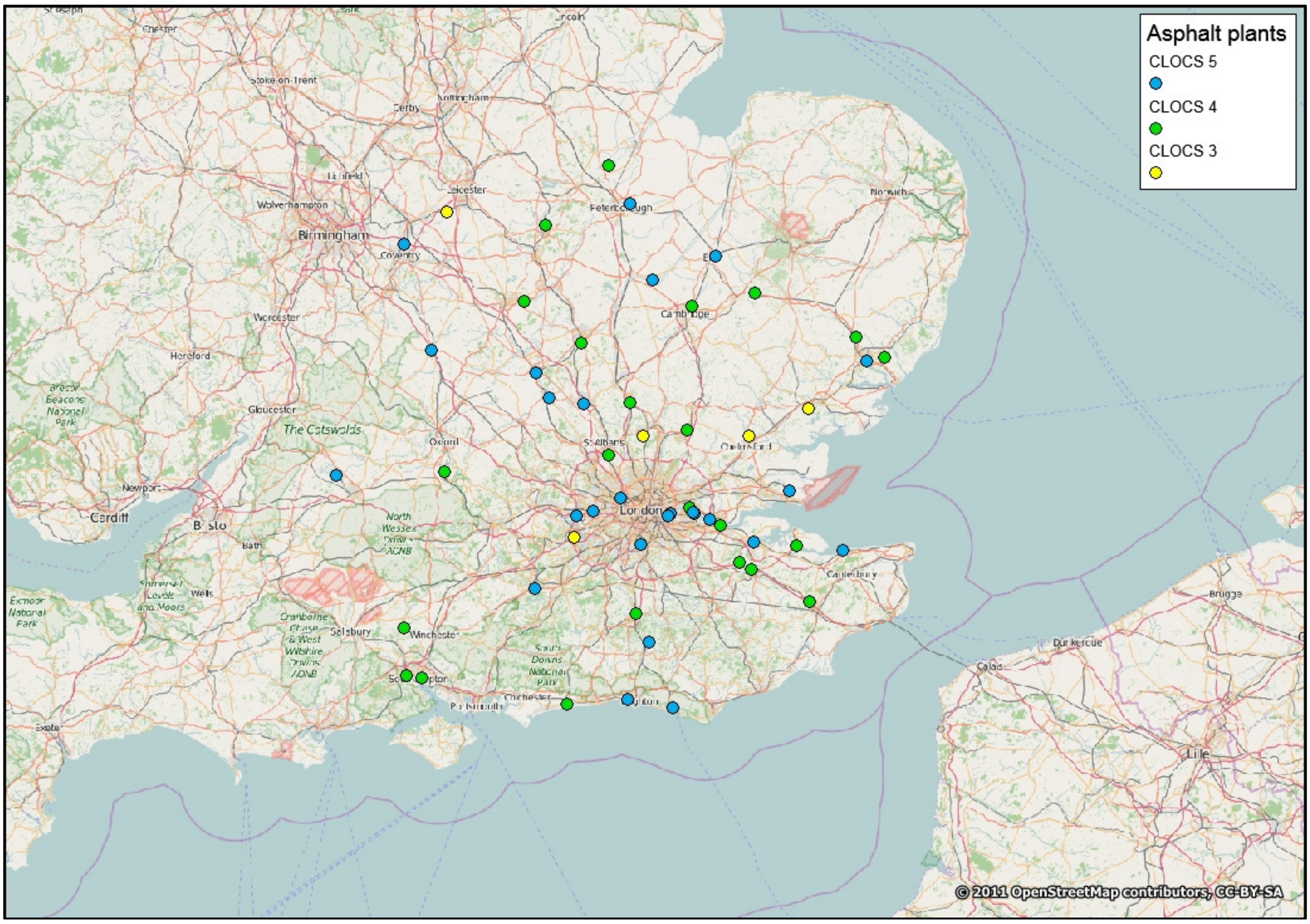

Figure 5-7 Virtual assessment of asphalt plants

Within Greater London, Bexley, Greenwich and Hillingdon have two asphalt plants, with Barking & Dagenham, Brent and Croydon each having one. The operator and location of each of the asphalt plants located within Greater London can be found in Table 5-3.

Operator	Location
Erith	Bexley
Lafarge Tarmac	Bexley, Greenwich and Hillingdon
Hanson	Barking & Dagenham
Aggregate Industries	Greenwich, Hillingdon and Brent
United Asphalt	Croydon

Table 5-3 Asphalt plant operators and locations in Greater London

5.6 Aggregate Served Railheads

Aggregate served railheads were sourced from the Network Rail Aggregate Freight Sites[17], which tracks strategic freight sites, by operator, from around the UK. Internal resources were also gathered and cross referenced with Network Rail information. There are 75 aggregate served railheads within the South East and East. Figure 5-8 shows the spatial distribution of these railheads. Of the 75 sites identified, 17 were provisionally rated as CLOCS 5 with a further 55 as CLOCS 4 and three as CLOCS 3.

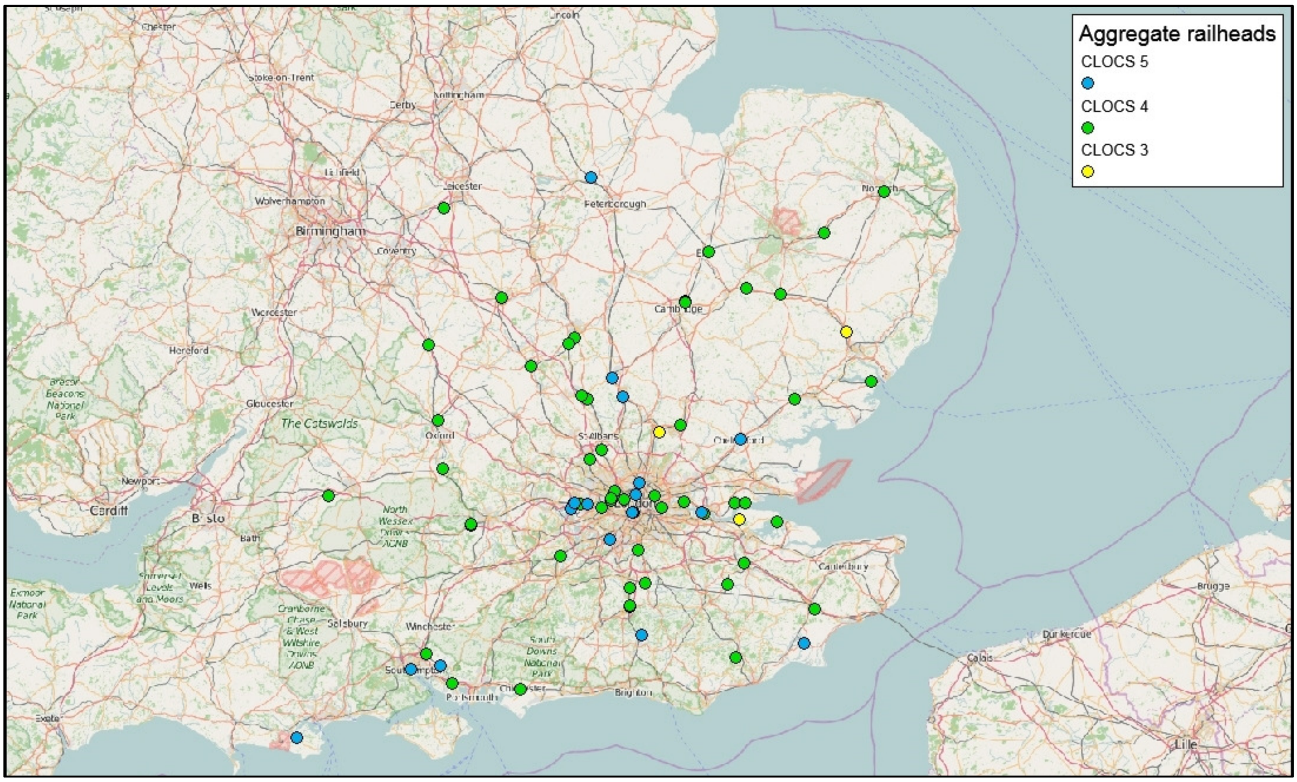

Figure 5-8 Virtual assessment of aggregate served railheads

Within Greater London there are 19 aggregate served railheads. The majority (3) of aggregate served railheads are located within the borough of Hillingdon. There are also two located in Greenwich, Ealing and Wandsworth. Table 5-4 shows all the aggregate served railheads currently in operation within Greater London.

Operator	Currently rail served	Location
Hanson	Yes	Hillingdon and Barking & Dagenham
DB Schenker	Yes	Camden and Newham
Bardon Aggregates	Yes	Greenwich, Brent, Ealing and Tower Hamlets
Lafarge Tarmac	Yes	Greenwich, Wandsworth, Hillingdon x2, City of Westminster and Ealing
London Concrete	Yes	Haringey
Day Aggregates	Yes	Croydon, Wandsworth, Kingston upon Thames and Hounslow

Table 5-4 Aggregate served railhead operators and locations in Greater London

[17] http://www.networkrail.co.uk/aspx/10520.aspx

5.7 Aggregate Served Wharfs

Aggregate served wharfs were sourced from the Local Aggregate Assessment for London 2013 (Revised)[18] and cross referenced with internal resources. There are 44 aggregate wharfs servicing the London and South East area (Figure 5-9). Of the 44 wharfs, 15 were provisionally rated as CLOCS 5, 28 as CLOCS 4 and one as CLOCS 3.

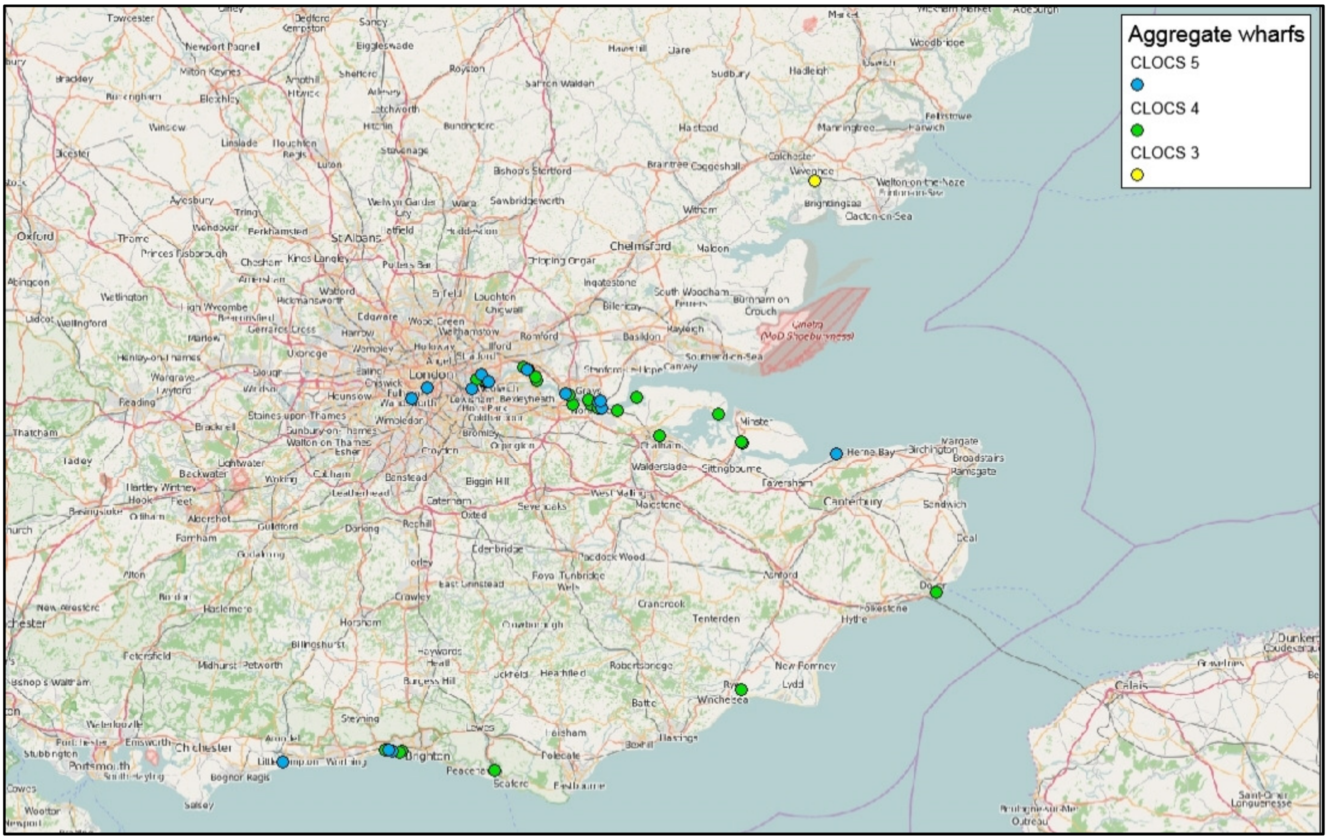

Figure 5-9 Virtual assessment of aggregate served wharfs

There are 15 aggregate served wharfs within Greater London. The operator and location of these sites are listed in Table 5-5. Of the sites identified, eight are located within Greenwich and Newham to the east of Greater London. The majority of aggregate wharfs deal with marine sand & gravel and crushed rock. Cemex and Aggregate industry wharfs located in Thurrock and Purfleet respectively, also handle cement.

Operator	Location
Hanson Aggregates	Wandsworth
Cemex	Wandsworth, Newham and Barking & Dagenham
Euromix	Greenwich and Newham
Stema Shipping	Greenwich
Aggregate Industries	Greenwich
Lafarge Tarmac	Greenwich and Bexley
Day Aggregates	Greenwich
Tarmac	Greenwich and Bexley
Eurovia Roadstone	Barking & Dagenham
Hanson Aggregates	Barking & Dagenham

Table 5-5 Aggregate served wharf operators and locations in Greater London

[18] https://www.london.gov.uk/sites/default/files/London%20LAA%202013%20October%202014.pdf

6 Global Best Practice

In order to incorporate global best practice into current operations within London and further afield, a desk based study was conducted to establish:

- Where countries have successfully reduced the requirement for off-road vehicles on construction and waste sites; and,
- Cost effective best practice for improving ground conditions.

In countries where cyclist fatalities involving vehicles are low, it has been found that investment in cycling infrastructure has been high. Perhaps the world leader for cyclist safety is the Netherlands, who has invested heavily in cycle infrastructure, which has reduced the conflicts born between motor vehicle drivers, cyclist and pedestrians. Transport for London is investing in cycling infrastructure within the capital similar to what is seen within the Netherlands, with the addition of cycle superhighways which aim to provide a safer environment for cyclists.

However, for the majority of mainland Europe, cyclist fatalities are similar in comparison with that of London's recent increase, with 15 cyclists killed in Berlin in 2012, seven through collisions with HGVs. Berlin has also invested heavily in cycling infrastructure so it is evident that the problems with HGVs persist. The findings from this search indicated that London and the CLOCS scheme are at the forefront of cyclist safety research including the provision to further introduce improved ground conditions and safer tipping vehicles.

6.1 Scandinavia

In London and the UK, previous research into construction, supply and waste site conditions suggest that off-road conditions are encountered the most at landfill and waste sites. This is mirrored in site visits conducted for the development of the site assessment handbook where cohesive materials, rutting, gradients, loss of traction and presence of standing water were identified as a barrier to adopting LEC or N3 vehicles.

In order to identify best practice in Scandinavia, where the requirement for N3G vehicles has been successfully reduced, key terms were translated into relevant languages including; Swedish, Norwegian, Finnish and Danish, which were subsequently used to conduct an internet based search. However the reason behind the reduction in N3G vehicles may not necessarily be due to improved conditions on-site, but how the waste is used. Sweden is at the forefront of recycling and green technology, with just 1% of municipal and construction waste ending up at landfill, with the remainder recycled or incinerated. The latest municipal waste recycling statistics by country indicate that Sweden is ranked fourth behind Germany, Netherlands and Belgium (Figure 6-1), the UK ranks 11th on the list.

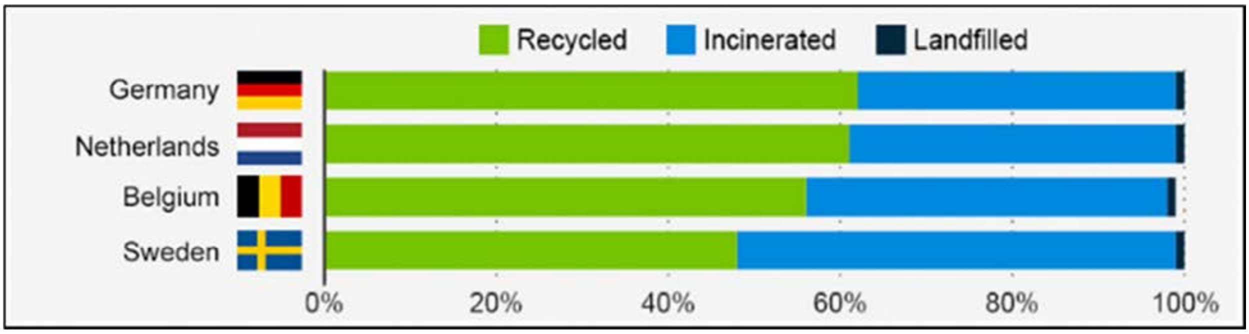

Figure 6-1 Municipal recycling statistics Europe, 2011 (%)[19]

In 2010 approximately 50% of construction and demolition waste was recycled in Sweden[20] which can be attributed to a number of factors including; sorting waste at the source, keeping inventories of materials in connection with all demolition and development of waste management plans for all

[19] https://www.statista.com/chart/1312/recycling-remains-a-rarity-in-eastern-europe/
[20] http://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6560-7.pdf

construction and demolition projects. These actions have been attributed to the reduction of the number of landfills from 1,600 in 1976 to 157 in 2008[21]. However, the quantity of waste produced in relation to the recycling statistics should also be taken into account. Table 6-1 shows that compared to the Scandinavian countries, the UK produces significantly more construction waste. Therefore, whilst Sweden has high recycling and incineration rates, the amount of waste being produced is significantly less than that produced in the UK. This results in fewer waste and landfill sites within Scandinavia and a decrease in associated traffic.

Country	Mining and quarrying	Manufacturing	Energy	Construction	Other economic activities	Households	Total
Denmark	18	1,610	893	3,867	6,216	3,727	16,331
Finland	52,880	14,531	1,011	16,034	5,635	1,734	91,825
Sweden	129,481	6,158	1,852	7,656	6,967	4,193	156,307
Norway	470	2,639	89	1,881	3,205	2,438	10,722
UK	24,044	13,596	4,965	100,230	70,759	27,506	241,100

Table 6-1 Waste generation by economic activity and households, 2012 (1,000 tonnes)[22]

6.2 Ground Improvement

Where adverse ground conditions cannot be avoided, the following techniques provide a cost effective way for maintaining haul roads to a suitable standard which may allow for the use of N3 and/or LEC vehicles.

6.2.1 Mechanical

Mechanical stabilisation can be defined as the improvement of the mechanical behaviour of an in-situ unbound granular material by including one or more geosynthetics layers such that deformation under applied loads is reduced by minimising movements within the unbound granular material[23]. There are two primary types of geosynthetics that can be used for mechanical stabilisation of haul roads; geogrids and geotextiles (Figure 6-2).

Figure 6-2 Geogrid (left) and geotextile (right)

[21] http://www.recobaltic21.net/downloads/Public/Conferences/Emerging%20trends%20and%20investment%20needs%20in%20waste%20management%202011/catarina_ostlund.pdf
[22] http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Waste_generation_by_economic_activity_and_households,_2012_(1000_tonnes).png
[23] Pavement Design and Maintenance: Design Guidance for Road Pavement Foundations HD25/17

The use of geogrids for mechanical stabilisation can be used in combination (geogrid installed over) or composite (geogrid laminated to) with geotextiles for filtration and separation. This may be beneficial to prevent upward migration of fine material into the overlaying capping or subbase, or downward loss of fines from the capping or subbase into the underlying subgrade, where water is present. Figure 6-3 shows where geotextiles are not used, the underlying subgrade can migrate into the capping layer/subbase and vice versa when load is applied at the surface. This action will ultimately lead to ruts and deformation of the surface.

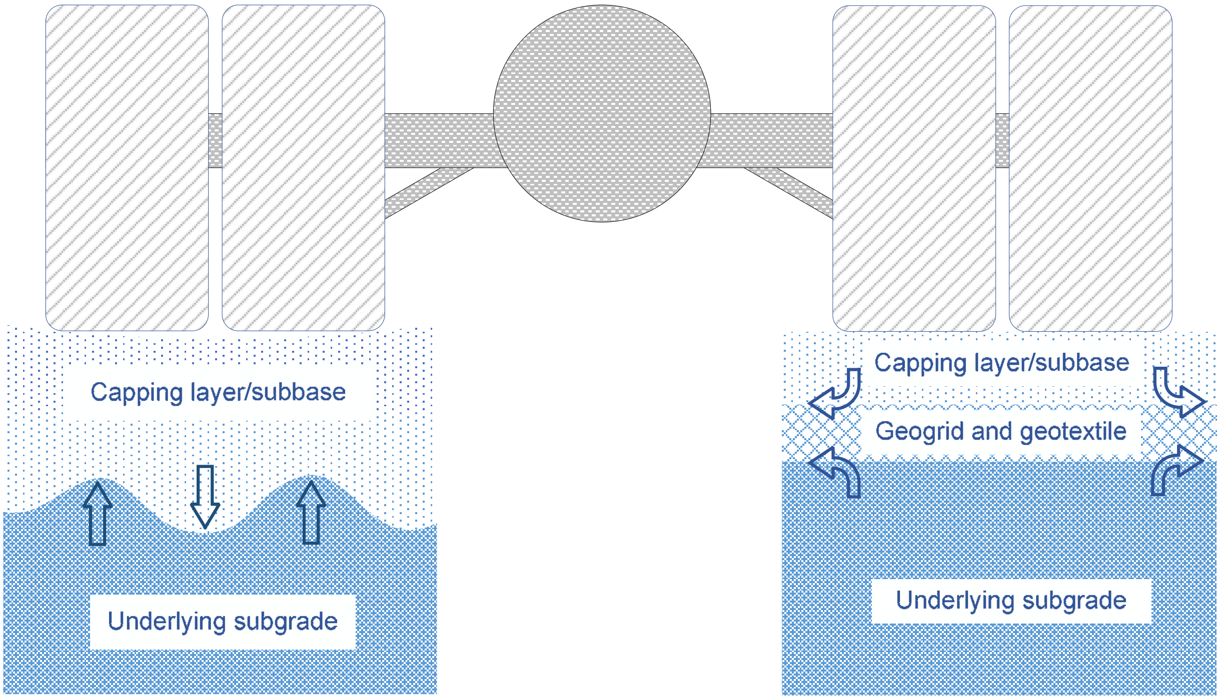

Figure 6-3 Schematic of how geogrid reinforcement can improve bearing capacity

When a geogrid is incorporated into a granular material the particles interlock with the geogrid and are confined within the geogrid apertures. The degree of confinement depends upon the aperture size in relation to the particle size, the stiffness of the geogrid, the geometry of the geogrid and the efficiency of the junctions. There are a number of variations of geosynthetics available, each tailored to a specific purpose.

The use of geosynthetics layers has the following benefits:

- Cost saving in comparison to chemical stabilising techniques;
- Make use of material already on-site, removing the need to import additional material; and,
- Specialist sub-contractor not required to install.

Geotextiles were in use at Tyttenhanger landfill that reportedly produced improved ground conditions on to which N3 vehicles would be able to operate. The initial investment and subsequent maintenance cost £80,000 for a 3km stretch of haul road up to the tipping area. This has resulted in additional business for the site, where vehicles cannot access other sites in poor weather conditions. Geotextiles are also regularly used by the Forestry Commission when creating temporary haul roads for HGVs in and over silt clay and peat formations.

6.2.2 **Chemical**

Where crushed rock or recycled aggregate are not available to construct suitable haul roads, chemical soil stabilisation can be used as a means to improve ground conditions. Chemical soil stabilisation techniques can be altered to suit the specific materials that are present on-site, and therefore performance is likely to be high. Clay and silt rich soils attract moisture, so during precipitation, water does not pass through the ground like it would in soils with a high gravel and sand content. Instead, the clay and silt particles retain water causing the soil to expand and cause defects that can be damaging to vehicles on-site.

When lime is applied to wet soils such as clay, the reaction between the lime and the water will cause 1/3 of the water to evaporate, 1/3 of the water to be absorbed and 1/3 of the water to remain. This reaction will produce relatively dry soils, however the process is not permanent and will be reversed upon commencement of precipitation. This can be classed as soil improvement, in order for the soil to be stabilised a more permanent solution has to be applied.

Stabilisation means the spreading of a hydraulic binder and/or lime on a layer of deposited or intact granular or cohesive material, and the subsequent process of pulverising and mixing followed by appropriate compaction to form the whole or a constituent layer of a capping[24].

When lime is applied to soils, a cementitious gel is formed once the pH level of the soil reaches 12.4, at which point the soil is the pulverised (Figure 6-4) and compacted to complete the process. However, lime used as the sole binder can be expensive due to the quantity of material required, typically costing £90 - £120 per ton. When used in combination with another hydraulic binder, material use can drop significantly incurring a cost saving. Hydraulic binders can include: Cement, PFA and Slag. When used in combination, chemical stabilisation becomes a three step process:

1. The first step is to apply the lime to the soil with at least two passes of the pulverised-mixer and pulverise. This will cause the soil to dry out;
2. The next step is to apply the hydraulic binder and pulverise again. No more than 96 hours can pass between steps one and two;
3. The final step is to seal the layer by rolling immediately after treatment.

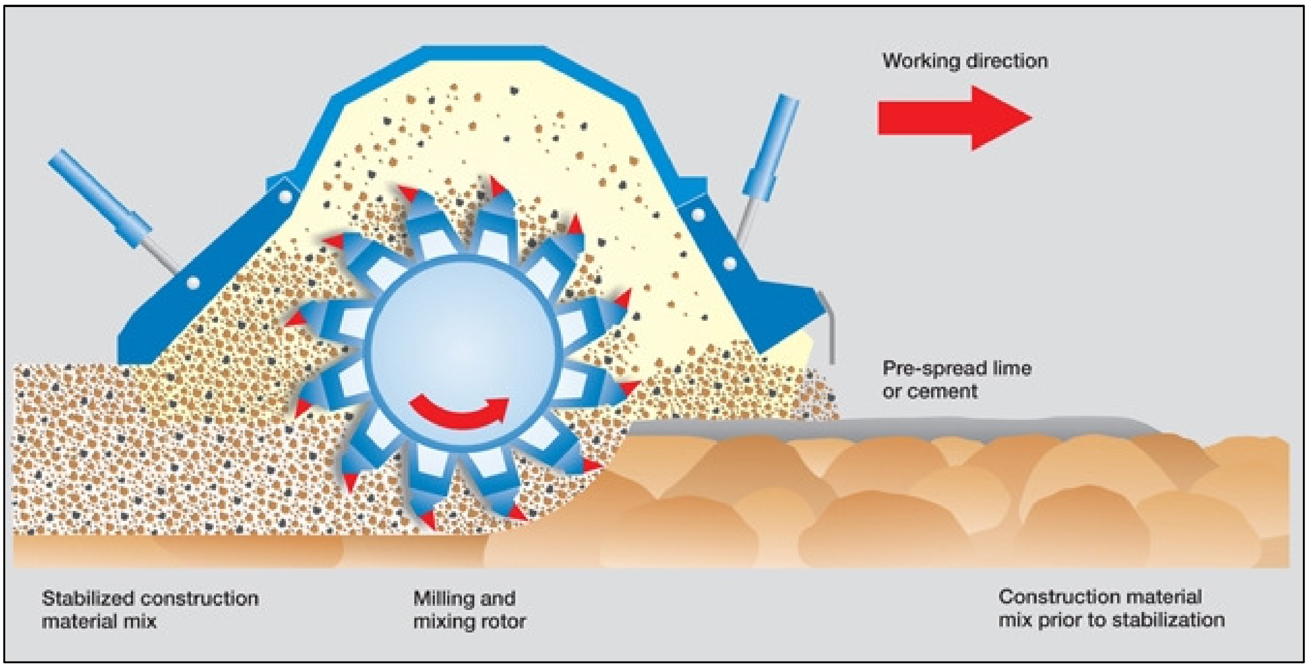

Figure 6-4 Hydraulic binder soil stabilisation pulverising process[25]

This method of soil stabilisation provides a more permanent solution, although will require regular maintenance. However, the cost associated with this technique is significantly greater than the mechanical stabilisation techniques discussed, as specialist sub-contractors and plant will be required to complete the process. As chemical stabilisation is a more permanent solution, it may not be viable for sites such as landfills, where the tipping area can change on a daily basis.

[24] Specification for Highway Works: Series 600 Earthworks
[25] http://www.trstabilisation.co.uk/blog/

7 Stakeholder Consultation

Throughout the study, stakeholders from industry were consulted to gain their input and insight, and also to discuss barriers to adopting LEC and N3 vehicles. Representatives from the construction, supply and waste away industries were present to give their input into the project. A number of concerns were raised as to the functionality of LEC vehicles and also the turnaround time associated with the maintenance of the vehicle itself.

Some LEC vehicle components, when trialled on sites, were reported to be less robust than their N3 and N3G counterparts. In particular the rubber bellows used within the air suspension has been found to break in off-road conditions. This may be due to the ground conditions, or the behaviour of the drivers on-site, who reportedly break site speed limits. As such, site operators have been found to intentionally leave ruts and pot holes on haul roads as a traffic calming measure, to deter speeding. When components do break on LEC vehicles, repairs and overall turnaround time has been in excess of five weeks from some of the major manufacturers, leaving vehicles idle. However, those that had trialled LECs on-site have been pleased with its performance, and have found it to be more than adequate in coping with the site conditions during the summer months. Drivers have described the vehicles as the perfect solution for urban material movement due to its manoeuvrability, improved visibility and safety features. These vehicles were also considered ideal for the asphalt industry as they would rarely leave a paved surface.

Conditions present on different sites mean vehicles have to be versatile in order to meet their requirements. For instance, conditions on permanent sites such as concrete batching plants, asphalt plants, waste treatment and waste transfer sites are likely to be significantly better than those found on landfills, which are much more dynamic. These suggestions have been realised in the provisional assessment of sites where the majority of CLOCS 5, 4 and 3 rated sites were permanent sites and CLOCS 2 rated sites were landfills.

On landfills, ground conditions significantly deteriorate during the winter months, where weather conditions worsen and waste away operations are at their peak. Therefore continual assessment of ground conditions on-site is required. On paved and hardstanding surfaces, weather conditions have minimal effect on the operational capability, however, on cohesive materials, conditions can deteriorate rapidly turning into slurry only passable by site plant. This situation has often been encountered by site management, who will, instead of sending vehicles to the normal tipping area, have them tip on the hardstanding recycling areas near to the entrance of sites.

It was also discussed that it is not economically viable for landfill management to install and maintain hardstanding haul roads. This is because vehicles will be required to operate on all areas of the site, and haul roads are often composed of previously tipped material. Installation of a hardstanding tipping apron near the entrance to the site would be a more viable option, where tipper vehicles can tip material to be transported around site to destination via site plant or conveyor belts. This will remove the need to improve conditions over the whole site and a relatively small, focused area could be improved facilitating for LEC and N3 vehicles, however site operators will have to pass on the cost associated with this solution which may be prohibitive.

There are multiple pathways to improve site conditions as discussed, however the single most important factor to site management is the financial implications of such work. The price of tipping and moving material around site will go up in conjunction with improved conditions and continual maintenance costs. Those that do not improve conditions and keep cost relatively low will result in competitive prices between low rated sites, not driving the required behaviours. Major projects, such as Thames Tideway, can be used to specify site standards that will be used on the project, and sites not meeting the requirements will not be used. A similar requirement was used on the Crossrail project where all tipping vehicles were required to have side under-run protection. It is thought that overtime suppliers will see the financial benefits of improving site conditions from both the client side, and vehicle maintenance side, where there should be a reduction in damage to vehicles.

Overall stakeholders were positive about the functionality of LEC vehicles but could not see viable applications for the vehicle on landfills. N3 vehicles had been purchased by stakeholders in significant numbers implying that they are capable of off-road travel, however it was suggested that N3 vehicles will not be able to operate on landfills during the worst winter months.

8 Conclusions

The conditions encountered on-site during the study period varied from road like to off-road conditions. This variation has resulted in fleet operators to issue off-road vehicles as standard to cope with the conditions that may be encountered. However, off-road conditions were rarely witnessed, with some instances observed on landfills. Construction sites in the confined city centre area are often within a few metres from a paved roadway, providing excellent ingress and egress routes. Waste treatment and waste transfer stations were mainly composed of hardstanding paved areas, due to the environmental legislations that govern them. Supply sites offered hardstanding areas due to the presence of railheads or site machinery which required firm foundations. Off-road conditions were witnessed at most landfill sites, particularly where vehicles were tipping on recently tipped cohesive material. However, the Tyttenhanger landfill site offered an excellent example of how ground conditions can be improved to the benefit of site management, drivers and fleet operators. The installation of geosynthetics and soil stabilisation offered an adequate haul road capable of accommodating N3 vehicles even in wet conditions.

Using our criteria a virtual assessment of each of the construction, supply and waste sites captured in the directory was undertaken to determine the number of sites that may be eligible for LEC and N3 vehicle use. This virtual assessment used satellite imagery to rate the sites and as such may not represent a final rating. However it does provide an indication of the number of sites that currently may be achieving exemplar site status. The results indicate that the vast majority of construction, waste treatment, waste transfer and aggregate supply sites and capable of operating LEC or N3 vehicles.

Of the 1,848 sites identified and virtually assessed (including sites that do not accept waste from London), 1,190 were provisionally rated as a CLOCS 5. This means that 64% of sites currently in operation are LEC vehicle accessible in all weather conditions. Of the CLOCS 5 rated sites, 949 were waste transfer or waste treatment sites which are required to have a hardstanding tipping area due to environmental legislation. A further 459 sites were rated as CLOCS 4 and 114 as CLOCS 3 meaning 95% of sites, from the virtual assessment, are LEC or N3 vehicle accessible. Of the CLOCS 2 sites, 75% were landfills, where N3G vehicles would be required. These findings show that in order to reduce the number of N3G vehicles on the network, it is important to improve conditions on landfills where the majority of construction waste will ultimately end. The variable nature of landfills means they are harder to assess than other permanent sites. Ground conditions will also be dictated significantly by the weather conditions which can change on a daily basis. A review of site conditions using the assessment handbook would be required on a regular basis to ensure ratings are kept up to date with current conditions. This changeability in potential ratings would require a real-time updatable directory to inform users of site ratings as they change.

A focus on ground conditions present within landfills is required in order to reduce the number of off-road capable N3G vehicles operating within London. If conditions on landfills could be guaranteed, fleet operators would have more confidence in purchasing LEC and N3 vehicles. As landfills are often very dynamic sites, and installation and maintenance of hardstanding haul roads is often not economically viable, alternative methods of improving ground conditions, such as tipping aprons, the use of site plant to transport material and mechanical or chemical soil ground improvement techniques may have to be considered.

9 Recommendations

This research study has highlighted, from the provisional ratings, that the majority of sites currently in operation in the South East and East have suitable conditions to provide access for the safer LEC and N3 vehicles. More detailed assessments will be required to capture the true nature of sites, however, the findings suggest the greatest barrier to adoption is conditions encountered on landfill sites. In order to achieve improved site conditions leading to further adoption of LEC and N3 vehicles, Transport for London and the industry may consider the following recommendations:

- Focus efforts on improving conditions on landfill sites;
- Push the use of mechanical soil stabilisation techniques as a cost effective way to improve haul road ground conditions;
- Ensure the site assessment and CLOCS rating standard is included in major project contracts for widest uptake;
- Produce robust communication material defining LEC, N3 and N3G tipper truck variants to be sent out to the industry;
- Establish the number of LEC, N3 and N3G vehicles currently in operation within London in order to gauge the level of change that is required;
- Fully test vehicle capabilities (LEC, N3 and N3G) to demonstrate to the industry the capabilities of each;
- Vehicle maintenance turnaround, particularly for LEC's, was found to be inadequate. Liaison with vehicle manufactures is essential to bring the service on par with the N3G counterparts;
- Develop a methodology for auditing site ratings either as site manager self-assessment, site manager self-assessment with random audits in the form of a 'mystery shop' or audit each site individually;
- Utilise modern technology to host waste and supply site directory. Software such as PowerBI and Tableau can be used to create interactive dashboards which can be pushed to the web and viewed by all who have the web link. An overview of PowerBI, its features and how it can be used for the CLOCS programme is explored in Appendix D;
- Create an electronic version of the site assessment handbook, along the lines of a smart phone/tablet app, which will negate the need to take a hard copy version of the assessment out onto site. Further details and concepts for a CLOCS app can be found in Appendix D.

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The research in this report was undertaken by AECOM in collaboration with Transport for London and key stakeholders who have helped shape and define the deliverables, conclusions and recommendations. We would like to thank all of our stakeholders for their contributions. We would also specifically like to acknowledge; Westley Pickup, Dominic Day, Jacqueline O'Donovan, Guy Mallard, Nathan Hopgood and Ben Dickens for organising and facilitating for site visits.

Appendix A. Site Visit Case Studies

Site name	Tyttenhanger	**Location / Postcode**	St Albans / AL4 0PF
Type	Landfill	**Operator**	Tarmac
Conducted by	Liza Troshka and Matthew Wainwright	**Visit date**	29/06/16
Description	Tyttenhanger landfill is located near Junction 22 of the M25, South East of St Albans. The majority of waste to landfill here originates from the county of Hertfordshire. The landfill has a permit for Inert LF waste with a basic waste category of Inert/C+D, receiving 573,899 tonnes in 2014. Approximately 380 tipping vehicles enter the site daily. Hardstanding was present from the site entrance, past the weigh bridge and up to the start of the haul road, providing excellent ingress and egress routes. The haul road has been reinforced with crushed concrete and geotextiles, proving much improved ground conditions up to the current tipping area. The site has been able to minimise the amount of vehicle movements by installing a conveyer to transport material to where it is needed. As such tipping vehicles were not required to deviate from the main haul road. Shallow standing water was present in the trafficked areas but did not pose a risk of damage to vehicles. This site would be suitable for N3 vehicles or LEC vehicles weather permitting.		

Parameter/visit conditions		**Comments**
Weather	Dry/light rain	
Site condition	Unpaved	
Material	Granular and fines	
Rutting	Ruts up to 50mm	
Risk of loss of traction	Low	No loss of traction witnessed
Structural performance	Hard – No flexing	
Ride quality	Undulating	
Width	Vehicles can pass unimpeded	
Edge condition	Kerb	
Loose material	Medium	
Swept or graded	Daily	Swept daily and graded twice a week
Drainage	Shallow puddles	

CLOCS Ground Condition Assessment			
Approach Angle	**Material Type**	**Rutting and Bumps**	**Water**
C5	**C4**	**C4**	**C4**

Figure A 1 Tyttenhanger landfill site case study

Site name	Brentford Waste Recycling Facility	**Location / Postcode**	Brentford / TW8 9HF
Type	Treatment/Supply	**Operator**	Day Aggregates
Conducted by	Liza Troshka and Matthew Wainwright	**Visit date**	14/03/16
Description	Brentford Waste Recycling Facility is located in Brentford, seven miles East of Heathrow Airport. The location of this site provides ideal access to central London via the M4 and A4. The site permit is A15: Material Recycling Treatment Facility for Inert/C+D waste and receives waste from Berkshire, Buckinghamshire, East Sussex, London and Surrey. In 2014 the site received 188,334 tonnes of waste. Approximately 80 tipping vehicles enter the site per day. Hardstanding areas were present at the entrance to the site and up to the weighbridge and treatment facilities. Unbound material was present thereafter in an excellent condition up to the tipping and loading areas. An Aggregate railhead was also present on-site which is regularly used to source material from as far as Somerset. In one area vehicles were required to traverse a gradient up to a tipping area. When trailing an LEC vehicle, damage was sustained on the gradient when the front bumper came into contact with a disused rail line at the bottom of the slope. Minor earthworks would be required to remove the rail line if desired. Standing water was present on-site but not in the trafficked area. The site would be suitable for N3 vehicles.		

Parameter/visit conditions		**Comments**
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Granular and fines	£50,000 - £100,000 spent on maintenance annually
Rutting	No ruts	
Risk of loss of traction	Low	
Structural performance	Hard – No flexing	
Ride quality	Flat	
Width	Vehicles can pass with care	
Edge condition	No kerb	
Loose material	Low	Rare occurrence of material falling from digger buckets
Swept or graded	Daily	
Drainage	Shallow puddles	There was evidence of water pooling towards the bottom end of the site which was no accessed by tipping vehicles

CLOCS Ground Condition Assessment			
Approach Angle	**Material Type**	**Rutting and Bumps**	**Water**
C4	**C4**	**C5**	**C4**

Figure A 2 Brentford Waste Recycling Facility site case study

Site name	Queen Mary Quarry	**Location / Postcode**	Laleham / TW18 1QF
Type	Treatment/Supply	**Operator**	Brett Aggregates
Conducted by	Liza Troshka and Matthew Wainwright	**Visit date**	14/03/16
Description	Queen Mary Quarry is located next to the Queen Mary Reservoir off the A308, just South of Heathrow Airport. The site recycles Inert construction and demolition waste from London and the South East. In 2014 waste was received from 14 individual London boroughs consisting of Brent, Camden, Ealing, Hammersmith & Fulham, Haringey, Harrow, Hillingdon, Hounslow, Kensington & Chelsea, Kingston Upon Thames, Merton, Richmond Upon Thames, Sutton and Wandsworth. Waste received from these boroughs accumulated to 5,649 tonnes. Ingress and egress routes to and from the site were adequate and paved up to the weigh bridge. Unbound material was present after this point and localised ponding of water was present in the trafficked area. The depth of standing water was difficult to assess, although N3G vehicles were able to drive through undamaged. Rutting and bumps were also present throughout the trafficked areas. Approach angles and gradients were minimal and considered appropriate for LEC use.		

Parameter/visit conditions		Comments
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Graded granular and fine and Cohesive	Graded granular and fines towards the entrance of the site turning to cohesive material further in.
Rutting	Ruts up to 100mm	
Risk of loss of traction	Medium	
Structural performance	Medium – Flexing under load	
Ride quality	Undulating	
Width	Vehicles can pass unimpeded	
Edge condition	No kerb	
Loose material	Medium	
Swept or graded	Daily	
Drainage	Puddles/surface ponding slurry	

CLOCS Ground Condition Assessment			
Approach Angle	**Material Type**	**Rutting and Bumps**	**Water**
C4	**C3**	**C3**	**C3**

Figure A 3 Queen Mary Quarry site case study

Site name	Sipson Landfill	**Location / Postcode**	Harlingdon / UB3 1RW
Type	Supply/Landfill	**Operator**	London Concrete
Conducted by	Liza Troshka and Matthew Wainwright	**Visit date**	14/03/16
Description	Sipson Landfill is located in Harlingdon, immediately North of Heathrow Airport. The site has a permit for Inert LF waste and a basic waste category of Inert/C+D. The site received waste from London, South East, South West and East of England in 2014. Waste received from London originates from Barnet, Brent, Bromley, Camden, City of Westminster, Ealing, Hammersmith & Fulham, Hillingdon, Hounslow, Kensington & Chelsea, Kingston Upon Thames, Merton, Richmond Upon Thames and Wandsworth. The total waste from these boroughs amounted to 260,368 tonnes. Approximately 150 tipping vehicles enter the site daily. The site is split in two half's, with Sipson Lane passing through the middle. The current tipping area to the South consisted of unbound material where loss of traction was witnessed. Coarse material had been used to improve traction. Surface water was not present in the trafficked areas. No significant approach angles were encountered on-site with the potential to cause damage to vehicles. To the North was the site reception and weigh bridge which was hardstanding. The site is considered suitable for N3 vehicles.		

Parameter/visit conditions		**Comments**
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Cohesive	
Rutting	Ruts up to 100	
Risk of loss of traction	Medium	Loss of traction was encountered at tipping area on cohesive material.
Structural performance	Medium – Flexing under load	
Ride quality	Trucks bouncing at site speed	
Width	Vehicles can pass with care	
Edge condition	No kerb	
Loose material	Medium	Aggregate has been used to increase traction with surface which has the potential to cause damage to vehicles.
Swept or graded	Daily	
Drainage	Well drained	

CLOCS Ground Condition Assessment			
Approach Angle	Material Type	Rutting and Bumps	Water
C5	**C3**	**C3**	**C5**


Figure A 4 Sipson Landfill site case study

Site name	Bow East Rail Terminal	Location / Postcode	Stratford / E15 2PJ
Type	Transfer/Railhead	Operator	Walsh
Conducted by	Liza Troshka and Matthew Wainwright	Visit date	24/02/16
Description	Bow East Rail Terminal is located to the South of the Queen Elizabeth Olympic Park in Stratford. The site is relatively new and as such waste information is not currently available. The site is a transfer station which is also host to a railhead. The ingress and egress route to the site are excellent with hardstanding present throughout. The site visit was conducted on a dry day, adequate drainage is present. No significant gradients or ruts and bumps were present on-site. The site is considered suitable for LEC vehicles.		

Parameter/visit conditions		Comments
Weather	Sunny/dry	
Site condition	Paved	
Material	Asphalt/concrete	
Rutting	No ruts	
Risk of loss of traction	Low	
Structural performance	Hard – No flexing	
Ride quality	Flat	
Width	Vehicles can pass unimpeded	
Edge condition	No kerb	
Loose material	Low	
Swept or graded	Daily	
Drainage	Well drained	

CLOCS Ground Condition Assessment			
Approach Angle	Material Type	Rutting and Bumps	Water
C5	C5	C5	C5

Figure A 5 Bow East Rail Terminal site case study

Site name	London Gateway Port Landfill	**Location / Postcode**	Stanford-Le-Hope / SS17 9DY
Type	Landfill	**Operator**	Walsh
Conducted by	Liza Troshka and Matthew Wainwright	**Visit date**	24/02/16
Description	The London Gateway Port Landfill will be used for warehouse construction once the ground has been raised to the required level. The site is relatively new so no waste data is currently available. The site is very dynamic and ever changing and as such haul roads were unbound and cohesive in areas. The site is suitable for N3 vehicle types although N3G may be required in wet weather.		

Parameter/visit conditions		**Comments**
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Cohesive	
Rutting	Ruts up to 100mm	
Risk of loss of traction	Medium	
Structural performance	Medium – Flexing under load	
Ride quality	Flat	
Width	Vehicles can pass with care	
Edge condition	No kerb	
Loose material	Low	
Swept or graded	Daily	
Drainage	Shallow puddles	

CLOCS Ground Condition Assessment			
Approach Angle	**Material Type**	**Rutting and Bumps**	**Water**
C4	**C3**	**C3**	**C3**

Figure A 6 London Gateway Port Landfill case study

Site name	East Tilbury Landfill	**Location / Postcode**	Tilbury / RM18 8PA
Type	Landfill/Remediation/Transfer	**Operator**	Walsh
Conducted by	Liza Troshka and Matthew Wainwright	**Visit date**	24/02/16
Description	East Tilbury Landfill is located to the East of Central London on the banks of the river Thames. The site is accessible from the A13 which links to the major construction zones within the city centre. The sites permit is for Inert LF with a basic was category of Inert/C+D. The site received waste from London, South East and the East of England in 2014. The waste transfer facility is located near the entrance to the site. Waste to the transfer station from London originated from the following boroughs; Barking & Dagenham, Camden, City of London, City of Westminster, Greenwich, Hackney, Hammersmith & Fulham, Haringey, Havering, Hounslow, Kensington & Chelsea, Lambeth, Lewisham, Merton, Newham Redbridge, Southwark, Sutton, Tower Hamlets, Waltham Forest and Wandsworth. In total the amount of waste received by the transfer station amounted to 282,793 tonnes. The landfill also received waste from the following boroughs; Barking & Dagenham, Barnet, Camden, City of Westminster, Greenwich, Hammersmith & Fulham, Haringey, Havering, Islington, Newham, Redbridge, Southwark, Tower Hamlets, Waltham Forest and Wandsworth. In total the amount of waste to landfill equalled 65,904 tonnes.Ground conditions consisted of hardstanding up to the weigh bridge and unbound thereafter. Significant ruts were present on the haul roads leading up to the tipping areas on the landfill. Where vehicles were tipping a loss of traction was experienced due to the cohesive material and the lack of weight on the rear axles after tipping. Approach angles were minimal, LEC vehicles had been used on the site in the summer but would not be used in winter when conditions deteriorate and traffic flow increases.		

Parameter/visit condition		**Comments**
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Cohesive	
Rutting	Ruts up to 100mm	
Risk of loss of traction	High	
Structural performance	Medium – Flexing under load	
Ride quality	Truck bouncing at site speed	
Width	Vehicles can pass with care	
Edge condition	No kerb	
Loose material	Medium	
Swept or graded	Daily	
Drainage	Surface ponding/slurry	

CLOCS Ground Condition Assessment			
Approach Angle	**Material**	**Rutting and Bumps**	**Water**
C4	**C2**	**C3**	**C4**

Figure A 7 Easy Tilbury Landfill site case study

Site name	Alperton Waste Transfer Station	**Location / Postcode**	Alperton Road / HA0 1DX
Type	Transfer	**Operator**	O'Donovan
Conducted by	Joanne Edwards	**Visit date**	24/03/16
Description	Alperton Waste Transfer station is located in the London borough of Brent, South West of Wembley Stadium. The Alperton facility is a relatively new and the waste records have not been released to date. The site is paved throughout. Debris is regularly swept to ensure damage is not sustained to vehicles through loose material. Drainage is excellent and no ponding of water was encountered. Banksmen are on duty for the confined and tight areas of the site. Minimal approach angles required therefore the site is considered suitable for LEC vehicles.		

Parameter/visit conditions		**Comments**
Weather	Cloudy/dry	
Site condition	Paved	
Material	Asphalt/concrete	
Rutting	No ruts	
Risk of loss of traction	Low	
Structural performance	Hard – No flexing	
Ride quality	Flat	
Width	Vehicles can pass unimpeded	
Edge condition	Kerb	
Loose material	High	
Swept or graded	Daily	
Drainage	Well drained	

CLOCS Ground Condition Assessment			
Approach Angle	**Material**	**Rutting and Bumps**	**Water**
C5	**C5**	**C5**	**C5**

Figure A 8 Alperton Waste Transfer Station site case study

Site name	Anchor Bay Wharf	Location / Postcode	Erith / DA8 2AW
Type	Treatment	Operator	Erith
Conducted by	Lizzie Pincombe and Matthew Wainwright	Visit date	05/04/16
Description	Anchor Bay Wharf is located in the London borough of Bexley on the banks of the river Thames. The site predominantly deals with asbestos treatment and has a permit type of A16: Physical Treatment Facility and a basic waste category of inert/C+D. In 2014 the site received 512 tonnes of waste. The site is paved throughout providing good ingress and egress routes from the main road. The wharf facility is easily accessible. There was evidence of localised ponding of water on unbound material but not in the trafficked area. No significant approach angles were required and the site is considered suitable for LEC vehicles.		

Parameter/visit conditions		Comments
Weather	Sunny/dry	
Site condition	Paved	
Material	Asphalt/concrete	
Rutting	No ruts	
Risk of loss of traction	Low	
Structural performance	Hard – No flexing	
Ride quality	Flat	
Width	Vehicles can pass unimpeded	
Edge condition	Kerb	
Loose material	Low	
Swept or graded	Weekly	
Drainage	Well drained	

CLOCS Ground Condition Rating			
Approach Angle	Material Type	Rutting and Bumps	Water
C5	C5	C5	C5

Figure A 9 Anchor Bay Wharf site case study

Site name	R.M.S Bradfield Road	Location / Postcode	Greenwich / E16 2AX
Type	Transfer/Supply	Operator	Recycled Material Suppliers
Conducted by	Lizzie Pincombe and Matthew Wainwright	Visit date	05/04/16
Description	The Recycled Material Suppliers Bradfield Road site is a transfer and supply facility located in the borough of Newham and is accessible from the A1020. Waste information is not currently available for this site. A hardstanding area is present at the entrance to the site which is swept on a daily basis. Unbound material is present thereafter with localised puddles forming in the trafficked area. Approach angles are not an issue on-site. Overall the site is considered suitable for N3 vehicles or LEC vehicles in dry weather conditions.		

Parameter/visit conditions		Comments
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Graded granular	
Rutting	Ruts up to 50mm	
Risk of loss of traction	Low	
Structural performance	Hard – No flexing	
Ride quality	Undulating	
Width	Vehicles can pass unimpeded	
Edge condition	No kerb	
Loose material	Low	
Swept or graded	Daily	
Drainage	Shallow puddles	

CLOCS Ground Condition Assessment			
Approach Angle	Material Type	Rutting and Bumps	Water
C5	C4	C4	C4

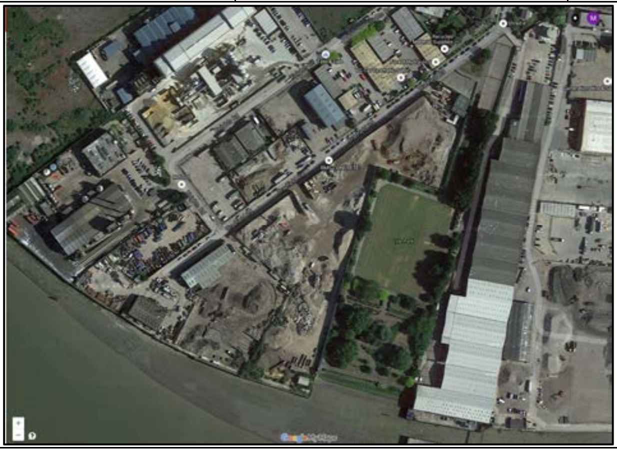

Figure A 10 R.M.S Bradfield Road site case study

Site name	Stone Pit 1	**Location / Postcode**	Dartford / DA9 9BB
Type	Landfill	**Operator**	Land Logic
Conducted by	Lizzie Pincombe and Matthew Wainwright	**Visit date**	05/04/16
Description	Stone Pit 1 is located in Dartford, to the south of the Queen Elizabeth II Bridge. No waste information is currently available for this site as it is relatively new. The gradient at the entrance to the site is in order of 21°-25°. This egress route was paved up to the weigh bridge, to help improve traction. However the egress route was unbound material which may be prone to loss of traction in wet weather. After the weigh bridge the material was unbound up to the current tipping area. Multiple gradients on-site have the potential to cause damage to LEC vehicles, particularly in inclement weather. Due to the approach angles required for the site, only N3G vehicles would be suitable. Standing water was not present on-site although the visit was conducted during dry weather.		

Parameter/visit conditions		Comments
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Granular and fines	
Rutting	Ruts up to 50mm	
Risk of loss of traction	Medium	
Structural performance	Hard – No flexing	
Ride quality	Trucks bouncing at site speed	
Width	Vehicles can pass with care	
Edge condition	No kerb	
Loose material	Medium	
Swept or graded	Daily	
Drainage	Shallow puddles	

CLOCS Ground Condition Assessment			
Approach Angle	**Material Type**	**Rutting and Bumps**	**Water**
C2	**C3**	**C4**	**C4**

Figure A 11 Stone Pit 1 site case study

Site name	Stone Pit 2	**Location / Postcode**	Dartford / DA9 9DX
Type	Landfill	**Operator**	Frontiers Developments
Conducted by	Lizzie Pincombe and Matthew Wainwright	**Visit date**	05/04/16
Description	Stone Pit 2 is located in Dartford, to the south of Stone Pit 1, adjacent the Blue Water Shopping Centre. The permit type for the landfill is Inert: LF with a basic waste category of Hhold/Ind/Com and Inert/C+D. The landfill receives waste from London, South East and East of England. In total 388,179 tonnes of waste were received in 2014. Waste from individual boroughs was not available at the time of reporting. The entrance to the site is paved up to and beyond the weigh bridge where the road winds downward on to the site. The haul road deviates from the main road leading up to the current tipping area. The haul road is unpaved and in a good condition. Gradients on-site ranged from 21° - 25°, where an N3 or N3G vehicle would be required. There was no evidence of significant ponding of water however the visit was conducted on dry day. Ruts and bumps up to a depth of 100m were present further into the site, past the weigh bridge and on to the tipping area. The site is considered suitable for N3G vehicles		

Parameter/visit condition		**Comments**
Weather	Sunny/dry	
Site condition	Unpaved	
Material	Granular and fines	
Rutting	Ruts up to 50mm	
Risk of loss of traction	Medium	
Structural performance	Hard – No flexing	
Ride quality	Undulating	
Width	Single track with passing places	
Edge condition	No kerb	
Loose material	Low	
Swept or graded	Daily	
Drainage	Shallow puddles	

CLOCS Ground Condition Assessment			
Approach Angle	**Material Type**	**Rutting and Bumps**	**Water**
C2	**C3**	**C4**	**C4**

Figure A 12 Stone Pit 2 site case study

Site name	Blueland Quarry (West Thurrock)	**Location / Postcode**	West Thurrock / RM19 1TD
Type	Landfill/Remediation	**Operator**	Walsh
Conducted by	Lizzie Pincombe and Matthew Wainwright	**Visit date**	05/04/16
Description	The Bluelands Quarry landfill and remediation facility is located in West Thurrock. The site is relatively new and as such waste information is not yet available. As the site expands vehicles may be required to travel further on to site where off-road conditions will be encountered. Vehicles enter the site from the main road (A1306). Ingress and egress to the site is excellent with clear and open routes to the tipping area and back out on to the main road. The site itself is paved throughout, providing a hardstanding tipping apron. Material is then transported further on to the site via plant removing the need for vehicles to travel off-road. No ruts and bumps are present with the surface generally in excellent condition. There are no significant approach angles required and the site is well drained. The site is considered suitable for LEC vehicles.		

Parameter/visit conditions		**Comments**
Weather	Sunny/dry	
Site condition	Paved	Paved tipping apron provided
Material	Asphalt/concrete	
Rutting	No rutting	
Risk of loss of traction	Low	
Structural performance	Hard – No flexing	
Ride quality	Flat	
Width	Single track with passing places	
Edge condition	Kerb	
Loose material	Low	
Swept or graded	Daily	
Drainage	Very shallow puddles	Site is well drained

CLOCS Ground Condition Assessment			
Approach Angle	**Material Type**	**Rutting and Bumps**	**Water**
C5	**C4**	**C5**	**C5**

Figure A 13 Blueland Quarry site case study

Appendix B. Supply and Waste Sites in London Boroughs

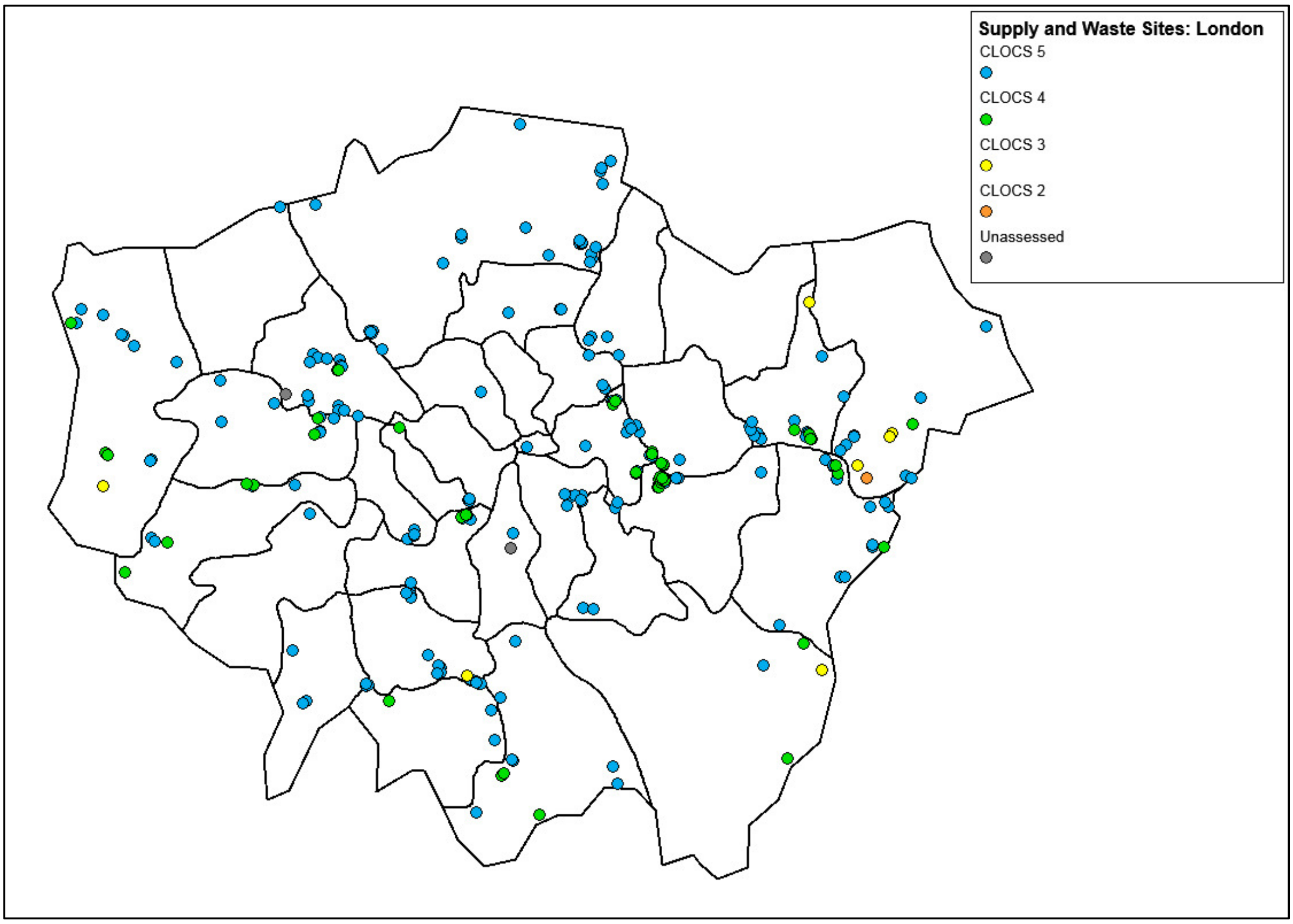

Figure B 1 Supply and Waste sites within a London borough

Within a London borough, 243 supply and waste sites were identified and given a provisional rating (Figure B 1). Of these sites 187 were CLOCS 5, 46 were CLOCS 4, seven were CLOCS 3, one was CLOCS 2 and two were unassessed. Table B 1 shows the breakdown of sites per borough and their provisional assessment rating.

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
Park Lodge Landfill Site	Landfill	Brett Aggregates Ltd	Brent	**Unassessed**
Sipson North East Inert Landfill	Landfill	Henry Streeter (Sand & Ballast) Ltd	Hillingdon	**C3**
Marks Warren Quarry Landfill	Landfill	Ingrebourne Valley Ltd	Barking and Dagenham	**C3**
Spring Farm Landfill	Landfill	Ingrebourne Valley Ltd	Havering	**C3**
Rainham Landfill EPR/EP3136GK/V003	Landfill	Veolia ES Landfill Limited	Havering	**C2**
South Hall Farm	Landfill	Havering Aggregates Limited	Havering	**C3**
Bournewood Inert Landfill Site	Landfill	Bournewood Sand And Gravel Ltd	Bromley	**C3**
Beddington Farmlands Landfill Site	Landfill	Viridor Waste Management Limited	Merton	**C3**
Alperton Waste Transfer Station	Transfer	O'Donovan (Waste Disposal) Ltd	Ealing	**C5**
Brixton Transfer Station	Transfer	Sita South East Limited	Lambeth	**Unassessed**
Barking Transfer Station	Transfer	Sita South East Limited	Newham	**C5**
Mitcham Transfer Station	Transfer	Sita South East Limited	Merton	**C5**
Wandsworth Transfer Station	Transfer	Sita South East Limited	Wandsworth	**C5**
Bridgemarts Waste Recovery Facility	Transfer	Bridgemarts Limited	Brent	**C5**
Garth Road Transfer Station	Transfer	The Royal Borough Of Kingston Upon Thames	Kingston upon Thames	**C5**
St Albans Farm Recycling Facility (Ron Smith)	Transfer	Ron Smith (Recycling) Ltd	Hounslow	**C4**
Yard 10 - 12 Hastingwood Trading Est	Transfer	A & A Skip Hire Limited	Enfield	**C5**
Enfield Waste Management Facility	Transfer	Powerday Plc	Enfield	**C5**
Ilderton Waste	Transfer	Ilderton Waste	Southwark	**C5**
Winters Haulage, Oakleigh Road South	Transfer	Winters Haulage Ltd	Enfield	**C5**
Millfields Waste Transfer & Recycling Facility	Transfer	The Mayor And Burgesses Of The London Borough Of Hackney	Hackney	**C5**
Gowing And Pursey	Transfer	B & K Environmental Services Limited	Hillingdon	**C5**
B & T @ Work	Transfer	Penfold Thomas	Merton	**C5**
Willesden Freight Terminal	Transfer	L Lynch (Plant Hire & Haulage) Ltd	Brent	**C5**
G & S Waste Recycling	Transfer	G & S Waste Management Limited	Havering	**C5**
Horn Lane Waste Transfer Station	Transfer	J Simpson Waste Management Ltd	Ealing	**C5**

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
Kershire Recyling	Transfer	Byne Mark	Hillingdon	C5
J B Riney & Co Ltd	Transfer	J B Riney & Co Ltd	Tower Hamlets	C5
Foots Scray Depot Refuse & Recycling Centre	Transfer	Bexley London Borough Council	Bexley	C5
Townmead Civic Amenity Site	Transfer	Richmond Upon Thames London Borough Council	Richmond upon Thames	C5
Thames Road Depot	Transfer	Bexley London Borough Council	Bexley	C5
Frizlands Lane Reuse & Recycling Centre	Transfer	ELWA Ltd	Barking and Dagenham	C5
Safetykleen Coulsdon	Transfer	Safety- Kleen U K Ltd	Croydon	C5
Ferry Lane South Waste Transfer Facility	Transfer	Adler & Allan Limited	Havering	C5
Barrowell Green Civic Amenity Site	Transfer	Sita U K Limited	Enfield	C5
Waste Transfer Station	Transfer	Space Rubbish Limited	Brent	C5
Purley Oaks Depot	Transfer	E M Highway Services Limited	Croydon	C5
Morden Transfer Station	Transfer	Sita U K Ltd	Kingston upon Thames	C5
Yard D, Harvil Road	Transfer	G B N Services Ltd	Hillingdon	C5
80 River Road	Transfer	Clearun Recycling Limited	Barking and Dagenham	C5
British Rail Goods Yard	Transfer	Iver Recycling (U K) Ltd	Ealing	C5
A M I Waste	Transfer	Tuglord Enterprises Ltd	Enfield	C5
Civic Amenity & Waste Recycling Centre	Transfer	Londonwaste Limited	Enfield	C5
Transfer Station	Transfer	Peter Norris (Haulage) Limited	Greenwich	C5
Factory Lane Special Waste Transfer Station	Transfer	Veolia E S (U K) Limited	Croydon	C5
Kimpton Park Way H R R C	Transfer	Veolia E S (U K) Limited	Sutton	C4
Garth Road Civic Amenity Site	Transfer	Veolia E S (U K) Limited	Kingston upon Thames	C5
Purley Oaks Civic Amenity Site	Transfer	Veolia E S (U K) Limited	Croydon	C5
Kingston Civic Amenity Site	Transfer	Veolia E S (U K) Limited	Kingston upon Thames	C5
Fishers Farm	Transfer	Veolia E S (U K) Limited	Croydon	C5
Gerpins Lane Reuse & Recycling Centre	Transfer	E L W A Ltd	Havering	C5
Greenwich Intergrated Waste Management And Recycling Facility	Transfer	Veolia E S Cleanaway (U K) Ltd	Greenwich	C5
Cory, Walbrook Wharf	Transfer	Cory Environmental Ltd	London	C5
L & B Haulage, Neasden	Transfer	L & B Haulage & Civil Engineering Contractors Ltd	Brent	C5

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
The Market Compound	Transfer	Budd Skips Ltd	Enfield	C5
Wastecare	Transfer	Wastecare Limited	Barking and Dagenham	C5
Greenford Depot Civic Amenity Site	Transfer	Ealing London Borough Council	Ealing	C5
Fowles Crushed Concrete Limited	Transfer	Fowles Crushed Concrete Ltd	Hounslow	C4
Jute Lane, Brimsdown	Transfer	Greater London Waste Disposal Ltd	Enfield	C5
Excel Skip Hire	Transfer	Excel Skip Hire Ltd	Barking and Dagenham	C5
Cringle Dock Ts, Cringle St, Sw8	Transfer	Cory Environmental Ltd	Westminster	C5
Unit 1, Stockholm Road	Transfer	R T S Waste Management Limited	Southwark	C5
Kershire West Ruislip	Transfer	Kershire Ltd	Hillingdon	C5
26/27 Claremont Way Ind Est	Transfer	Mc Govern Haulage Ltd	Enfield	C5
Mc Governs Yard, Claremont Way	Transfer	Mc Govern Haulage Ltd	Enfield	C5
32 Willow Lane	Transfer	New Era Recycling Ltd	Merton	C5
O' Doherty - Pegamoid	Transfer	J O'Doherty Haulage Ltd	Enfield	C5
75 - 77 Chequers Lane	Transfer	R White Waste Management Ltd	Barking and Dagenham	C5
I O D Skip Hire Ltd	Transfer	IOD Skip Hire Ltd	Newham	C5
W Riverside S W T S , Smugglers Way, Sw18	Transfer	Cory Environmental Ltd	Hammersmith and Fulham	C5
Peter Norris (Haulage) Ltd	Transfer	Peter Norris (Haulage) Ltd	Bromley	C5
Docklands Wharf Transfer Station	Transfer	Multi Services Kent Limited	Barking and Dagenham	C5
Glynn Skips	Transfer	X- Bert Haulage Ltd	Brent	C5
Hunt Skips, Commercial Road, Edmonton	Transfer	Hunt Christopher Joseph Thomas	Enfield	C5
G & B Compressor Hire, Dock Road	Transfer	G & B Compressor Hire Ltd	Tower Hamlets	C5
Ruislip Depot Hazardous Waste Containment Bay	Transfer	Balfour Beatty Rail Projects Limited	Hillingdon	C5
Scrubs Lane, Willesden	Transfer	United Kingdom Tyre Exporters Ltd	Brent	C5
Quattro Park Royal	Transfer	Quattro (U K) Ltd	Ealing	C5
Hinkcroft Transport Ltd	Transfer	Hinkcroft Transport Ltd	Southwark	C5
Donoghue, Claremont Rd	Transfer	P B Donoghue (Haulage & Plant Hire) Ltd	Enfield	C5
Leyton Reuse & Recycling Centre	Transfer	Waltham Forest London Borough Council	Waltham Forest	C5
Quattro - Brentford	Transfer	Quattro (U K) Ltd	Hounslow	C5
Crews Hill Transfer Station	Transfer	Enfield Skips Ltd	Enfield	C5
Maguire Skips	Transfer	Maguire Skips Ltd	Merton	C5

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
Twyford Waste Transfer Station	Transfer	West London Waste Authority	Brent	C5
Victoria Road, South Ruislip	Transfer	West London Waste Authority	Hillingdon	C5
Bywaters (1986) Limited	Transfer	Bywaters (1986) Limited	Waltham Forest	C5
R.M.S Bradfield Road	Transfer	Recycled Material Supplies Ltd	Newham	C4
Malby Waste Disposal Ltd	Transfer	Dem'cy Contractors Ltd	Waltham Forest	C5
Cripps Skips	Transfer	Ground Waste Recycling Ltd	Enfield	C5
G B N Services Ltd	Transfer	G B N Services Ltd	Enfield	C5
Space Waye Civic Amenity Site	Transfer	Hounslow London Borough Council	Hounslow	C5
Mc Grath Bros (Waste Control)	Transfer	Mc Grath Brothers (Waste Control) Ltd	Newham	C5
Euro Waste Barking	Transfer	Euro Waste Barking Limited	Barking and Dagenham	C5
Brewsters, Dock Road	Transfer	Brewsters Waste Management Ltd	Lewisham	C5
Sydenham Road	Transfer	H Sivyer (Transport) Ltd	Lewisham	C5
Docklands Waste Recycling, Dock Road	Transfer	Docklands Waste Recycling Ltd	Tower Hamlets	C5
Toulouse Plant Hire Ltd	Transfer	Toulouse Plant Hire Ltd	Greenwich	C5
Kilnbridge Construction Services Ltd	Transfer	Kilnbridge Construction Services Ltd	Barking and Dagenham	C5
Tipmaster Ltd	Transfer	Tipmaster Limited	Waltham Forest	C5
Oakwood Plant Ltd, Edmonton	Transfer	Oakwood Plant Ltd	Enfield	C5
New Years Green Lane Civic Amenity Site	Transfer	London Borough of Hillingdon	Hillingdon	C5
Williams Environmental Management Ltd	Transfer	Williams Environmental Management Ltd	Newham	C5
O' Donovan, Tottenham	Transfer	O'Donovan (Waste Disposal) Ltd	Haringey	C5
C & G Demolition & Site Clearance Ltd, Mercury Way, Se14	Transfer	C & G Demolition & Site Clearance Ltd	Lewisham	C5
Economic Skips Ltd, Mercury Way, Se14	Transfer	Economic Skips Ltd	Southwark	C5
Ace Waste - Neasden Goods Yard	Transfer	Ace Waste Haulage Ltd	Brent	C5
64 Northwood Rd, Thornton Heath, Cr7	Transfer	Mr John Oliver Curley	Croydon	C5
Fourth Way Waste Transfer Facility	Transfer	Brent Oil Contractors Limited	Brent	C5
Sam Smith, Peartree Fm, Addington, Cr0	Transfer	Mr Samuel Smith	Croydon	C5
G B N Services	Transfer	G B N Services Ltd	Waltham Forest	C5
Albright Transfer Station	Transfer	Albright Transfer Station Limited	Havering	C5

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
X - Bert Haulage	Transfer	X - Bert Haulage Limited	Brent	C5
Bow East rail terminal	Transfer	S.Walsh	Tower Hamlets	C5
Lee's Yard	Transfer	Easy Load Limited	Bexley	C5
Dartford Heath	Transfer	Kent County Council	Bexley	C4
Knockholt Station Goods Yard	Transfer	B S P (Knockholt) Ltd	Bromley	C4
Weir Road Waste Transfer Station	Treatment	Maguire Skips Limited	Merton	C5
Raven Recycling	Treatment	Raven Waste Paper Company Ltd	Sutton	C5
77 Weir Road	Treatment	N J B Recycling Limited	Wandsworth	C5
Angerstein Wharf	Treatment	Aggregate Industries U K Ltd	Greenwich	C5
The Willows Materials Recycling Facility	Treatment	Cappagh Public Works Ltd	Merton	C5
O'Donovan - Markfield Road	Treatment	O'Donovan (Waste Disposal) Ltd	Haringey	C5
777 Recycling Centre	Treatment	777 Demolition & Haulage Co Ltd	Merton	C5
Brentford Aggregate Materials Recycling Facility	Treatment	Day Group Ltd	Hounslow	C4
Rainham Recycling Facility	Treatment	O'keefe Utilities Limited	Havering	C4
Orion Support Services	Treatment	Orion Support Services Limited	Newham	C5
Roll On Off Services Limited	Treatment	Roll On Off Services Limited	Bexley	C5
Stone Terminal	Treatment	Aggregate Industries U K Ltd	Ealing	C5
Day Aggregates Purley Depot	Treatment	Day Group Ltd	Croydon	C5
Day Aggregates Stewarts Lane Depot	Treatment	Day Group Ltd	Wandsworth	C4
Henry Woods Waste Management Ltd	Treatment	Henry Woods Waste Management Ltd	Sutton	C5
Day Aggregates	Treatment	Day Group Limited	Greenwich	C5
Crows Nest Farm	Treatment	Country Compost Ltd	Hillingdon	C5
Camden Plant	Treatment	Camden Plant Ltd	Enfield	C5
Westminster Waste Ltd	Treatment	Westminster Waste Ltd	Southwark	C5
George Killoughery Limited (Mitcham)	Treatment	George Killoughery Limited	Merton	C5
Mc Grath Bros (Waste Control) Ltd	Treatment	McGrath Bros (Waste Control) Ltd	Hackney	C5
Anchor Bay Wharf	Treatment	Erith Remediation Technologies Limited	Bexley	C5
D R Plant Solutions	Treatment	D R Plant Solutions Ltd	Tower Hamlets	C5
Volker Highways Depot	Treatment	Volker Highways Limited	Enfield	C5

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
S U C Exc Uk Ltd	Treatment	S U C Exc U K Ltd	Barking and Dagenham	C5
Anchor Bay Commercial Haulage Waste Treatment Facility	Treatment	Mr George Dugdale, Mr Mark Dugdale And Mr Steven Dugdale	Bexley	C5
Manns Waste Management Ltd	Treatment	Manns Waste Management Ltd	Barking and Dagenham	C5
London & Metropolitan Recycling Facility	Treatment	London & Metropolitan Recycling Limited	Enfield	C5
Belinda Road (Brixton) Waste Transfer Facility	Treatment	Powerday Plc	Lambeth	C5
Waste Transfer And Recovery Facility	Treatment	Reston Waste Management Ltd	Merton	C5
Regional Waste Recycling (Commercial) Ltd	Treatment	Regional Waste Recycling (Commercial) Ltd	Newham	C4
Recycled Material Supplies	Treatment	Recycled Material Supplies Ltd	Bexley	C5
Landau Way Transfer Station	Treatment	J & H Haulage Ltd	Bexley	C5
Able Waste Services Ltd	Treatment	Able Waste Services Limited	Sutton	C5
Victoria Deep Water Terminal	Treatment	H Sivyer (Transport) Limited	Tower Hamlets	C5
Burts Wharf Recycling Depot	Treatment	Highway United Limited	Bexley	C5
Veolia Inert Soils Coldharbour Lane	Treatment	Veolia E S Cleanaway (U K) Ltd	Havering	C3
6powerday Waste Recycling & Recovery Centre	Treatment	Powerday P L C	Brent	C5
Seneca Environmental Solutions Ltd	Treatment	Seneca Environmental Solutions Ltd	Brent	C5
Southwark Integrated Waste Management Facility	Treatment	Veolia ES Southwark Ltd	Southwark	C5
Bywaters Recycling And Recovery Centre	Treatment	Bywaters (Leyton) Ltd	Tower Hamlets	C5
Scratchwood Quarry	Treatment	Quality Recycling Solutions Ltd	Enfield	C5
Frog Island WM Facility EPR/ZP3533BS/V006	Treatment	Shanks Waste Management Ltd	Havering	C5
Forefront Utilities Ltd	Treatment	Forefront Utilities Ltd	Havering	C5
Seales Road Haulage Ltd	Treatment	Seales Road Haulage Limited	Havering	C5
Juliette Way Materials Recycling & W E E E A T F	Treatment	B P R Group Europe Ltd	Havering	C5
Elstree Hill South	Treatment	Reviva Composting Ltd	Harrow	C5
GULLY WASTE RECYCLING FACILITY, ROCHESTER WAY, DARTFORD	Treatment	FM Conway Ltd	Bexley	C5

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
Cookham Road Composting Facility	Treatment	T J Composting Ltd	Bromley	**C4**
The Gas Holding Station	Treatment	L M D (crushed Aggregates) Limited	Croydon	**C4**
Dagenham	Concrete Works	Hanson	Barking and Dagenham	**C5**
Denham	Concrete Works	Hanson	Hillingdon	**C4**
Edmonton	Concrete Works	Hanson	Enfield	**C5**
Erith	Concrete Works	Hanson	Bexley	**C4**
Silvertown	Concrete Works	Hanson	Tower Hamlets	**C4**
Victoria Deep	Concrete Works	Hanson	Tower Hamlets	**C4**
Wandsworth	Concrete Works	Hanson	Hammersmith and Fulham	**C5**
West Drayton	Concrete Works	Hanson	Hillingdon	**C4**
Wimbledon	Concrete Works	Hanson	Merton	**C5**
Croydon	Concrete Works	Cemex	Merton	**C5**
Sydenham	Concrete Works	Cemex	Lewisham	**C5**
Chiswick	Concrete Works	Cemex	Hounslow	**C5**
Fulham	Concrete Works	Cemex	Hammersmith and Fulham	**C5**
Battersea	Concrete Works	Cemex	Westminster	**C5**
Angerstein	Concrete Works	Cemex	Greenwich	**C4**
Canning Town	Concrete Works	Cemex	Tower Hamlets	**C5**
Stepney	Concrete Works	Cemex	Tower Hamlets	**C5**
Edmonton & North London	Concrete Works	Cemex	Enfield	**C5**
Hendon	Concrete Works	Cemex	Enfield	**C5**
Wembley	Concrete Works	Cemex	Brent	**C5**
Battersea	Concrete Works	Tarmac	Wandsworth	**C4**
Hayes (Pump Lane)	Concrete Works	Tarmac	Hillingdon	**C5**
Mulberry Wharf Depot	Concrete Works	Tarmac	Bexley	**C5**
Murphys Wharf	Concrete Works	Tarmac	Greenwich	**C5**
Park Royal	Concrete Works	Tarmac	Ealing	**C5**
Silvertown (Trad Wharf)	Concrete Works	Tarmac	Newham	**C4**
Bow	Concrete Works	Aggregate Industries	Tower Hamlets	**C4**
Greenwich	Concrete Works	Aggregate Industries	Greenwich	**C4**
Purley	Concrete Works	Aggregate Industries	Croydon	**C4**
Tolworth	Concrete Works	Aggregate Industries	Kingston upon Thames	**C5**
Feltham	Concrete Works	Hope Construction	Hounslow	**C5**
Cricklewood	Concrete Works	Hope Construction	Enfield	**C5**
Enfield	Concrete Works	Hope Construction	Enfield	**C5**
Bow	Concrete Works	Brett	Hackney	**C5**
Croydon	Concrete Works	Brett	Sutton	**C5**

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
Charlton	Asphalt Plant	LafargeTarmac	Greenwich	C5
Croydon	Asphalt Plant	United Asphalt	Croydon	C5
Dagenham	Asphalt Plant	Hanson	Barking and Dagenham	**C4**
Erith	Asphalt Plant	Other	Bexley	C5
Greenwich	Asphalt Plant	AI	Greenwich	C5
Hayes	Asphalt Plant	LafargeTarmac	Hayes	C5
Mulberry	Asphalt Plant	LafargeTarmac	Mulberry	C5
Neasden	Asphalt Plant	AI	Neasden	C5
Dagenham	Aggregate Railhead	Hanson	Barking and Dagenham	**C4**
Bow Midland West	Aggregate Railhead	Bardon Aggregates	Tower Hamlets	**C4**
Bow Midland East	Aggregate Railhead	DB Schenker	Tower Hamlets	**C4**
St Pancras Churchyard	Aggregate Railhead	DB Schenker	Camden	C5
Angerstein Wharf (Greenwich)	Aggregate Railhead	Bardon Aggregates	Greenwich	**C4**
Angerstein Wharf (Greenwich)	Aggregate Railhead	Tarmac Marine Dredging	Greenwich	**C4**
Ferme Park	Aggregate Railhead	London Concrete	Haringey	C5
Neasden	Aggregate Railhead	Bardon Aggregates	Brent	**C4**
Battersea	Aggregate Railhead	Lafarge Tarmac	Wandsworth	C5
Purley	Aggregate Railhead	Day Group	Croydon	**C4**
Stewarts Lane (Battersea)	Aggregate Railhead	Day Group	Wandsworth	**C4**
Tolworth	Aggregate Railhead	Day Group	Kingston upon Thames	C5
Acton	Aggregate Railhead	Bardon Aggregates	Ealing	**C4**
Brentford	Aggregate Railhead	Day Group	Hounslow	**C4**
Dawley (West Drayton)	Aggregate Railhead	Hanson	Hillingdon	**C4**
Hayes	Aggregate Railhead	Lafarge Tarmac	Hillingdon	C5
Paddington New Yard	Aggregate Railhead	Lafarge Tarmac	Kensington and Chelsea	**C4**
Park Royal	Aggregate Railhead	Lafarge Tarmac	Ealing	**C4**
Greenwich wharfs	Aggregate Wharf	Aggregate Industries	Greenwich	**C4**
Dagenham	Aggregate Wharf	CEMEX	Barking and Dagenham	**C4**
Wandsworth	Aggregate Wharf	CEMEX	Westminster	C5
London Dockland Wharfs	Aggregate Wharf	Cemex	Tower Hamlets	**C4**
Greenwich wharfs	Aggregate Wharf	Day Aggregates	Greenwich	**C4**
Newham	Aggregate Wharf	Euromix	Tower Hamlets	C5
Greenwich wharfs	Aggregate Wharf	Euromix	Greenwich	C5

Site Name/Location	Site Category	Operator	Borough	Provisional CLOCS Rating
Dagenham	Aggregate Wharf	Eurovia Roadstone	Barking and Dagenham	**C5**
Dagenham	Aggregate Wharf	Hanson Aggregates	Barking and Dagenham	**C4**
Wandsworth	Aggregate Wharf	Hanson Aggregates	Hammersmith and Fulham	**C5**
Erith	Aggregate Wharf	Lafarge Tarmac Ltd	Bexley	**C4**
Greenwich wharfs	Aggregate Wharf	Lafarge Tarmac Ltd	Greenwich	**C4**
Greenwich wharfs	Aggregate Wharf	Stema Shipping	Greenwich	**C4**
Erith	Aggregate Wharf	Tarmac	Tower Hamlets	**C4**
Greenwich wharfs	Aggregate Wharf	Tarmac	Greenwich	**C5**

Table B 1 Supply and waste sites within a London borough

Appendix C. All Mapped and Assessed Waste Sites

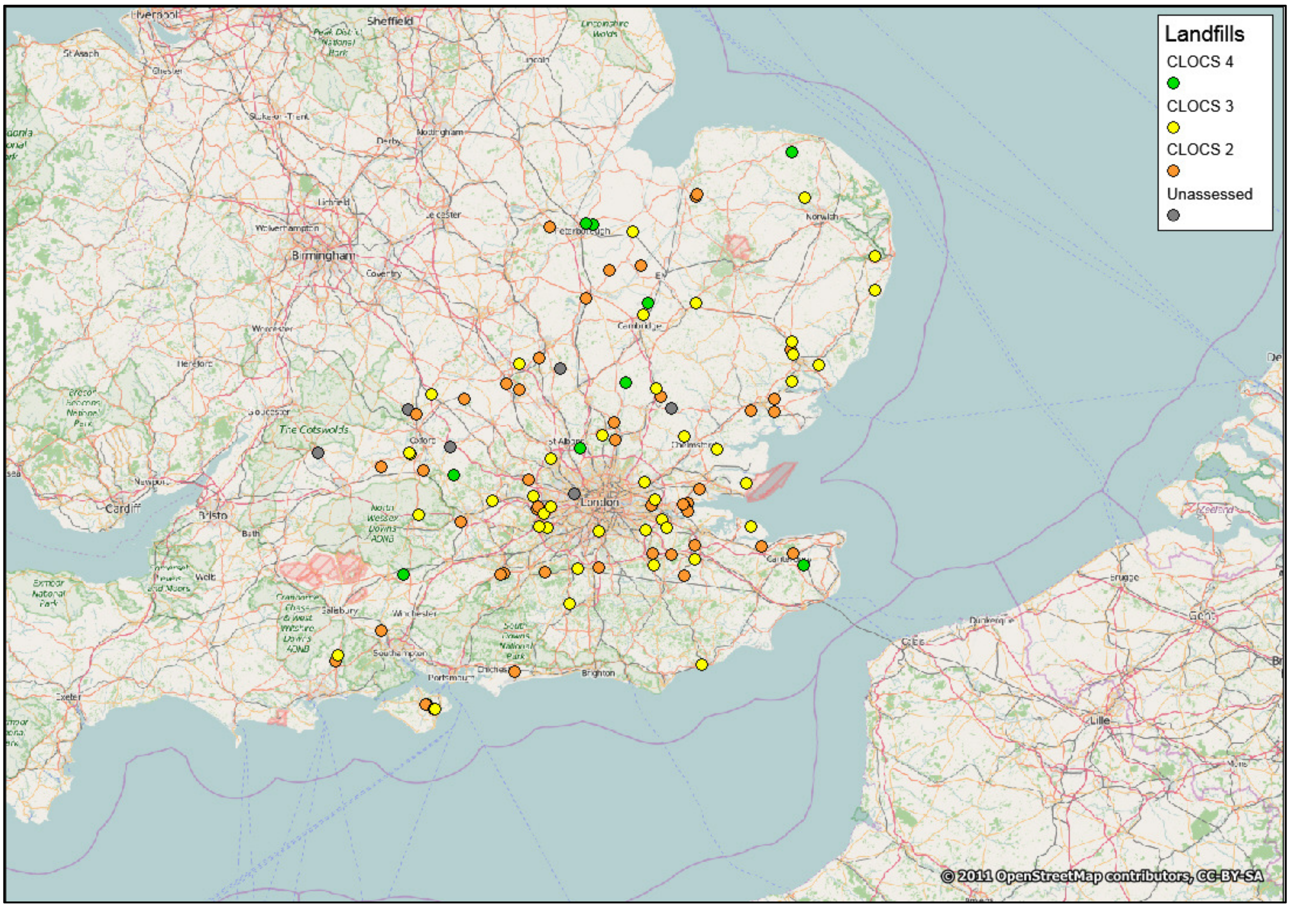

Figure C 1 All provisionally assessed landfill site locations

In total 106 landfills were identified within the South East and East. Of these ten were provisionally rated as CLOCS 4, 44 as CLOCS 3, 46 as CLOCS 2 and 6 were unassessed (Figure C 1).

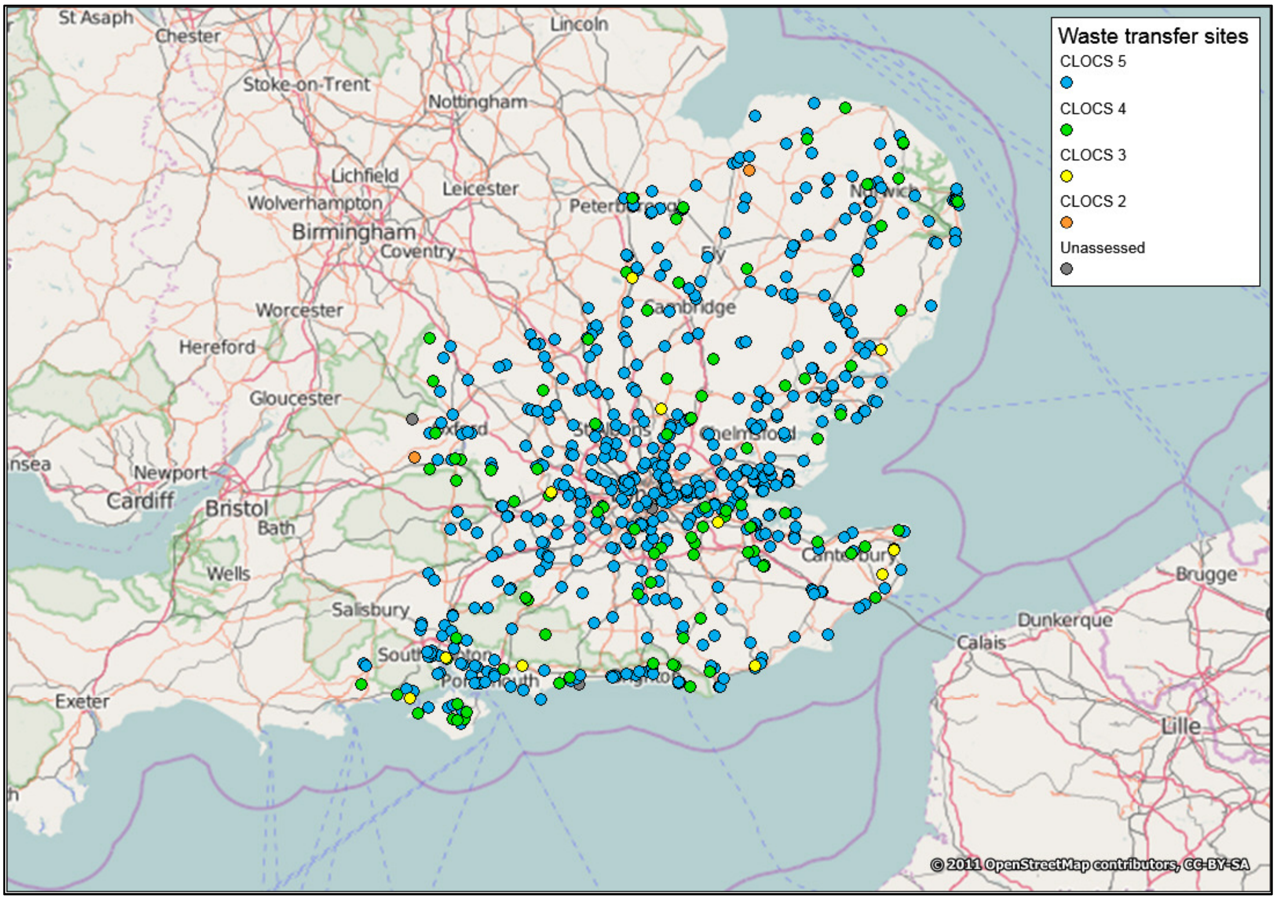

Figure C 2 All provisionally assessed waste transfer site locations

In Total 723 waste transfer sites were identified within the South East and East. Of these sites 607 were provisionally rated as CLOCS 5, 100 as CLOCS 4, 11 as CLOCS 3, two as CLOCS 2 and three as unassessed (Figure C 2).

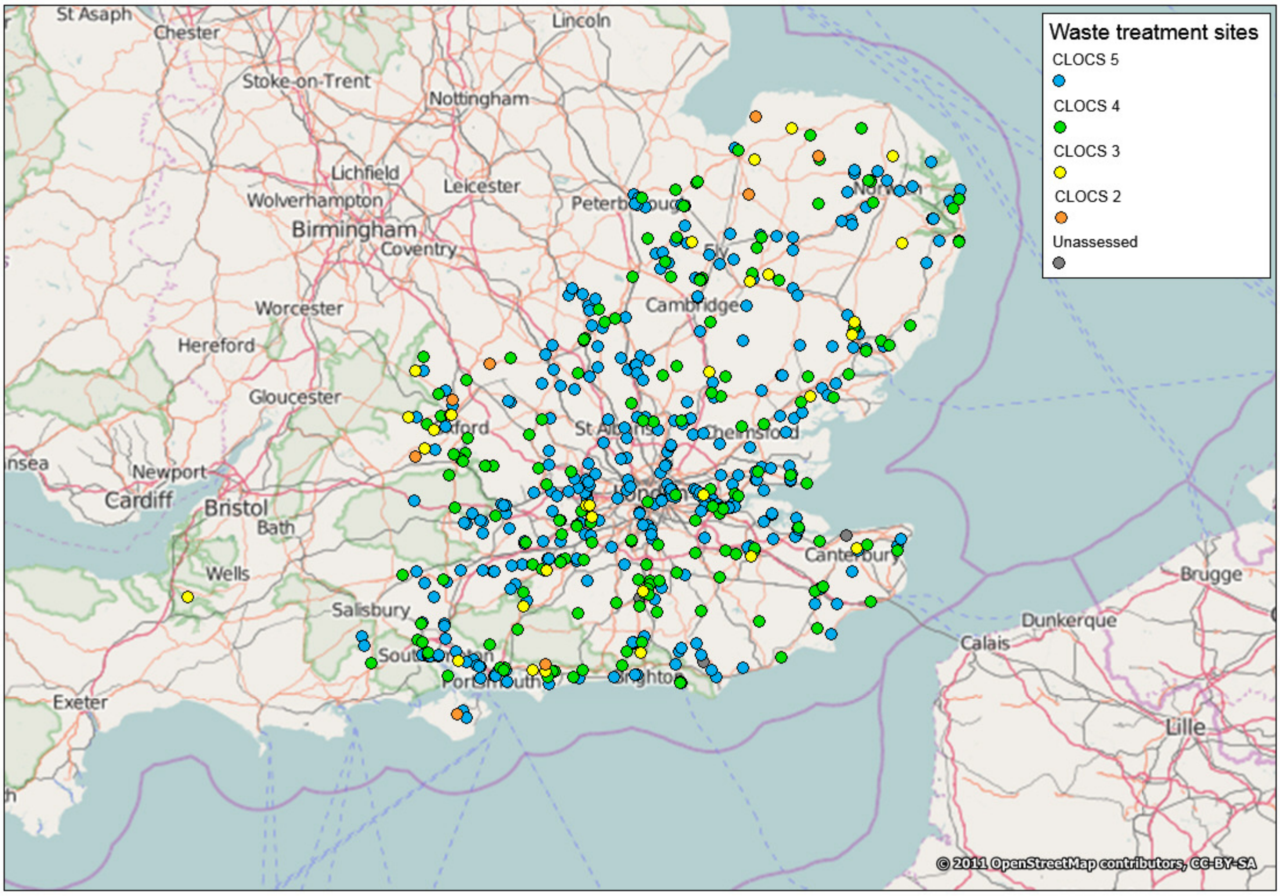

Figure C 3 All provisionally assessed waste treatment site locations

A total of 553 waste treatment sites were identified within the South East and East. Of these sites 342 sites were provisionally rated as CLOCS 5, 169 as CLOCS 4, 31 as CLOCS 3, eight as CLOCS 2 and three were unassessed (Figure C 3).

Appendix D. PowerBI for Waste and Supply Site Directory

PowerBI is an analytical business tool in which data can be analysed and visually represented on dashboards that can be published to websites to be viewed by both the industry and the public. There are both free and paid versions of the software, however the features demonstrated in the following section are available in the free version. PowerBI uses background data sources, such as Excel spreadsheets, to generate interactive dashboards which are both visually appealing and informative. For the purpose of this study a dashboard was created using the supply and waste site directory and uses the provisional CLOCS ratings. The following screen shots show how the software can be used to display the supply and waste site directory, and the overall functionality of the software.

Once data has been loaded into PowerBI, the 'fields' tab will be populated with the column headers from the background spreadsheet. Data can be displayed in PowerBI through 'visualisations'. Various visualisations can be selected dependant on the type of data that is being displayed. Figure D 1 shows how the table and bar chart visualisation can be used to display information.

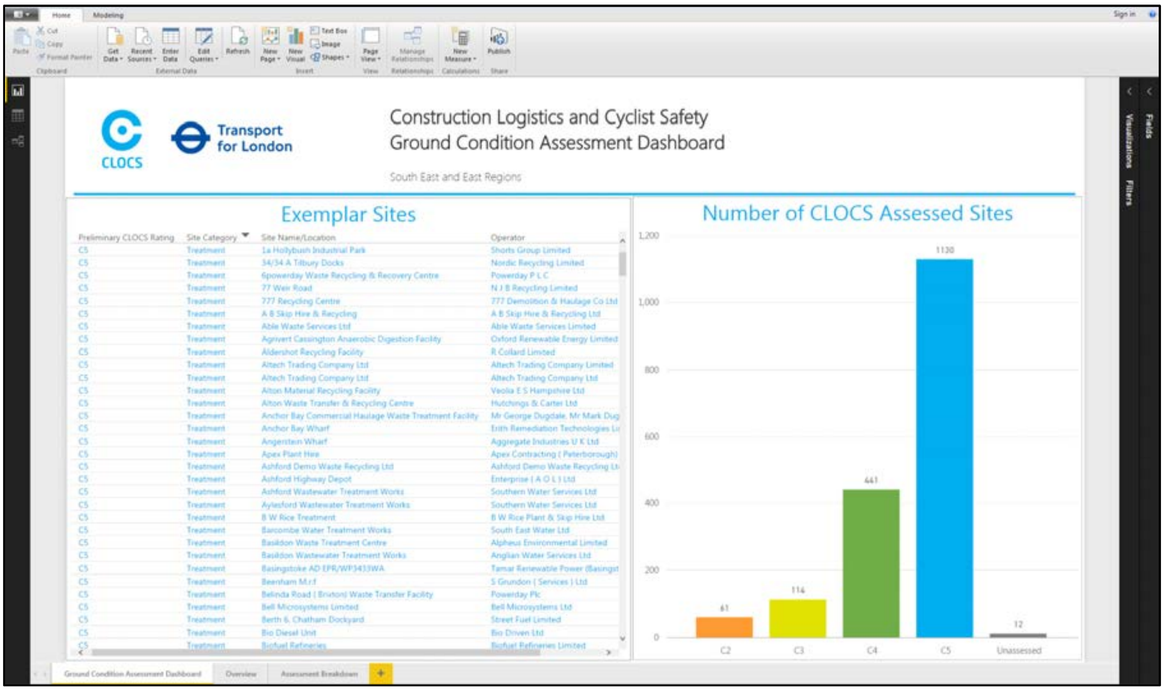

Figure D 1 Dashboard summary of exemplar sites and total number of assessed sites by CLOCS category

Each dashboard created within PowerBI can have multiple tabs, in the same way excel can have multiple sheets. The first tab can be used to provide a summary of current site conditions, with a breakdown of exemplar sites and how many sites are currently in each of the categories. Figure D 1 shows how this information can be displayed. Branding, such as the Transport for London and CLOCS logos, can also be added.

The second tab named 'Overview' provides a breakdown of each site by site category and if the site accepts London waste (Figure D 2). For mapping, Latitude and Longitude coordinates can be displayed over Bing maps so the location of each site can be determined quickly and with ease. In this instance all supply and waste site are mapped and the point colour represents their provisional CLOCS rating.

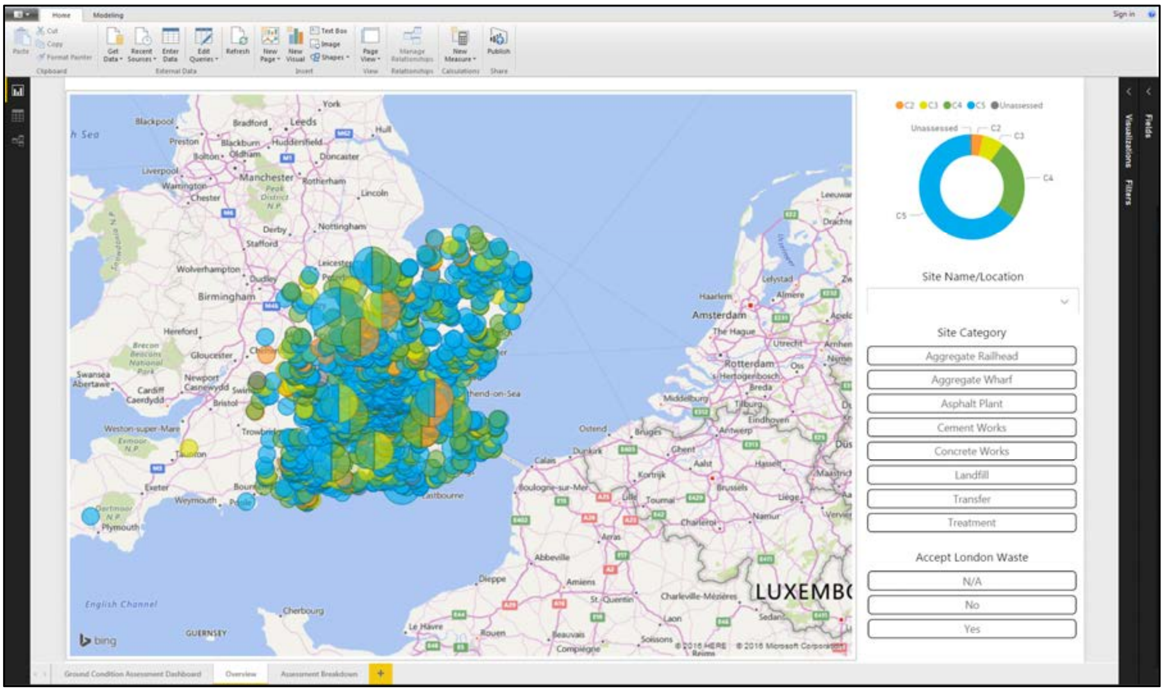

Figure D 2 Map and site breakdown by category and acceptance of London waste

Sites can be filtered using the CLOCS categories, site categories or if the site accepts London waste. All aspects of the dashboard are interactive and will influence one another. For instance, Figure D 3 shows where just the CLOCS 2 rated sites have been selected, which automatically updates the map.

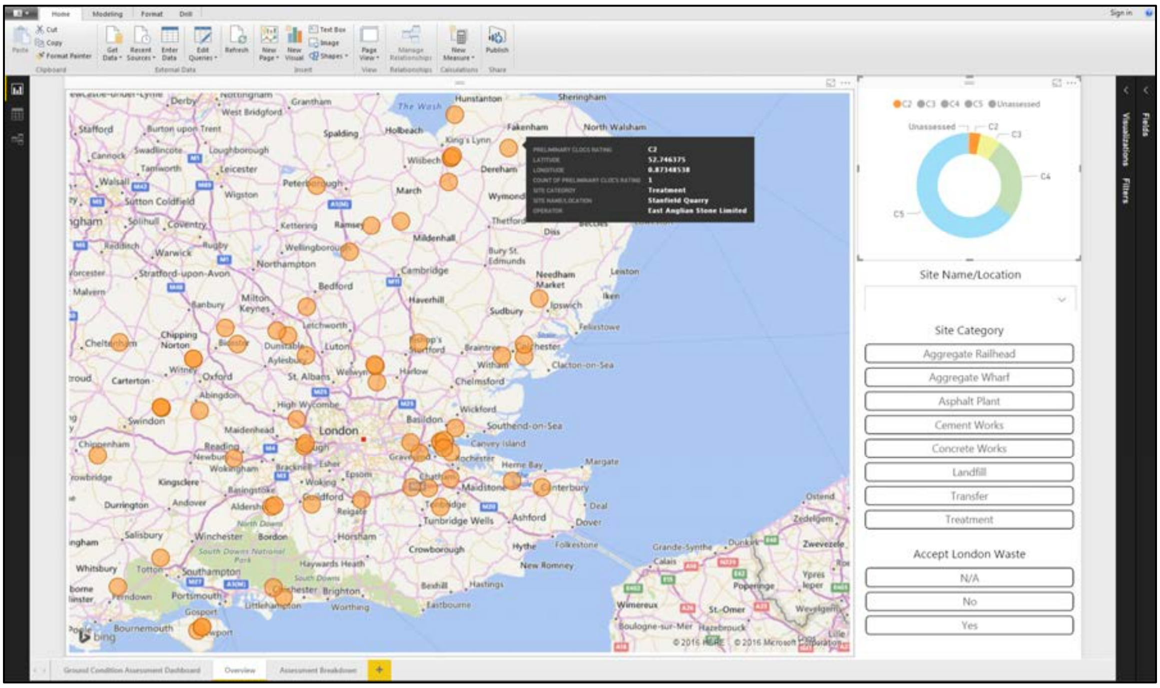

Figure D 3 Dashboard filtered by CLOCS rating

By hovering over each point on the map, the site name, operator and location is displayed. Search functionality can also be added so if there is a specific site of interest, the user can type the site name in a pull up information on that site on its own. The CLOCS rating can be further broken down to see how each site has scored regarding the assessment categories of approach angles, material type, rutting and bumps and water.

PowerBI dashboards can be published to the web using a unique address or incorporated into existing websites. When the background spreadsheet is updated, in this case if more sites are added or an assessment score changes, the versions of the dashboard on the web will automatically update to show the latest information. This dashboard can be incorporated into the current CLOCS website so the industry and the public can easily see where they can take their vehicles, relative to their location. There is also a mobile App version of PowerBI which can be used if out on-site or do not have access to a computer.

In order to publish a PowerBI dashboard to the web, an account must be created. This account will only accept company email addresses, such as @tfl.gov.uk. A link will be provided in order to embed the dashboard into current websites, such as the CLOCS website. The dashboard will work in the same way as the desktop version enabling the user to make use of the interactive features, however data will only be editable through the source input. Figure D 4 shows how a PowerBI dashboard may be presented on the current CLOCS website.

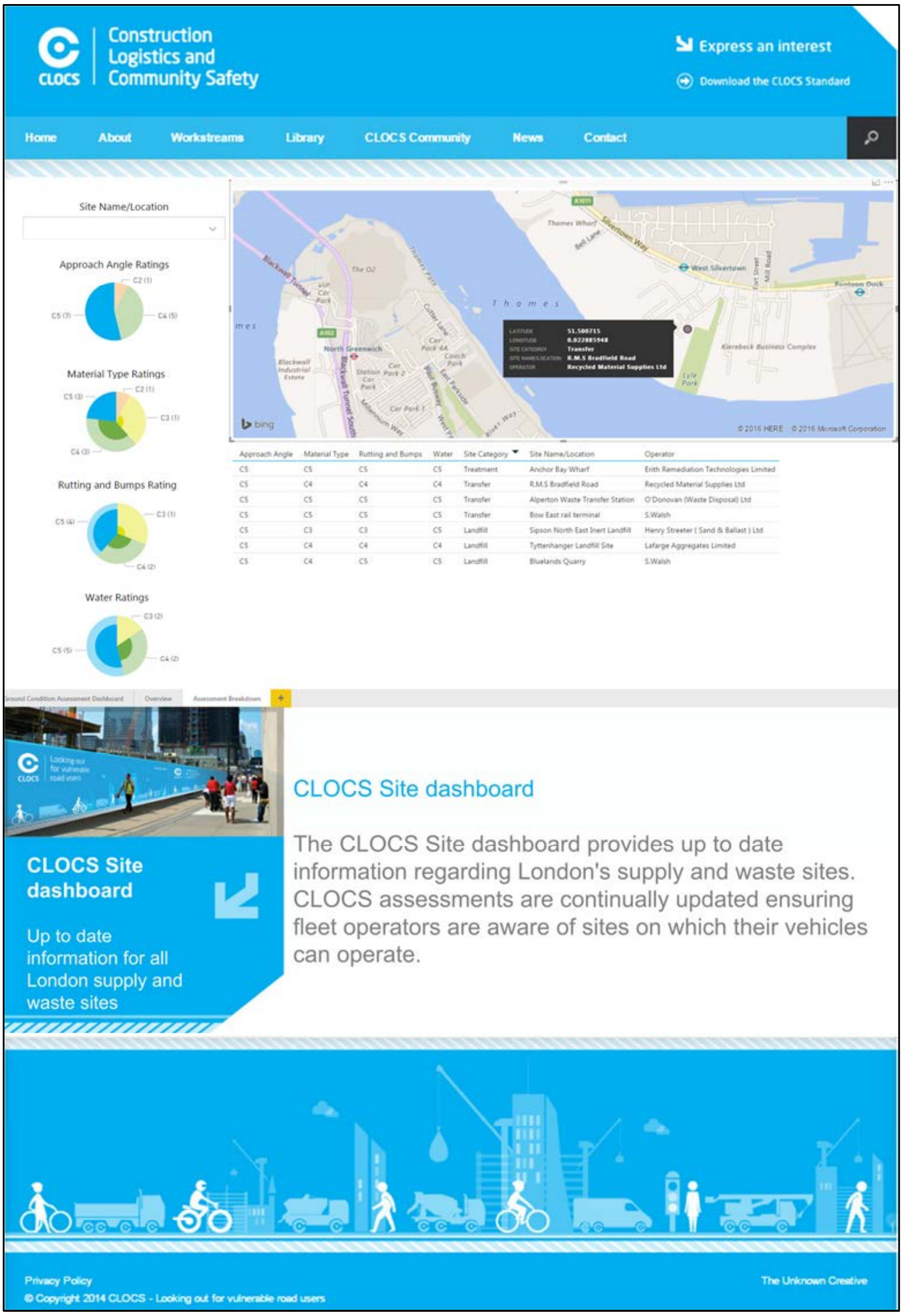

Figure D 4 CLOCS website concept with embedded PowerBI dashboard

Appendix E.CLOCS App Concepts

The following pictures are concepts for a CLOCS smart phone/tablet app that incorporates the site assessment as well as the site directory, where users will be able to view ratings for all sites in the London area and also complete and upload their own ratings. By eliminating the paper and pencil element of the assessment it is hoped many more people will contribute their site ratings to the project. In order to achieve the widest adoption in the industry the app should be a free download and made available to all via iOS and Android devices. The following concepts are what the app could look and function like, and where it can utilise existing technologies, such as smart phone/tablet gyroscopes, to help measure approach angles.

Users will be able to select the app from the home screen of their smart phone/tablet and immediately view the latest assessed sites and exemplar sites. Whilst the concepts presented here are specifically tailored for this particular project, the app could be expanded to include CLOCS compliance and training. Figure E 1shows the app selection and loading screens.

Figure E 1 App selection and loading screen

Each site can be clicked on and expanded to view the assessment breakdown, add comments and view pictures taken during the assessment. A search button will allow users to search for specific sites that they are interested in. Discussions with stakeholders highlighted that material to be transported, particularly in muck away operations, can change regularly. As such having an app that allows the user to determine which sites are suitable for their payload, without having to log onto a computer, should prove useful.

Allowing users to view pictures of the assessments for each site and also add comments will allow for live monitoring. Functionality could be added whereby drivers or anyone who visits the site can agree or disagree with the rating as a quick way to flag up any ratings that may be inaccurate. A menu bar on the top left hand corner of the screen will allow users to navigate the app including a login section, vehicles specification information, view and select sites from a map screen and take the assessment themselves. The map screen will allow users to find their nearest site, what rating that site is and ultimately whether the vehicle they are in is suitable for the site. Again search functionality should be included for faster navigation. Figure E 2 shows how these features could work seamlessly from within the app.

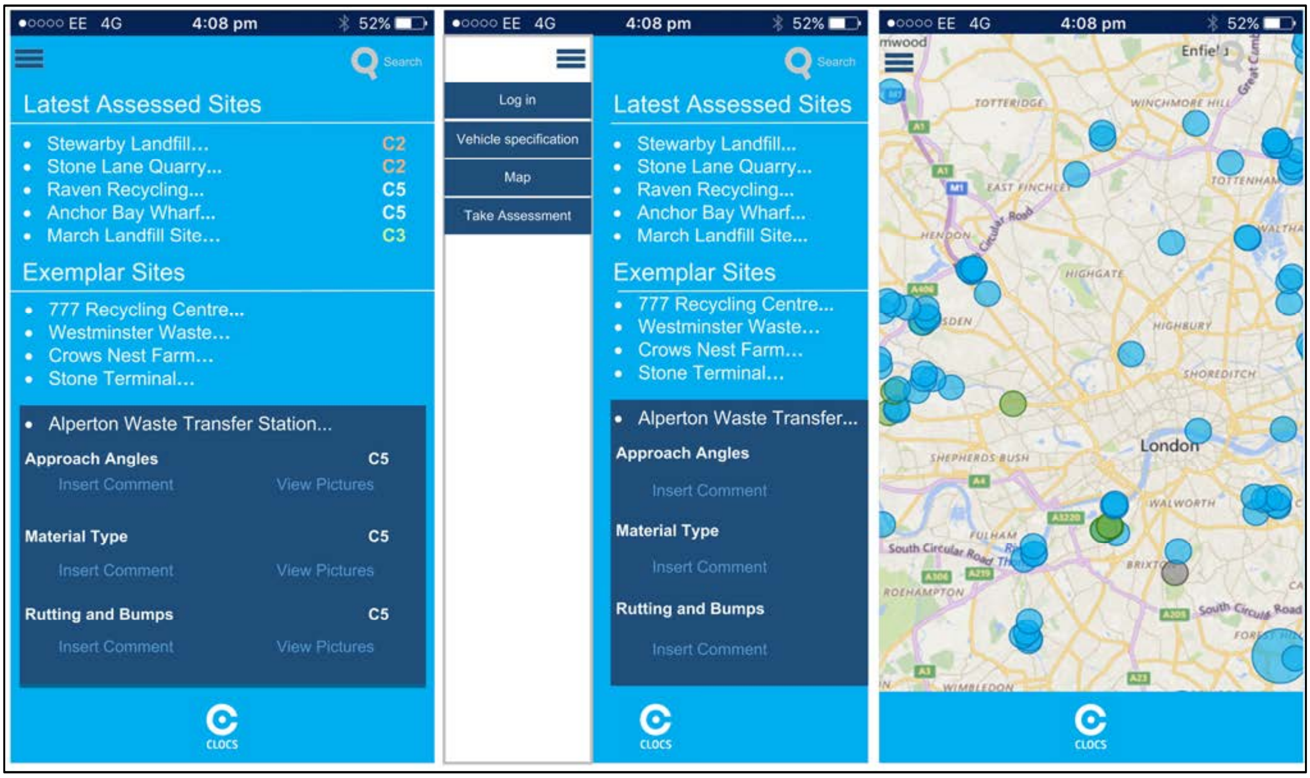

Figure E 2 Dashboard, navigation and map screens

The site assessment should be incorporated into the app to be completed and submitted back to Transport for London or the service provider directly, as shown in Figure E 3. This will remove the extra step of filling in a digital version of the assessment to be sent back via email.

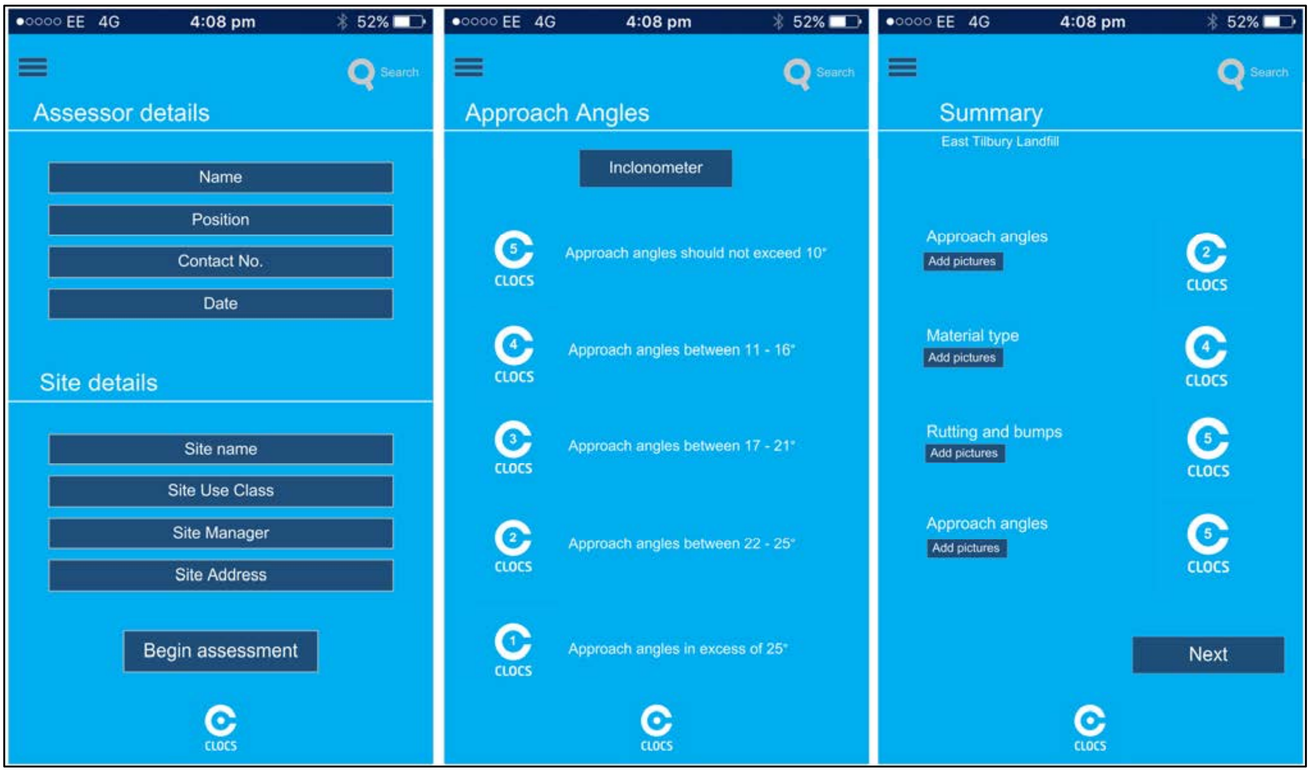

Figure E 3 Assessment screen and assessment summary screen

The app will hopefully lead to the widest uptake of the standards as it is quick and simple to complete. This will also allow for use of built in features of the device, such as overlaying camera images with an inclinometer, right from within the app (Figure E 4). Photos can be attached to each assessment criteria and uploaded to the server to be viewed and commented on by all.

Figure E 4 Example of gyroscope and image overlay functionality

About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With approximately 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $6 billion.

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