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School of Civil Engineering and the Environment

Sustainable Forward and Reverse Logistics Practices across Competing Supply Chains

by

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Abstract

In recent years, rapid changes in markets including outsourcing and globalisation of trade and production systems have led to a dramatic upsurge of interest in retail logistics with the aim to minimise operational and logistics costs, improve responsiveness and ameliorate customer services. The notable massification and commodification of production and consumption have created structural changes in traditional urban distribution systems with the establishment of peripheral trans-shipment and hub systems. In the light of sustainable development, green logistics and transparency on emissions have become a further requirement conforming to the times with a special focus being placed on the logistics of collecting, processing and recycling waste materials. This has increased the need to develop more efficient and effective city distribution plans and to establish optimised logistics models which will integrate the delivery of materials and the collection of waste and returns in order to reduce congestion, costs and emissions.

To this end, this thesis aims to investigate opportunities to improve existing delivery mechanisms in a dedicated shopping centre in the UK in order to minimise freight activity and emissions, while optimising the reverse flow system for product returns and waste. Using a substantial database of logistics operations compiled for 92 businesses in Southampton's shopping centre, the study aimed to understand the current opportunities to better utilise the existing back-load capacity and assess the potential logistical and environmental savings that could arise from the use of a peripheral consolidation centre for core goods and waste.

Following statistical analysis of the responses gathered from *WestQuay* managers, logistics providers, waste contractors and head offices, it was found that the fill rates of delivery vehicles were considerably low and therefore there was a great potential to increase back-load rates and consolidation among loads of different businesses. In examining the waste and return flows, it was found that there were already centrally managed collections of general waste and some recyclables and therefore further opportunities to reduce the logistics and environmental impact would lie into the consolidation of forward traffic and the back-loading of specific waste streams such as hazardous materials. The examination however of specific case study examples

exhibited the variety in the characteristics and properties of hazardous wastes and the role of material-specific legislation on the way different waste streams should be managed and disposed of which limited the collaboration opportunities among businesses producing different waste streams. Instead the study highlighted the considerable transport, environmental and economic gains that could be achieved by individual businesses through the use of regional waste contractors and recycling sites.

With regard to the consolidation of forward flows, the study reviewed a number of existing consolidation schemes and their characteristics to identify potential strengths, weaknesses and risks that would impact the operation of a consolidation centre in the outskirts of Southampton. Various scenarios regarding the operation of the consolidation scheme were examined considering different take up combinations among different vehicle modes and loads. The scenario analysis suggested that the establishment of the consolidation centre could offer great opportunities to reduce the overall urban freight activity, while mitigating the environmental impacts and cutting down the total costs to businesses.

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Academic Thesis: Declaration Of Authorship

I, Maria K. Triantafyllou declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

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I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;

2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

3. Where I have consulted the published work of others, this is always clearly attributed;

4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

5. I have acknowledged all main sources of help;

6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

7. Parts of this work have been published as:
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Definitions

Throughout this thesis there are a number of terms used which shall have the meanings described in Table 1. An extensive list of definitions, all pertinent to this study, is contained in the Glossary at the end of this report.

Table 1: List of main terms used in the thesis and their definitions.

Term	Definition	Source
Supply Chain Management	It encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.	Council of Supply Chain Management Professionals (CSCMP, 2010)
Logistics	The management of all activities which facilitate movement and the co-ordination of supply and demand in the creation of time and place utility.	Heskett *et al* (1973)
	That part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements.	Council of Logistics Management (CLM, 2002)
Reverse Logistics	The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.	Rogers and Tibben-Lembke (1998)
	The movement of products or materials in the opposite direction for the purpose of creating or recapturing value, or for proper disposal.	Rogers and Tibben-Lembke (1998)
Green Logistics	Supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution. It includes material handling, waste management, packaging and transport.	Rodrigue *et al* (2009)
	Attempts to measure and minimize the ecological impact of logistics activities.	Rogers and Tibben-Lembke (1998)
Core Goods	Products of fundamental importance to the main commercial activity being undertaken by a business (e.g. for retail stores these would be goods sold to final customers and for restaurants the essential supplies of food and drink).	Cherrett *et al* (2002)
Product Returns	Products returned to retailers, suppliers or manufacturers either by customers (e.g. warrantee, service and end-of-use returns) or by retailers (e.g. recalls, surplus and stock adjustments, unsold or wrong/damaged products, quality control returns, by-products and re-usable packaging).	Hickford *et al* (2007)
Waste	Any substance or object which the producer or the person in possession of it discards or intends or is required to discard.	Waste Framework Directive [75/442/EC]
Waste Management	The collection, transport, recovery and disposal of waste, including the supervision of such operations and after-care of disposal sites.	Waste Framework Directive [75/442/EC]

Abbreviations

ABP	Associated British Ports
AC	Alternating Current
ANOVA	ANalysis Of VAriance
Arts	Articulated Lorries
BERR	Business Enterprise and Regulatory Reform
BESTLOG	Establishing a Dissemination and Promotion Platform for Logistics Best Practice
BESTUFS	Best Urban Freight Solutions
BIFFA	British Isles Flying Fifteen Association
BPEO	Best Practicable Environmental Option
BPF	British Plastics Federation
BTHA	British Toy and Hobby Association
B2B	Business-to-Business
B2C	Business-to-Customer
CbB	Cardboard Boxes
CE	Conformite Europeenne
CEC	Commission of the European Communities
CLM	Council for Logistics Management
CLS	City Logistics Solutions
CNG	Compressed Natural Gas
CORINAIR	CORe INventory of AIR emissions
CRC	Centralised Return Centre
CSCMP	Council of Supply Chain Management Professionals
CSR	Corporate Social Responsibility
CSRGT	Continuing Survey of Road Goods Transport
C&I	Commercial and Industrial
DC	Direct Current
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food & Rural Affairs
Del	Delivery (ies)
DERV	Diesel Engine Road Vehicles
DfT	Department for Transport
D/K	Don’t Know
DTI	Department of Trade and Industry
DTS	Distributor Take-back Schemes
DUKES	Digest of UK Energy Statistics
EA	Environment Agency
EC	European Commission
ECR	Efficient Consumer Response
EEE	Electrical and Electronic Equipment
EMEP	European Monitoring and Evaluation Program
EMS	Environmental Management Standards
EPA	Environmental Protection Act
EPR	Extended Polluter Responsibility
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union
EWC	European Waste Catalogue
FdW	Food Waste
FGP	Factory Gate Pricing

FIDEUS	Freight Innovative Delivery in European Urban Space
Fri	Friday
GHGs	Greenhouse Gases
GIC	Global Investment Company
GL	Green Logistics
GSCM	Green Supply Chain Management
GW	General Waste
GWP	Global Warming Potential
HFCs	cHloroFluoroCarbons
HGVs	Heavy Goods Vehicles
HR	Hanging Rails
ICs	Integrated Circuits
IKEA	Ingvar Kamprad Elmtaryd Agunnaryd
IMC	Inter-modal Marketing Company
INH	INHouse
IPCC	Intergovernmental Panel on Climate Change
IPL	International Port Logistics
IS	Information Systems
ISO	International Organisation for Standardisation
IT	Information Technology
JIT	Just-In-Time
JL	John Lewis
LCA	Life Cycle Assessment
LGVs	Light Goods Vehicles
LoW	List of Wastes
LPG	Liquefied Petroleum Gas
LSD	Least Significant Difference
LTP	Local Transport Plan
MCG(s)	Main Core Good(s)
MHRA	Medicines Healthcare products Regulatory Agency
Mon	Monday
MP	Mixed Paper
MRF	Materials Reprocessing Facility
M&S	Marks and Spencer
N/A	Not Available
NAEI	National Atmospheric Emissions Inventory
NICHES	New and Innovative Concepts for Helping European transport Sustainability
NIMBY	Not In My Back Yard
NIMTO	Not In My Term Office
NRTS	National Road Traffic Survey
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
ONS	Office for National Statistics
PCB	Printed Circuit Board
PFCs	PerFluorinated Chemicals
PhD	Doctor of Philosophy
Pl	Plastic
PlB	Plastic Boxes
Plt	Palettes
PoDr	Pack of Drinks
Pth	Polythene

PUSH	Partnership for Urban South Hampshire
QR	Quick Response
RC	Roll Cages
RDC	Regional Distribution Centre
RDIF	Radio Frequency Identification
RoHS	Restriction of Hazardous Substances
RSA	Royal Society for the encouragement of Arts, manufactures and commerce
RTV	Return to Vendor
S	Sacks
Sat	Saturday
SCG(s)	Secondary Core Good(s)
SF_6	Sulfur hexafluoride
SI	Statutory Instrument
SIC	Standards Industrial Classification
SLI	Starting Lighting and Ignition
SMEs	Small and Medium Enterprises
SP(s)	Service Product(s)
Sun	Sunday
T	Trays
TfSH	Transport for South Hampshire
Thu	Thursday
TRB	Transportation Research Board
TRG	Transportation Research Group
TSE	Tourism South East
Tue	Tuesday
UCC	Urban Consolidation Centre
UK	United Kingdom
USA	United States of America
VOSA	Vehicle and Operator Services Agency
VMT	Vehicle Miles Travelled
WC	Waste Contractor
Wed	Wednesday
WEEE	Waste Electrical and Electronic Equipment
WRAP	Waste and Resources Action Programme
3PL	Third Party Logistics
4PL	Fourth Party Logistics

Notations

A	Surface (m^2)
Ca	Cadmium
CO_2	Carbon Dioxide
CO_{2e}	Carbon Dioxide Equivalent
df	Degrees of freedom
Kg	Kilogram(s)
Km(s)	Kilometre(s)
l	Litre(s)
m	Metre(s)
m^2	Square metre(s)
m^3	Cubic metre(s)
max	Maximum
min	Minimum
MS	Mean Squares (error variance in ANOVA-test)
n or N	Number of
n_{aver}	Average number
n_{tot}	Total number
P	Probability
r	Ratio or Pearson product-moment correlation coefficient
S	Distance (km)
S_{aver}	Average distance (km)
S_{tot}	Total distance (km)
St.Dev.	Standard Deviation
Σx or Σx	Sum of x or y values
Σx^2 or Σx^2	Sum of the square of x or y values
$(\Sigma x)^2$ or $(\Sigma x)^2$	Square of the sum of x or y values
Σxy	Sum of the product of x and y values
t	Tonne(s)
tot	Total
Vol. or V	Volume

Chapter 1: Introduction

1.1 Background

In recent years, the freight transportation industry has been facing major challenges due to rapid technological, market and organisational changes. More recent supply chain trends such as the upsurge of online shopping and globalised production have resulted in longer distances travelled, smaller size of consignments, higher service frequency and more timely deliveries (Lehtonen, 2008). In response, distribution networks have faced structural changes such as the development of peripheral trans-shipment and hub systems and the notable increase in the use of vans in urban centres (DfT, 2010c). Consequently, congestion in urban centres has increased in most cases and emissions in the final leg of distribution have risen disproportionately to overall emissions (Edwards *et al*, 2010).

At the same time, increased unsold products, returns, packaging materials and waste add pressures on the effective design of reverse logistics networks which are characterised by irregular flows, diverse quality and random assortment of product returns and waste materials (Wyld, 2006). To enable the movement of these products and materials in the opposite direction for the overall perspective of compliance, performance and revenue, businesses need to treat the reverse portion of logistics with the same seriousness and deliberation as the forward portion and integrate the two (Beltran, 2002).

While traditionally the performance of logistics systems has been measured in terms of costs and customer services, today environmental concerns have gained increasing prominence on company agendas (Skjøtt-Larsen, 2000) as a result of stringent regulations and greater public awareness. Environmental awareness has led to the development of green logistics whose activities include measuring the environmental impact of different distribution and collection strategies, reducing the energy usage and the waste produced and treating waste and product returns by more sustainable ways (Shakantu *et al*, 2002). The emerging concept of the 'closed loop[1]' supply chain to reduce the environmental impacts and the costs of logistics necessitates a total

[1] 'Closed loop' is a production system in which the waste or by-product of one process or product is used in making another product.

product life cycle approach starting with the design of products and ending in efficient recycling operations (Bernon, 2005). It is not enough to focus on the end result of reverse logistics by just adopting sustainable treatment options such as recycling, reuse, repair, renovation, reprocessing and cannibalisation to manage waste and returns (Thierry *et al*, 1995), because these operations may add an additional burden on the transport system by the construction of more transport networks and the operation of more transport vehicles. It is therefore essential to put reverse logistics squarely into the initial design and development phases of a product’s life cycle (Beltran, 2002).

Effective management of the logistics flows and network configuration will have a significant impact on the distances end-of-life materials and product returns will have to travel (Bernon, 2005). To ensure sustainable reverse logistics activities it is important that businesses effectively monitor product returns, use appropriate support tools, maximise consolidation opportunities, increase back-load rates and where possible, group with rival businesses through coordinated collection practices to reduce the number of overall freight vehicle trips, the distance travelled and the number of less-than-vehicle loads generated.

To help individual retail businesses, logistics and recycling firms to find the best match between environmental considerations and profitability (Rodrigue *et al*, 2001) it is important to investigate the market through additional, in-depth empirical research (Murphy *et al*, 1998) and help businesses design effective strategies and deploy successful initiatives to move beyond reverse logistics to the development of ‘green’ supply chains (Van Hoek, 1999).

1.2 Research Objectives

The principal aim of the project is to investigate potential opportunities to improve existing delivery mechanisms in a dedicated shopping centre in the UK in order to minimise freight activity and emissions, while optimising the reverse flow system for product returns and waste. In addition, this thesis aims:

Through a review of the literature:

- To provide an overview of current supply chain trends and operations through the examination of the types, physical network structures and disposition routes of core goods, product returns and waste materials.
- To identify the drivers of forward and reverse logistics practices in the UK retail sector.
- To explore the opportunities to combine, adapt, generalise and modify existing logistics mechanisms in order to minimise freight activity and pollution levels.
- To examine a number of existing emission assessment models in order to select the method which is used to evaluate the carbon footprint of established and proposed freight movements using a routing model (*MapPoint*).
- To review a number of existing consolidation schemes and their characteristics (e.g. types, sizes, locations, beneficiaries) to identify potential strengths, weaknesses and risks.
- To examine previous freight transport studies to identify specific data requirements, collection and analysis methods, as well as research gaps and opportunities for future research.

Through the use of a dedicated shopping centre as a case study example:

- To examine the delivery vehicle movements servicing the retail centre to aid understanding of the current opportunities to better utilise the existing delivery mechanisms through increased consolidation and utilisation of the existing back-load capacity.
- To understand how current policy agendas and institutional arrangements influence corporate strategic planning for product returns and waste management, and examine the associated logistics operations.
- To demonstrate best practice examples in recyclate generation and returns management.
- To investigate potential opportunities to reduce the transport footprint of waste collection mechanisms through the use of local recycling markets.
- To appraise the transport and environmental effects that arise from the use of an urban consolidation centre considering a number of different operational regimes.
- To identify current research needs and future priorities.

1.3 Report Outline

This report is organised as follows: The second chapter describes the background to supply chain and logistics concepts and mechanisms, and provides thorough insights into the current regulatory framework and the social and economic conditions impacting the development of forward and reverse logistics operations in the UK (Chapter 2). In Chapter 3 a special focus is given on the role that urban consolidation centres could play in reducing freight impacts. For this reason an in-depth study of the background of existing retail structures is made to identify their main operational characteristics, as well potential benefits and risks that should be considered during their planning stages. Using a dedicated shopping centre as a case study example the next sections describe the methodology approach undertaken (Chapter 4) to quantify the transport and environmental footprint of established and projected (19 scenarios) freight distribution and collection practices (Chapter 5). They examine forward activities undertaken by retail outlets and catering units in order to identify the potential to increase back-loading practices (Chapter 6). In addition customer take-back systems and waste/recyclate collection activities at stores are investigated in order to identify best practice examples, and explore the opportunities to develop synergies among rival businesses and increase back-loading rates (Chapter 7). Chapter 8 describes the establishment of a consolidation centre to tackle increased freight activity and emissions taking into account the needs of *WestQuay* tenant businesses considering their operational and functional specifications. Findings are discussed and areas seeking further research are identified (Chapter 9).

1.4 Organisational Structure of Thesis

The following diagram (Figure 1) summarises the key elements of the thesis.

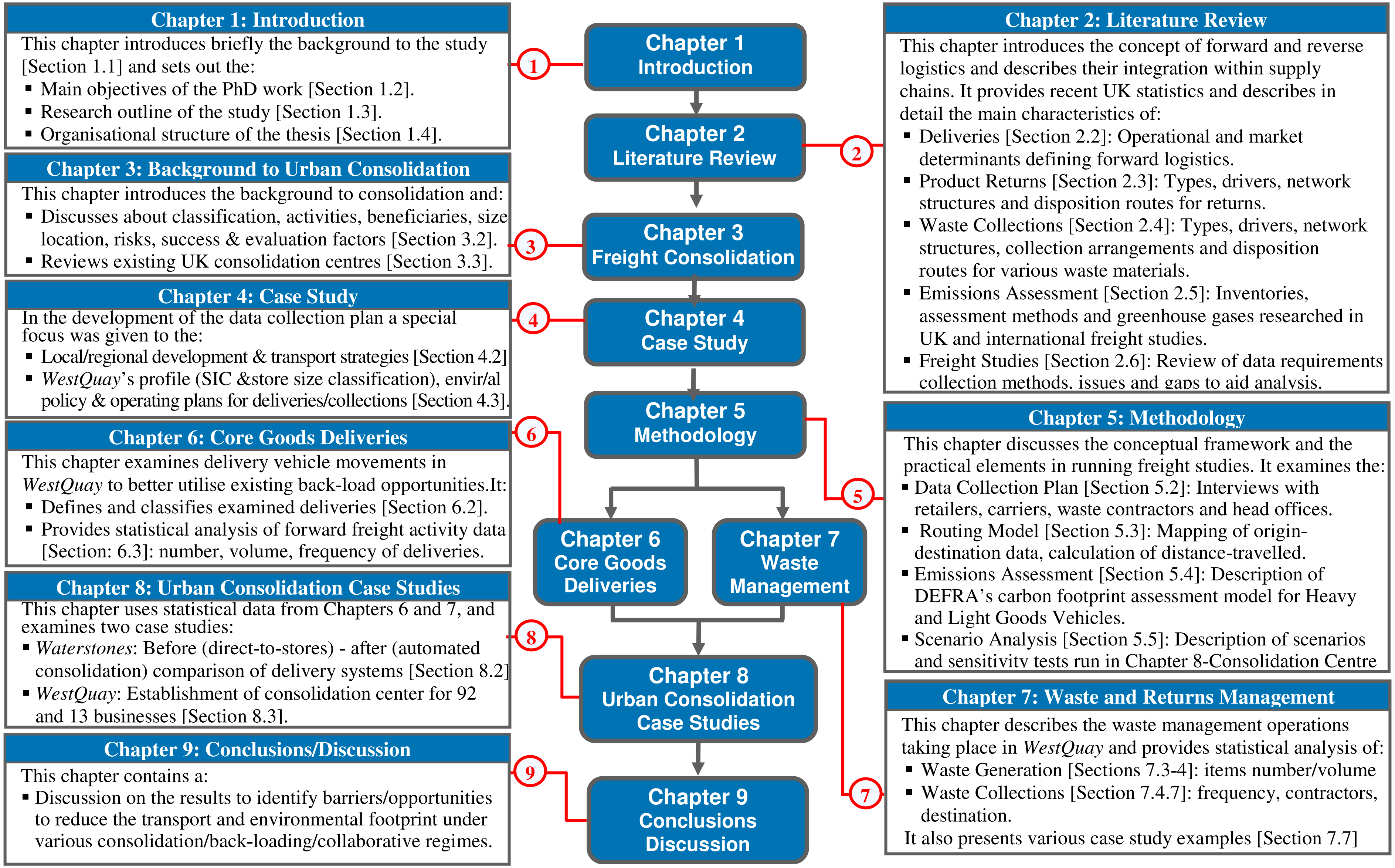


Figure 1: Organisational structure of PhD thesis.

Chapter 2: Literature Review

2.1 Introduction

Logistics is that part of the supply chain that '*plans implements, and controls the efficient, effective flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers requirements*' (CLM, 2002). It includes both upstream and downstream movement of goods among manufacturers, suppliers, retailers, customers, recyclers or other end-users with the aim to deliver superior customer value at less cost to the supply chain as a whole (Ritchie *et al*, 2000). Traditional logistics models have concentrated on providing customers with superior service through inventory availability, speed and service consistency (Bowersox and Closs, 1996). This trend is currently changing with green considerations and governmental regulations impacting on numerous logistical decisions throughout the supply chain including facility location, sourcing of raw materials, modal selection, integration of forward and reverse logistics operations and development of supply chain partnerships, among others (Wu and Dunn, 1995; Bernon and Cullen, 2007).

Following the rapid development of logistics, a plethora of studies and reports have been conducted to investigate various elements, challenges and advances facing the sector. Logistics is a field that has been increasingly researched since the middle of the previous century however the growing awareness on sustainability has induced a new wave of research that has appeared periodically in the literature since 1990s and deals with the environmental impacts of logistics operations. As logistics and market trends evolve rapidly, the industry and academia must strive in tandem to keep in pace with the latest trends in the field, to develop sustainable logistics management systems and induce stakeholder engagement and collaboration with the aim to reduce the overall environmental footprint of freight activities.

To this end, this chapter describes the growth of logistics over years and the integration of sustainable logistics practices within supply chains. The main purpose is to survey a number of previous studies, research projects and case studies from the retail sector to present briefly the progress of UK logistics over years. In addition, it provides thorough insights into the development of forward (deliveries) and reverse logistics (product returns and waste collections) in the UK. In each case, an extensive report of the types and the characteristics, the drivers, the network structures, the transport arrangements and the final disposition routes are provided along with relevant UK statistical data. To identify the framework around which one can assess the impact of freight transport on the environment, this chapter also includes a detailed description of the level and the problems related to the measurement of greenhouse gases emissions caused as a result of freight transport. This chapter closes with a review of previous UK and other logistics studies in the commercial sector to identify the research gaps and embrace the best research practices. A range of journal and conference papers, government and company reports, books and freight project websites served as the key bibliographic sources used to identify the material drawn for review.

2.1.1 Historical Background of Logistics

The concept of logistics and supply chain is not new but has always been fundamental to the manufacturing, storage and movement of goods. Logistics has evolved over years to get relatively recently recognised as a vital function within the market and the financial environment (Rushton *et al*, 2010). In 1950s distribution systems were characterised by lack of planning and control of supply chain functions. In response research was limited to the delineation of basic logistical concepts with a focus on the role of logistics in military operations and the development of efficient data-processing systems (e.g. Campbell *et al*, 1957; Geisler, 1958). In 1960s, the relationship between the various distribution functions (e.g. transport, storage, materials handling and packaging) was gradually recognised with research focusing on planning and managing trade-offs between distribution functions to improve service and reduce costs (e.g. Smykay *et al*, 1961; Heskett, 1966; Bowersox, 1969). The need to integrate distribution in the functional management structure of a business was widely recognised in 1970s. This took effect through the decline in the power of manufacturers and suppliers and the development of local and regional distribution centres servicing large retail chains (Rushton *et al*, 2010). Much of the research concentrated on the organisation of corporate logistics systems and the development of strategic distribution plans (e.g. Geoffrion and Graves, 1974; Heskett, 1977). Longer-term planning and cost-saving measures, such as centralisation of distribution, reduction of stockholding and efficient inventory management using information and equipment technology became the focus of 1980s with the aim to reduce costs and improve customer service (e.g. Rosenfield *et al*, 1985; Back, 1985; Meyers, 1989).

It was in the 1990s that the concept of supply chain management emerged with businesses creating strategic alliances with manufacturers and outsourcing distribution activities to third-party contractors to ensure the efficient and effective flow of products to customers. The main goal was '*to deliver superior customer value at less cost to the supply chain as a whole*' (Christopher, 1998). In response, an extensive body of research was produced to examine the role of supply chain management in logistics (e.g. Bowersox, 1990; Christopher, 1992; Cooper *et al*, 1997), the development of third-party logistics (e.g. Ellram and Cooper, 1990; Murphy and Poist, 1998; Razzaque and Sheng, 1998; Berglund *et al*, 1999) and advances in simulation programming for logistics networks (e.g. Disney *et al*, 1997; Wilding, 1998). At the same time, major changes in market dynamics occurred with customers increasing their power by demanding greater variety of quality products at a low cost and through enhanced customer services (Vokurka and Lummus, 2000). This led to increased competition between rival businesses and a gradual globalisation of the market searching for high and cheap skills (Bhatnagar and Viswanathan, 2000). Consequently, the design of distribution approaches changed, with Hub-and-Spoke systems being widely used to deal with product flows from numerous origins and to many destinations (Lumsden *et al*, 1999). Several studies started examining the establishment of inter-modal transhipment centres (e.g. Konings, 1996; Whiteing and Edwards, 1996) with the aim to minimise the road use in city centres and support the frequent and rapid replenishment (just-in-time deliveries; Section 2.2.2.4) of goods that were selling well (e.g. Water-Fuller, 1995; Vokurka and Lummus, 2000).

During this period also, leading businesses started to recognise that the scope of logistics extended from traditional business functions that included products availability, cost reduction and customer service, to value-adding activities, such as quality controls and products testing (e.g. Braglia and Petroni, 2000), online shopping (e.g. Rao, 1999; Gurau *et al*, 2001), and product returns and waste collection practices (e.g. Rogers and Tibben-Lembke, 1998; Dowlatshahi, 2000; Fleischmann *et al*, 2000; Stock and Lambert, 2001). Although returns were an issue that had attracted the interest of the market for over fifty years, it was only in 1990s that it was recognised as a key component in the logistics function. Rooted in both the marketing and logistics disciplines (Mollenkopf *et al.*, 2007), the notion of returns was initially studied and approached as an accounting or production quality issue (Corsani, 1930; Ardemani, 1944; Onida 1951). In 1980's it became an issue related to sustainable development largely focused on consumer-level issues within the reverse channels for waste materials and packaging recycling (Stanton and Zikmund, 1971; Jahre, 1995). In the late 1980s and early 1990s, emerging green European policies increased the sensitivity about products at the end of their life, a trend seen by many as an opportunity for the transportation industry to present a more environmentally-friendly face. However this interest was more in terms of exploiting new markets such as recycling, recovery and re-use (Kopicki *et al*, 1993; Rodrigue *et al*, 2001).

The adoption of 'Green Laws' was initially introduced in Germany (Blumberg, 2004) as a measure against the solid waste pollution, raw materials scarcity (Ginter and Starling, 1978) and landfill saturation problems (Kroon and Vrijens, 1995). This movement grew substantially throughout the rest of Europe where legislation and national regulations were developed and clearly placed responsibility on producers to bear the costs of collection, sortation, treatment, recycling or recovery of returned products (Cherrett *et al*, 2007). Based on the wider environmental concept of the '*Polluter Pays Principle*', several pieces of European environmental legislation, such as the '*Landfill Directive [1999/31/ EC]*' and the '*Packaging and Packaging Waste Directive [94/62/EC]*' (Section 2.4.2.6), aimed to mitigate long-term health risks and effectively deal with waste by more sustainable means. Their aim was to put some 'bite and clout' into the concept of holding the manufacturer ultimately responsible (*Duty of Care*) for the disposal of waste materials (Bernon, 2005). The '*Landfill Directive*' banned certain types of waste from landfill, and imposed pre-treatment requirements to reduce the impact of waste that had to be landfilled and increase the amount of waste that had to be recycled, while the '*Packaging Directive*' required the reduction of packaging and the management of packaging waste by more sustainable means, such as recovery and recycling. Both were developed on the basis of the 'waste hierarchy', *reduce-reuse-recycle-recover-dispose*, that formed the cornerstone of waste minimisation strategies (Section 2.4.2.3).

Waste minimisation strategies focused on the reduction of raw materials and energy consumption during a product's lifecycle. Starting from the use of fewer raw materials in products manufacture, their concept encompassed the reduction of in-store stock and packaging volume, the minimisation of trips made to stores, the selection of less polluting transport modes, and the diminution of waste and pollution generation through efficient loading, scheduling and routing (Wu and Dunn, 1995). To further reduce materials used in manufacturing, the waste hierarchy suggested that products should be re-used through efficient refurbishment and repairs (Subramaniam *et al*, 2004). A considerable potential to reduce the amount of waste ending up in landfills lied into the re-use of product and transport packaging, in line with the '*Packaging Directive*' (Kroon and Vrijens, 1995). The first positive responses came from the industry, where companies such as *Johnson & Johnson*, and *Deere & Co* implemented successful reusable container programs (Rogers and Tibben-Lembke, 1998). For several other companies though (e.g. *Harley-Davidson*), such programs proved to be uneconomical in terms of handling, transporting and tracking of shipments (Wu and Dunn, 1995). In those cases, recyclable packaging was deemed more effective in reducing the environmental impact. Despite the apparent benefits of recycling (e.g. conservation of resources and reduction of waste dumped), several studies such as the one from Nagel (1997) on single-use or re-usable *Agfa* cameras, revealed that recycling required extra resources and the cost was not always justified. As a result, recycling became the last resort of sustainable reverse logistics, but only on a case by case basis and using proper cost estimates, one should actually determine which would be the most beneficial to the environment option (FEFCO, 2003).

In response to the changing and stricter regulatory environment in the 1990's, academic research focused on the planning and organisation of returns systems. Environmental concerns created markets for recycling, recovery and disposal and led to the development of a new logistics facet: reverse logistics (Rodrigue *et al*, 2001). The 'Reverse Logistics Executive Council' described reverse logistics as '*the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal*' (Rogers and Tibben-Lembke, 1998). Initially, the major concern was the optimisation of facility network planning and transportation routing for individual business operations, using mathematical models to determine the type, location and size of treatment and disposal facilities (e.g. Re Velle *et al*, 1991; Koo e*t al*, 1991; Stowers and Polekar, 1993; Nema and Gupta, 1999). Several studies were also carried out to investigate issues ranging from the establishment of consolidation and return centres, and the selection of transport modes (Wu and Dunn, 1995) to the way logistics managers were undertaking these functions (e.g. Muller, 1992). A considerable amount of research was centered around the '*Cradle-to-Grave*' approach of product management (e.g. Witt, 1986; Barry *et al*, 1993; Andel 1995) based on the concept of '*Closed-Loop Lifecycle*' of materials that was assuming that every element in the corporate value chain was involved in the minimisation of the firm's total environmental impact from start to finish of the supply chain and from beginning to end of the product life cycle. Wu and Dunn (1995) highlighted the importance of integrating environmental management in business activities, while others (e.g. Pohlen and Farris, 1992; Fleischmann *et al*, 1997; Carter and Ellram, 1998) examined how collection, separation, transitional processing and delivery functions could be integrated and contained within a typical reverse logistics channel.

Despite several attempts were made to find the balance between environmental factors and profitability (e.g. Thierry *et al*, 1995; Edwards and Whiteing, 1995), it became apparent in late 1990s that the logistics sector as a whole failed to take account of the direct environmental impacts of logistics activities (e.g. climate change, emissions, noise and vibration). Rodrigue *et al* (2001) identified a number of inconsistencies between the objectives of logistics at the time and sustainability (Table 2):

Table 2: The paradoxes of reverse logistics (source: Rodrigue *et al*, 2001).

Dimension	Outcomes	Paradox
Costs	Reduction of costs through improvement in packaging and reduction of wastes. Benefits are derived by the distributors.	Environmental costs are often externalised.
Time/Flexibility	Just-in-Time and Door-to-Door services provide flexible and efficient physical distribution systems.	Extended production, distribution and retailing structures consume more space and energy, and produce more emissions (CO2, NOx etc)
Network	Increasing system-wide efficiency of the distribution system through network changes (Hub-and Spoke structure)	Concentration of environmental impacts next to major hubs and along corridors.
Reliability	Reliable and on-time distribution of freight and passenger.	Modes used, trucking and air transportation are the least environmentally efficient.
Warehousing	Decreasing stock-holding reduces the needs for warehousing facilities.	Inventory shifted in part to contributing to congestion and space consumption.
E-commerce	Increased business opportunities and diversification of the supply chains.	Changes in physical distribution systems towards higher levels of energy consumption.

Environmental concerns gained ground in 2000s when logisticians first started assessing the environmental impacts that resulted from freight activities (e.g. Abukhader and Jönson, 2004; Handfield *et al,* 2005). An increasing number of 'life cycle assessment (LCA)' studies were carried out (e.g. Clift and Wright, 2000) with the aim to quantify the emissions produced during the full lifecycle of a product (Abukhader and Jönson, 2004). Several companies started to adopt *Green Supply Chain Management (GSCM)* initiatives (Zhu *et al*, 2008; Srivastava, 2007) by designing more environmentally friendly products, by using less polluting transport modes and by changing their network design to reduce the environmental impacts of their activities (Vachon and Klassen, 2006). The rapid development of GSCM increased the importance of sustainability for logistics and the consideration of the environmental externalities signalled a new trend in the field: green logistics (Skjøtt-Larsen, 2000).

2.1.2 Green Logistics – A Challenge for the 21st Century

Green logistics has a three-fold mission with a main objective: to reduce environmental externalities while achieving a sustainable balance between environmental, economic and social objectives (Green Logistics, 2010). Rodrigue *et al* (2009) defined green logistics as '*supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution and focus on material handling, waste management, packaging and transport*'. The scope of green logistics is very extensive and includes a set of objectives that aim to mitigate the broad range of issues and paradoxes currently challenging the logistics sector (e.g. Table 2).

2.2 Core Goods Deliveries in Urban Centres

Deliveries constitute the final leg of the forward flow of materials and information from consignor to consignee, potentially using a range of materials handling and movement functions across a variety of supply channels (Hughes *et al*., 1998). The real importance of forward logistics is to keep retail outlets adequately replenished with supplies (McKinnon, 1996a) while providing customers with superior service through increased product quality, low damage rates, on-time products delivery and order cycle time reliability (Bowersox and Closs, 1996). Stock (1998) named these attributes as the 'price of admission' to the competitive arena and concluded that when achieved, other factors, such as after-sales services and reverse logistics, become differentiators in the customer's purchase decision.

Stringent government regulations and increased environmental concerns have a major impact on the way goods are manufactured and distributed. Under the '*Extended Producer Responsibility*' concept, producers and manufacturers are assigned with responsibilities concerning the design of environmentally-friendly products and the sustainable and safe handling of end-of-life materials (Vandermerwe and Oliff, 1990; Thierry *et al,* 1995; Guide *et al*., 2000). Thus, a more holistic view to reduce material in the forward system and increase re-use and recycling is required (Beltran, 2002). This has increased the importance of 'closed-loop supply chains' that include both traditional forward and additional reverse logistics supply chain activities. Using the back-load capacity of delivery vehicles is a good incentive to add value to an often empty return journey and at the same time improve recycling performance, reduce vehicle visits and minimise costs (Freight Best Practice, 2005; Maynard and Cherrett, 2010).

2.2.1 Main Characteristics of Forward Logistics

Forward logistics is initiated as a result of firms planning, future sales forecasting and decision making. It is generally the movement of merchandise from one origin to many destinations (Fleischmann *et al*, 1997). Rushton *et al* (2010) identified a number of distribution channels which link manufacturers to retailers (Figure 2):

- *Direct*: Goods are delivered directly from the manufacturer to the retailer either using its own or third-party logistics provider (3PL)'s fleet (Type A).
- *Via Manufacturer's Depot*: Products are shipped to retailers via the manufacturer's own regional depot either using their own or 3PL's fleet (Type B).
- *Via Retailer's Depot*: Products are shipped to retailers depots (usually regional distribution centres) prior to being shipped to shops either using retailers own or 3PL's fleet (Type C).
- *Via a 3PL Provider's Depot*: 3PLs involved at any stage of the above distribution channels transport and often store products at their own depots prior to delivering them to shops (Type D).

- *Via Wholesaler's Depot*: Wholesalers act as intermediaries buying products in bulk at discounted prices and selling them on to small retailers. Deliveries are usually made using wholesalers own fleet (Type E).
- *Via Cash and Carry*: In this case retailers collect products themselves from a wholesaler's depot (Type F).

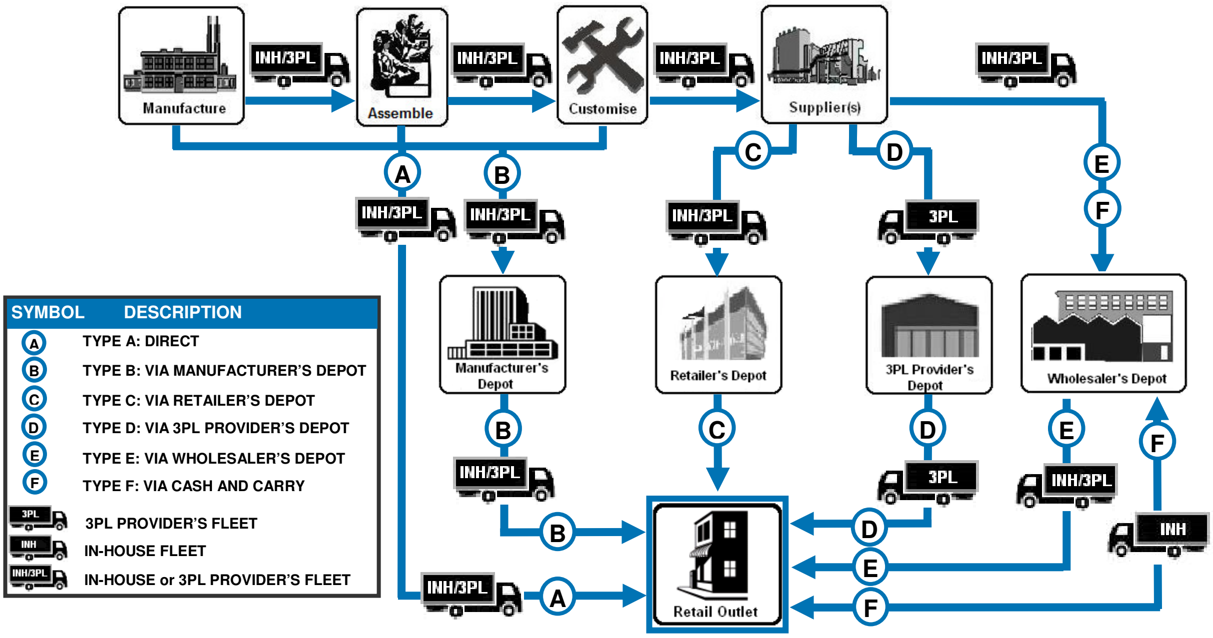


Figure 2: Physical network structures for distribution of core goods and service products in the supply chain.

A decision about the next destination (depot or retail outlet) of each item is usually made as soon as products are collected in manufacturers or suppliers depots. Distribution vehicles from a forward distribution centre may stop at multiple stores ('milk runs') usually in the same order (Tibben-Lembke and Rogers, 2002). New products are of uniform quality and come in complete packaging which protects them during transit and allows them to be handled easily (palletised, stacked, tracked and conveyed). Costs are well defined and well known and accounting systems are built to handle the comprehensive cost development for products as they move through the forward channel.

2.2.2 Factors Impacting Forward Logistics

A number of factors impact on the movement of goods and services in urban areas, the most critical of which can be regarded as the design of the distribution system, the type of premises serviced, the range and variety of the products used/sold and the time of deliveries to premises (Allen *et al*, 2000). In addition, the position of reverse logistics in the business agenda impacts on numerous logistical decisions throughout the supply chain such as facility location, raw materials sourcing and modal selection (Wu and Dunn, 1995).

2.2.2.1 Design of Distribution System

In accordance with Anderson (2000) the factor that is more likely to impact on the level of vehicle activity needed to service urban areas is the design of the distribution system. Urban distribution was categorised into three supply systems:

- *Centralised Supply System*: This system refers to commercial premises that receive all their goods from a single final point of dispatch.
- *De-centralised Supply System*: This system refers to commercial premises that receive goods from several or many final points of dispatch.
- *Hybrid Supply System*: This system refers to commercial premises that receive a significant proportion of their goods from one final point of dispatch and the rest of their goods from a number of different points of dispatch.

Many researchers have supported the theory that the centralisation of distribution systems can cause an increase in the total amount of transport work because of the long distances often separating central hubs from final recipients (Kohn and Brodin, 2007). More recent studies though (e.g. Allen *et al*, 2000) have suggested that the level of centralisation tends to generate fewer goods vehicle deliveries and collections due to the existing opportunities to improve consolidation of freight, shift in larger or more environmentally friendly transport modes and reduce the amount of emergency deliveries. In developing a centralised system, businesses need to consider the risk of affecting customer services in terms of delivery frequency and lead times, and having low control over the system flows due to unpredictable consumer demands and varying load requirements in different legs of the trip (Kohn and Brodin, 2007).

2.2.2.2 Push vs Pull Supply Chain Models

Current trends in retailing including globalisation of production activities, consolidation of retail, growth of retailers own label, multi-channel retail, larger store formats and information technology have resulted in the shift of the supply chain control from manufacturers to retailers.

- *Manufacturers/Suppliers-led (Push) Supply Chain Model*: This is a traditional distribution model (also known as built-to-inventory or built-to stock model) in which production and distribution decisions are made manually by manufacturers based on demand forecasts (Sun *et al*, 2010). Products are manufactured and supplied in pre-specified ways based on anticipated customer orders without considering actual end-consumer demand. The push supply chain model is mostly adopted by businesses receiving off-the-shelf, low cost and standardised products such as toys, school supplies, clothing and hygiene products (Coyle *et al*, 2008). In those cases, retailers receive bulk, cheaper, homogeneous and long-cycle time orders directly from the manufacturers/suppliers warehouses to ensure that the particular product will reach and fulfil the demand requirements of all customers. However, as this system is unable to meet dynamic market conditions such as slumps in demand caused by changing customer needs, seasonal weather and volatile financial conditions, it may result in unnecessary production of items, or inversely, fail to meet increased customer demand and raise revenues. Thus, the adoption of this model, dependent on the supply chain it is applied at, may lead in high inventory holding, warehousing and distribution costs.
- *Retailers-led (Pull) Supply Chain Model*: This is a highly dynamic and effective distribution model (also known as built-to-order or configured-to-order model) in which retailers have assumed greater control over manufacturers supply chains and hold the dominant position in logistics and distribution decisions (Sun *et al*, 2010). Products are manufactured and supplied under specific customer requests with the aim to optimise supply while minimising the inventory carrying. This model is mostly applied by large retailers with economies of scale when demand is volatile and when a high rate of product customisation is required e.g. in the IT high tech, the automotive and the high end luxury market industries. In those cases, a reduced level of stock is consolidated in large regional distribution centres controlled by the retailer, while manufacturers' warehouses are reduced both in number and size. Deliveries are smaller and more frequent, order cycles are

shorter and the logistics systems for products with different physical characteristics and shelf-lives are varying. A high level of supply chain visibility is required to avoid unneeded suppliers capacity, or inversely, excess inventories at stores (Shizhen, 2008). To coordinate effectively the upstream production quantities, retailers need to use extensively sophisticated IT systems to reduce unnecessary stock, optimise vehicle routing, save warehousing, inventory carrying and capital costs, and eliminate waste. Further cost reductions and cuts in the associated environmental impacts can be made through the use of smaller and greener delivery vehicles in urban areas, the increase of back-hauling practices and the establishment of cross-docking stations allowing the storage of minimum stock quantities. For this reason, many businesses nowadays outsource the operation of distribution centres and logistics services to 3PL providers having the expertise and the resources to provide shared, flexible and quality services at a low cost. In response, large logistics providers such as DHL (2012) have moved towards the establishment of consolidation platforms close to multi-retailer environments such as airports, high streets and shopping centres and provide reliable, secure and convenient fully-integrated logistics services tailored to the needs of individual customers.

- *Hybrid (Push-and-Pull) Supply Chain Model:* Controlling replenishment flows to the stores is also not a main distinction, as nearly all retailers use a mix of push and pull control (Chopra and Meindl, 2004). New assortments, own label goods and promotional products are often pushed, whereas the normal assortment is usually pulled to meet specific customer demands. Alternative configurations are often applied across a single logistics chain. Many stores have moved to point-to-sale information systems and barcode technologies to be more reactive on a customer order basis (Dawson, 2005). In segmented logistics chains, the last segment operating under such a pull mode may be preceded by a segment operating under a push mode, and vice versa (Klaas, 1998).

2.2.2.3 Number of Suppliers and Variety of Products Used/Sold

In recent years retail businesses offer a great diversity of products including general merchandise and many different unrelated products, often referred as ‘scrambled merchandise' (Dunne and Lusch, 2005). In addition, they receive a number of 'service products', essential for day-to-day operations (e.g. promotional items, packaging and cleaning products). The variety in product ranges implies a variety of suppliers and is normally expected in stores selling a wide variety of goods (e.g. supermarkets, department stores and other multi-stores). Many businesses use a wide base of suppliers for the same product to secure availability, and also increase their bargaining power over suppliers (Coe, 2004). On the other hand, several researchers such as Oxborrow (2000) and Christopher *et al* (2004) demonstrated examples of businesses in the apparel sector (e.g. *Marks & Spencer* and the *Aurora Group*) that are deliberately reducing the number of key suppliers with whom they deal with in order to attain economic security and stability, ensure traceability of products and speed of response, and receive high quality of value-added services such as quality assurances and process controls. To this add the fact that many apparel and food businesses now trade their own-label products sourced by a single or a limited base of suppliers/ manufacturers (Coe, 2004). On this basis, two main types of purchasing policies between retailers and suppliers were identified:

- *Single Sourcing*: In this model businesses use one supplier for a particular product or service to ensure enhanced services in terms of higher quality and a greater level of cooperation. This model is usually embraced by buyers who control a large share of the respective market (Coe, 2004). In the UK, a characteristic example is the *Aurora Group* that has eight apparel brands under its umbrella including *Coast*, *Warehouse*, *Karen Millen* and *Oasis*.
- *Multiple Sourcing*: In this case, businesses maintain contracts with a large base of suppliers of products or services. This model prevents reliance on any one supplier, creates bargaining power in order to drive down prices, ensures access to a wide variety of goods, improves access to information, but also entails more administration (Amihud, 1976; Homburg and Kuester, 2001).

The establishment of a single or a multiple sourcing model is also determined by the nature of products. Different products may have different shelf-lives and storage requirements; therefore they may be sourced by different suppliers and be replenished on a different frequency to enable business to hold an efficient inventory. Fresh foods, for example, may be ordered on a daily basis from one supplier, while longer life foods (e.g. chilled and frozen) may be ordered on a less frequent basis from one or more different suppliers (IGD and Business in the Community, 2003). In addition, several products (e.g. foods and medicines) are strictly regulated and have a fixed shelf time forcing retailers that handle products with different expiration dates to process separate collections (Weng and McClurg, 2001). Tibben-Lembke and Rogers (2002) stated that the range of reverse logistics issues facing a particular supply chain can be as diverse as the number of product ranges it holds. In combination with the rapid globalisation of business due to the transfer of many manufacturing activities in economically developing countries, this can result in high frequency of long-haul transportation increasing dramatically the total environmental impact (Van Hoek, 1999).

2.2.2.4 Time of Deliveries

Currently, the time at which product flows, and hence delivery work, take place is of importance to residents and policy authorities because of issues relating to increased traffic congestion, accessibility and noise. In addition deliveries timing is bound by the scheduling of production, warehousing and retailing operations and other working practices in the sector (McKinnon, 1999). Allen *et al* (2000) identified two factors determining the times at which delivery and collection work is carried out:

- *Time restrictions on vehicle activity*, and more specifically:
  - *On Loading/Unloading Activities*: It may include limited access to premises with no off-street loading/parking bays and limited access-time on street loading areas.
  - *On Vehicle's Performance:* It mainly relates to drivers performance and refers to maximum continuous drive time allowances. Under the '*Drivers Hours Regulations [561/2006/EC]*' the persons performing road transport can work up to 9 hours daily with a minimum rest period of 45 minutes and non-stop driving not exceeding 4.5 hours, and 56 hours weekly with a minimum rest period of 45 consecutive hours.
- *Time windows during which premises can accept vehicle deliveries and collections*, and more specifically:
  - *When Shop Staff Are Present*: This depends on the times staff members are on duty and available to receive deliveries.

- *When Shop Staff are Absent*: Deliveries can take place when the driver has access (keys or codes) to the premises or can drop products in a secure place near the premises, on street or at back door. *ByBox* (www.bybox.com), for example, is a company offering smart locker-bank unattended delivery services for the express parts delivery market.

In light of the current proliferation of products, as discussed in Section 2.2.2.3, many retailers adopt strategies of demanding small initial orders supported by frequent and rapid replenishment of goods that sell well. The adoption of 'Just-In-Time (JIT)' and 'Quick Response (QR)' deliveries aims to reduce inventory by sourcing products in small quantities at frequent intervals and satisfy unpredictable consumer demand, while reducing costs and risks of retail stock holding such as increased unsold products, returns, packaging and waste (Van Hoek, 1999; Lehtonen, 2008).

Through a review of previous studies, Lehtonen (2008) demonstrated a level of uncertainty about the net impact of JIT systems. He referred to the works of Whitelegg (1995) that suggested that JIT deliveries would tend to lower load factors and generate more traffic and empty-running, and the works of Rodrigue *et al* (2001) that indicated potential increases in the radius of sourcing. He contested their assumptions by referring to arguments brought by McKinnon and Marchant (1999) who supported that JIT systems can reduce the traffic volumes as the actual load payload weights during the same period (1985-1995) increased. He highlighted to this the contribution of structural changes in logistics systems (e.g. consolidation and centralisation of distribution services). He suggested that retailers should transport goods to a single distribution centre prior to cross-shipping them to other centres, use the back-load capacity of delivery vehicles for collections and employ 3PLs offering upstream consolidation services to increase the net impact of JIT systems. Oxborrow (2000) suggested that a single sourcing regime would offer further opportunities to achieve higher consolidation of products and therefore reduce the overall number of deliveries. This trend has been particularly prevalent in the automotive industry (Lehtonen, 2008).

Woxenius (2006) highlighted the role of timing in three current trends in distribution networks. First, distribution efficiencies have been enhanced in terms of speed as a result of technological developments in materials handling such as ready-to-shelf packaging and use of information technology like RDIF (Radio Frequency Identification) systems (Fernie *et al*, 2000). As a result, the demand of customers for faster and timelier deliveries has increased (Lehtonen, 2008). Second, competition pressures have increased the need for more frequent deliveries through a shift of logistics operations from inventory-based to replenishment-based logistics (JIT and QR deliveries). Finally, emerging trends in planning and coordination of distribution systems have increased demand on accuracy and have narrowed time-windows within which goods have to be delivered. Especially in the case of short-distance transport, timing is far more important variable than speed (Woxenius, 2006).

Beullens *et al* (2004) discussed how timing of deliveries can be impacted by reverse logistics activities. In contrast with forward logistics, typical reverse logistics are not bound by narrow time windows and therefore the overall time pressure is low, unless collections refer to time-sensitive products such as electronics sent for repair (Guide *et al,* 2006). McKinnon and Edwards (2010) stressed the need for logistics providers and store managers to have confidence in the scheduling in order to process back-loads, as there may be upper bounds on the total time a vehicle can be deployed and enter an loading/unloading area. Further delays may be caused as a result of regulatory and operational constraints such as restrictions in mixing certain new and end-of-life products and the potential need for on-board load re-arrangements. Beullens *et al* (2004) suggested that whenever possible back-hauling, in which deliveries would precede the collection of old products or waste, should be used as an alternative to ensure that businesses are serviced within a specified time interval.

2.2.2.5 Types of Premises Serviced

Ambrosini and Routhier (2004) concluded that the types of activity and current trends on the size of retail premises can impact on the number of deliveries. The rapid growth of big chains expanding their retail activities into a wide range of merchandise has resulted in the increase of out-of-town super-centres and urban shopping centres. More modern integrated retail structures such as shopping centres offer better accommodation for retailers in terms of services (e.g. central waste management operations) and physical layout (e.g. storage rooms, service bays, offices). On the other hand, several businesses (e.g. grocery stores) have been shrinking in both size and range of merchandise to cope with the current economic pressures and increase convenience at a local level (Dunne and Lusch, 2005). The actual site layout and the storage arrangements can impact on the volume and the frequency of products delivered (Agapiou *et al*, 1998). The logistics concept requires accurate scheduling of materials to match the optimum storage capacity. In situations where storage capacities are small and usage rates are high, businesses require smaller and more frequent deliveries and collections of products and waste. This can lead to an increase in the level of less-than-load and JIT deliveries and emergency collections, and potentially result in a shift in the transport mode used. To this end, Cherrett *et al* (2002) indicated the prevalence of light vans delivering to smaller town centre premises and larger vehicles delivering to larger establishments.

2.2.2.6 Vehicle Types and Capacities

According to the latest freight statistics report released by the UK Department of Transport (DfT, 2010a), the profile of the UK road freight traffic has changed significantly during the period 1999-2009. Statistics for HGVs were derived from the 2009 '*Continuing Survey of Road Goods Transport (CSRGT)'* (DfT, 2010c). The *CSRGT* surveys are made on an ongoing basis and collect data about one week's activity from each rigid and artic HGV vehicle on the sample. The 2009 survey recorded a significant decrease in the activity of HGVs, with the amount of goods lifted and the amount of freight moved being 9% and 12% lower than 1999 figures, respectively. Instead, the average length of haul increased by 19% to 93 kilometres (58 miles) for all HGVs since 1989; and more specifically to 122 kilometres (76 miles) for articulated lorries and 52 kilometres (32 miles) for rigid lorries, while the average tonne-kilometre figure remaining relatively static. These changes were more radical between 2008 and 2009. As of 2009, there were 415,000 HGVs over 3.5 tonnes accounting for 90% of all freight moved by road.

Van statistics were derived from the latest (2008) '*Van Activity Baseline Survey for England*' (DfT, 2010c). Unlike the *CSRGT* survey of lorries over 3.5 tonnes, the *'Van Activity Survey*' is only conducted occasionally (in 1992-3, 1998, 2004 and 2008) and is not confined to vans carrying freight. In accordance with McKinnon (2007b), only 35% of the distance travelled in 2004 by company-owned vans, involved the collection and/or delivery of goods or related empty-running. The 2008 survey recorded a significant increase (38%) in the vans population between 1999 and 2009, which as of 2009 exceeded 3.2 million. This was followed by an increase in van traffic by 29% to 66.6 billion vehicle kilometers. A further DfT survey, the '*2009 Low Carbon Vans Survey*', recorded 18,262 low carbon vans in the UK with a gross vehicle weight of 7.5 tonnes and below (DfT, 2009). The study identified that the population of low carbon vans had remained fairly static since 2004, while as of 2008 they made up 0.5% of the national van fleet.

Today, most logistics businesses use non-homogeneous vehicle fleets with different capacities and operating characteristics such as average speeds of travel and service times at unloading points (Sbihi and Eglese, 2007). The selection of a specific vehicle type for deliveries or collections (e.g. articulated or rigid lorry or van) is determined by a number of variants. Different kinds of products may demand different types of vehicles due to specific handling requirements. For example, frozen foods need refrigeration, some clothes need to be hung, and many delivery companies who do local parcel pick-ups and drop-offs use cargo vans and walk-in-lorries (IPL, 2011). Two studies, one in Winchester (Cherrett *et al*, 2002; Cherrett and Smyth, 2003) and another one in the Netherlands (OECD, 2003), linked the usage of different vehicle modes with different types of businesses. Both revealed that articulated lorries were used more by manufacturing and warehousing businesses, while vans were predominantly used by the services sector and rigid lorries by the vast majority of retail businesses. In another freight study in Norwich/London, Allen *et al* (2000) noted a great variation in vehicle types and sizes in independent businesses receiving a large number of relatively small consignments sourced by many different suppliers. A study in Colchester (Steer Davies Gleave, 2005) examined the relationship between vehicle types and number of deliveries and revealed the use of larger lorries (articulated) by businesses receiving a high number (>40 a week) of deliveries.

The selection of specific vehicle types and sizes can also be determined by specific regulations and policies in place. The most characteristic example is the current debate over the replacement of 7,000 UK registered double-decked lorries by standard four metres trailers as part of a potentially upcoming EC policy, the '*Whole Vehicle Type Approval for Lorries*' (McKinnon, 2010). In the last few years, many companies (e.g. *John Lewis*, *Boots*, *B&Q*) have taken advantage of the lack of any restriction on the UK vehicles height and have commissioned double-decked fleets usually 4.9 metres in height, to enable consolidation of massive loads and cut down carbon emissions. McKinnon (2010) researched the additional economic and environmental costs that would result from this shift and estimated that the removal of double-decked lorries from UK roads would increase the distance travelled by articulated lorries by 4.5% and the annual haulage costs by £305 million. This would increase CO_2 emissions and fuel consumption by a mid-range estimate of 64%. On the other hand, Allen *et al* (2000) observed a shift towards the use of smaller vehicles (vans or cars) due to weight restrictions and narrow road widths in Norwich's City Centre. They also observed that the amount of work a driver could perform in a day was restricted by the '*Drivers Hours Regulations*' (Section 2.2.2.4) setting a maximum level on the volume of goods that could be handled (loaded/unloaded) per trip. In turn, this was affecting the vehicle size selected for use.

2.2.2.7 Vehicle Fill Rates and Empty-Running

A challenge for the logistics sector is the high rates of empty-running (proportion of vehicles per kilometre that run empty). McKinnon and Campbell (1997) noted a reduction in the average density of loads due to changes in the nature of products, increases in the amount of packaging material used, rises in the usage of unitised handling equipment and a decline in the height to which products are stacked. These trends have pressed the logistics sector to reduce the rates of empty-running in the UK (Table 3); however a slight increase was noted during the last decade: from 32.6% in 1980, to 26.9% in 2000, 27.4% in 2005 and 28.3% in 2009 (DfT, 2010c). As of 2009, rigid lorries presented the highest level of empty-running (28.9%) contrary to articulated lorries (27.6%). In a *Freight Best Practice* project survey of 22 UK fleets of non food retail distribution companies including *Argos*, *B&Q*, *Comet*, *House of Fraser* and *Woolworths* (DfT, 2003), vehicle fill for HGVs was measured against the vehicle capacity by weight (average: 54%, range: 18.7-80.9%), volume (average: 51%, range: 22.6-88.6%) and number of unit loads (average: 74%, range: 57.5-91.7%). According to the latest DfT study (2010c) the average weight utilisation has increased up to 52% for rigid lorries, 60% for articulated lorries, 58% for all HGVs and 40.3% for all LGVs (Chapter 5, Tables 14 and 16).

Table 3: Annual UK lading factors and percentage of empty-running by vehicle type. (DfT, 2010c).

Vehicle Type	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	% Empty-Running (Proportion of vehicles/km that run empty)										
Vans	10-15 (DfT's estimation)										
Rigid	27.5	27.3	27.2	27.6	27.9	27.7	28.4	27.5	28.4	29.0	28.9
Articulated	26.8	26.4	25.5	25.3	25.2	25.8	26.5	26.1	26.4	28.7	27.6
All HGVs	27.2	26.9	26.4	26.5	26.5	26.8	27.4	26.8	27.4	28.9	28.3
	Lading Factor (Ratio of actual goods moved to max tonne/km achieved)										
Vans	N/A										
Rigid	0.54	0.54	0.52	0.53	0.52	0.52	0.53	0.53	0.53	0.52	0.50
Articulated	0.62	0.63	0.62	0.60	0.58	0.59	0.58	0.58	0.59	0.60	0.60
All HGVs	0.60	0.60	0.59	0.58	0.57	0.57	0.57	0.56	0.57	0.58	0.57

The general decline in the level of empty-running in the UK has been attributed to an increase on the number of opportunities available for carriers to find return loads and the desire of the distribution industry to save money by improving vehicle utilisation. It is also supported by a series of additional changes within the road distribution market, including outsourcing of road haulage operations, increase in average length of haul, change in trip structure (more multiple collections and drops), greater balance of inter-regional flows, the introduction of new management initiatives such as supplier collection, factory gate pricing and network systems, and new improved communication tools such as online platforms for freight or auction-based trade exchanges (Freight Best Practice, 2005). McKinnon (2003) also highlighted the role of the liberalisation of road haulage operations that granted operators freedom to collect return loads. Coupled to the current growth in the return volume of reusable packaging, packaging waste and handling equipment there are increased opportunities to better utilise the available back-load capacity of delivery vehicles.

The rates of empty-running can be further reduced however they cannot be zeroed due to a wide range of factors. The most important is that freight consignments generally move in one direction (from point of production to point of consumption). As a result return vehicles are empty, unless back-loads for legs of the return trip are found (McKinnon and Ge, 2006). The Freight Best Practice study (DfT, 2003) stressed the need for companies to '*strike a fine balance to ensure intermediate and final legs are better utilised while still ensuring the fleet's primary role i.e. delivery, is protected* *and optimised*'. Beilock and Kilmer (1986), and McKinnon (1996b) observed a close direct correlation between the trip length and the probability of a truck being loaded. Mason and Lalwani (2006) also emphasised the pressure put on vehicle fill rates due to JIT deliveries and QR practices. McKinnon (2007a) and McKinnon and Edwards (2010) identified a number of constraints that set specific limits on the volume of returns and waste a delivery vehicle can back-load:

- *Market Constraints*: Spatial pattern of trade and fluctuations on freight flows.
- *Regulatory Constraints*: Vehicles size, weight and loading/unloading, timing of deliveries, and health and safety.
- *Inter-Functional Constraints*: Conflicts in transport operations of different departments within the same business.
- *Infrastructural Constraints*: Physical capacity of transport networks and storage capacity of origin-destination points.
- *Equipment-Related Constraints*: Incompatibility of vehicles, handling equipment, and loads.

In order to retain transport efficiencies when businesses are replenished continuously with small quantities of products, Mason and Lalwani (2006) suggested that the above constraints could be mitigated through the introduction of consolidation centres, the deployment of milk-run operations and the provision of joint deliveries and collections among rival businesses. Jones *et al* (1997) suggested that consolidation centres should be sited near suppliers to reduce the distance travelled by lightly loaded vehicles and increase the trunking leg length to the customer where full vehicle loading can be achieved in consolidation centres.

2.2.3 From Forward to Reverse Logistics

Traditionally, most companies operate supply chains that principally have only one gear – forward (Elliot and Wright, 2004). Logistics in terms of moving products from one origin to many destinations has been the business priority for many years (Rogers and Tibben-Lembke, 2002). For most companies, success in business has been gauged upon being able to successfully produce, distribute and sell products, whilst improving vehicle utilisation and minimising the impacts on traffic congestion. Many firms have also focused their efforts on improving supplier quality through the implementation of formal quality assurance procedures to achieve improved product quality without increased costs (Carter and Ellram, 1994). While it is clear that most companies now recognise the importance of putting in place a proactive strategy for forward logistics, it is also clear that many are still unaware of the need to take a similar stance with regard to reverse logistics. Reverse logistics and recycling remained for years outside the core areas of competence of manufacturers and retailers as they were dissuaded from adopting such processes due to operational and financial difficulties (Elliot and Wright, 2004). Often due to different priorities and lack of awareness regarding the benefits in handling returns, reverse logistics has been viewed as an inconvenience rather than an opportunity (Chan and Chan, 2008; Gardner, 2005).

The introduction of stringent environmental legislation, on one hand, and the increasing streams of unsold products, product returns, packaging materials and waste, on the other, have put pressure on businesses to make arrangements for the efficient flow of those materials in the reverse channel, while creating or recapturing value (Rogers and Tibben-Lembke, 2001). Both economic motives including the recovery of the value still incorporated in the used product, and environmental motives including the reduction of solid waste pollution (Ginter and Starling, 1978), landfill saturation (Kroon and Vrijens, 1995) and the maximisation of the use of scarce raw materials (Ginter and Starling, 1978) are critical issues for specific industries such as the auto parts, the magazine and book publishing and the catalogue industry that experience high volumes of returns (Section 2.3.1, Beltran, 2002). Also, in fast-moving industries, such as small high-tech manufacturing firms, reverse logistics attributes such as reduced cycle time of customer transactions, replacement of returned products and increased convenience of making returns, can be key differentiators in the customer's purchase decision (Campbell and Fisher, 2001).

In the retail sector the reverse logistics chain starts with the customer, the producer being the last link (Gonzales-Torre *et al*, 2004). Retailers use reverse logistics processes to clean-out other obsolete or slow-moving inventories, packaging materials and waste, to prevent them from occupying valuable retail space so customers can purchase newer goods (Andel, 1997). In the success of planning, implementing and controlling the backward flow of products, it is important that retailers communicate with consumers (Pohlen and Farris, 1992) and make appropriate arrangements with suppliers to help them identify their strategic priorities, increase their competitive advantage and gain a strategic edge (Rogers and Tibben-Lembke, 1998).

2.3 Reverse Logistics and Product Returns

New supply chain trends including shortened product life cycles, generous return policies and greater product availability coupled to the development of new channels such as e-commerce result in increased unsold products, customer returns and packaging materials passing back up the supply chain (Moise, 2008). Marketing strategies and policy decisions can have a significant impact on the type and timing of product returns, which can influence the nature and extent of reverse logistics activities a firm would have to undertake (Mollenkopf *et al*, 2007). Planning, managing and controlling the reverse flow of products is a complex procedure for retail businesses because firms have to respond to irregular return flows initiated by consumers or downstream members and therefore develop reactive systems with much less visibility (Subramaniam *et al*, 2004; Rogers and Tibben-Lembke, 2002).

2.3.1 Product Returns in the UK

Returns of goods appear virtually in all sorts of industry, but for some sectors their levels are significantly high (De Brito and Dekker, 2004). In a DfT study on UK product returns and the associated logistics costs (DfT, 2004a), it was found that most of the surveyed organisations reported returns of 1-5%, with those facing the highest returns rates being the catalogue retailing and internet shopping sector (30%), the books market (10-20%) and the music and entertainments industry (10%). At that time (2002), annual UK sales amounted to £230.5 billion which equated to £5.75 billion of returned goods, if a middle figure of 2.5% for returns was considered (Bernon and Cullen, 2004; Bernon and Cullen, 2007). As of 2010, total annual UK sales amounted to £292.4 (ONS 2011a) which equated to £14.62 billion of returned goods, if a 5% figure for returns was applied to allow for potential increases due to the growth of online shopping. Bernon and Cullen (2004; 2007) estimated that the monetary magnitude of logistics associated with handling returns accounted for around 5% of total logistics costs. They suggested that an integrated supply chain approach for the management of returns would give the opportunity to companies to cut down their logistics costs in the order of 20-40%.

2.3.2 The Drivers of Product Returns

Flows in the reverse channel can be driven by a series of legislative, economic and social factors.

2.3.2.1 Legislation

There are several pieces of legislation impacting the retail sector and require the more efficient management of take-back schemes. In Europe, the most important regulations in this body of legislation are based on the '*Extended Producer Responsibility*' concept which aims to promote the integration of environmental costs of the full life cycle of goods into their market price (OECD, 2001; Section 2.3.2.3), and include the EC Directives on '*Packaging and Packaging Waste [94/62/EC]*' and the *'Waste Electrical and Electronic Equipment (WEEE) [2002/96/EC]*'. The former aims to reduce packaging and manage waste by more sustainable means, while the latter is based on the wider environmental concept of the '*Polluter Pays Principle*' which requires that the costs of pollution be borne by those who cause it, by encouraging retailers to separately collect and take all appropriate steps for the treatment, re-use, recovery, recycling and environmentally sound disposal with the aim to reduce the overall amount of electronic waste ending up in landfills. In addition, the '*Distance Selling Directive [97/7/EC]*' includes a general right to return purchases made at a distance (e.g. by phone, fax, mail order) seven working days following the delivery of the products (DTI, 2005). Existing and ongoing amendments in the regulatory frame exert pressures on retailers to develop customer take-back schemes at stores and make appropriate arrangements for the efficient collection and disposal of those materials.

2.3.2.2 Cost Pressures

Many companies are dissuaded from adopting reverse logistics processes because they are not able to overcome the financial implications (Beullens, 2004). One of the main reasons to this is that the costs of checking, sorting, batching, processing and disposing returned items are incurred before the retailer achieves any monetary gains from the recovery of products (Rogers and Tibben-Lembke, 2001). Therefore returns can turn into a salient issue that impacts the liquidity and financial management of firms, and creates ramifications for the availability of and demand for cash (Horvath *et al*, 2004). On the other hand though, retailers opting to send returned products back to manufacturers have more chances to get a generous refund and recapture lost value (Shulman *et al*, 2010). By returning products for recycling, recovery or re-use businesses can also save money by not paying the *Landfill Tax* which from April 2011 increased from 8£ to £56 a tonne (LetsRecycle, 2011).

2.3.2.3 Social Concerns

'*Extended Responsibility*' concerns a set of values or principles that drive organisations towards more environmentally friendly and charity conscious engagements. Being proactive towards environmental issues and enhancing a charity reputation has now become an important marketing tool that can improve customer relations. Andersen and Skjøtt-Larsen (2009) discussed about the role of '*corporate social responsibility (CSR)*' in global supply chains in reference to the environmental and labour practices of multi-national companies and their trading partners (suppliers, 3PL providers and intermediaries). Using *IKEA* as a case study, they highlighted the pressures placed by the media towards the adoption of ethical practices and the development of codes of conduct for businesses and their global partners. Other studies (e.g. Enquist *et al*, 2007; Kumar, 2008) presented various corporate charity programs set by businesses (*IKEA*, *H&M*, *Body Shop*, *Starbucks*; and supermarkets accordingly) with the aim to promote philanthropic and green values, and benefit from potential tax exemptions or reductions, while reducing inventory handling and reverse logistics processing, transportation and costs.

2.3.2.4 E-commerce

E-commerce has presented a rapid development in the last decade due to advances in network technologies and the opportunity given to consumers to shop from the convenience of their own homes while enjoying a wealth of product discounts and cash back rewards. According to the latest *Verdict Research* annual report on e-retail, online sales will keep on growing and in 2011 the monthly market value of e-retail will be £28 billion (Verdict Research, 2010). National statistics on the share of online sales output in total market sales corroborated these findings and recorded an annual increase from 3% in January 2007, to 4.8% in January 2008, 6.6% in January 2009, 7.6% in January 2010 and 9.8% in March 2011 (ONS, 2011). Rigby (2010) remarked that although these figures may well reflect a rise in inflation rather than a pure rise in the quantity of goods sold, they still display a significant growth of e-sales. Inevitably, the increase in e-sales has knock-on effects on the volume of returns, which in turn escalate and can lead to a rise in the relevant costs even in excess of 30% of sales levels (DfT, 2004a). In a research run from *Stockshifters.com* in May 2010, it was found that increases in online sales have induced a 22% increase in the percentage of returns (Supply Chain Standard, 2010). These trends are underpinned by the provisions of the '*Directive on Distance Contract [97/7/EC]*' transposed into UK law by the '*Consumer Protection (Distance Selling) Regulation 2000 [S.I. 2000/2334]*' which stipulates that anyone buying through the internet can return goods should they change their mind without providing any explanation up to seven days after the goods are received.

According to the *Verdict Research* report, average annual growth of e-sales between 2009 and 2010 was equal to 14% mainly due to sales rises in the clothing sector. Accessories, electrical goods, gifts and health products performed less well, but peaked in November and December. A particular growth on sales (13%) was observed in multi-channel retailers in contrast to online only retailers who faced a 7.6% fall. This highlighted the value consumers place on high-street retailers with regards to returning products bought from the internet due to trust issues, safety of transactions and availability of return and exchange options offered at stores (Verdict Research, 2010). A study run by *MultiChannel*, a UK e-commerce solutions provider, presented three types of e-retailers when it comes to returns: those that actively try and make returns difficult for the customer, the ones who keep relatively quiet about returns, but once the customer puts the wheels in motion they are very efficient, and finally those that actively promote their returns policy to attract new customers (MultiChannel Merchant, 2007). Today, many businesses provide customers with prepaid postage labels to encourage exchanges rather than returns and have developed collection mechanisms either through partnerships with 3PL providers or the provision of collection services in local retail outlets, as a tool to encourage customers to buy.

2.3.3 Types of Product Returns

Murphy (1986) identified three main types of initiatives generating reverse flows: from customers who return the goods because they do not meet minimum statutory requirements, from industry interested in recycling/re-using obsolete, over-stocked, out of season, after sales or unwanted stock in order to recover value from a service failure (DfT, 2004a) and finally from government, which through a set of legislative instruments aims to promote the reintegration of used products into productive processes in order to close their life cycle and reduce their impact on the environment (Gonzalez-Torre *et al*, 2004). In addition, many companies occasionally deal with emergency recalls of products (e.g. cars, toys, drugs and electronics, Section 2.3.3.5) that violate certain safety criteria and can pose a danger to consumers (Chu *et al*, 2005).

2.3.3.1 Customer Returns

Customers usually return products to stores because items are damaged, do not meet their expectations or have reached the end of their lives and need disposal (Smith, 2005). The rights of consumers with regards to product returns are protected by the '*Sale of Goods Act [1994, c.35]*' under which retailers are obligated to sell goods that match the description provided, are fit for their purpose and are of satisfactory quality. If goods do not meet these criteria, customers may claim for a refund within a reasonable period of time in line with the return policy of each product. In addition, retailers are liable for any faults that develop within the first 6 months following the product's purchase and must offer customers compensation in the sort of refund, repair or replacement. In England, consumers have up to six years to claim for compensation (Scotland: 5 years), but after the first six months the onus of proof that goods were faulty when sold is on them (Business Link, 2011).

Convenient return policies and processes may influence the purchasing decisions of customers and impact on the sales and the return volumes. Increased competition and marketing drives have pushed companies to implement more liberal return policies to attract consumers. Different product types may be covered by different refund or exchange policies with the aim to enhance consumer confidence and promote sales. Triantafyllou and Cherrett (2009) demonstrated differences among the return policies of food products (liberal returns), footwear, clothing and jewellery (specific return periods - usually 30 days), electronics (strict return or exchange policies unless covered by manufacturer's or additionally purchased warranty), and cosmetics, underwear and pierced earrings (exempt from returns policies due to hygiene reasons).

Returned products must be generally in new and re-saleable condition, unopened, with all original packaging material and accompanied by a receipt of purchase. Upon receipt of products at stores, retailers may also collect data and information on the product, run a preliminary check to assess its quality and decide whether to move it in the next step in the return process: resell, return to vendor or supplier, transfer to other stores, or sell in secondary markets (Figure 3). Preliminary and main ‘gate-keeping’ functions (products checks) can play an important role in assessing the suitability of a product for re-sale, repair, re-manufacture or cannibalisation, and managing the movement of returned products (Triantafyllou and Cherrett, 2010). The location of gate-keeping operations in the supply chain (Figure 3) is crucial in reducing transport impacts. Damaged, seasonal and overstock products and items with no packaging are usually sent back to suppliers via return or distribution centres where main gate-keeping operations take place (Smith, 2005). Rogers and Tibben-Lembke (1998) argued that short disposition cycle times related to return product decisions are critical to reverse logistics management, movement and processing. Delays in the passage of products through the various treatment processes to reach their final re-use, remanufacture or disposition point reduce the likelihood of economically viable re-use options and increase the probability of items entering the waste stream.

2.3.3.2 Overstock

Businesses remove old or slow-moving stock and replace it with newer, more desirable products to help promote sales (DfT, 2004a). Unused, obsolete, end-of-line, end-of-season, discontinued and un-saleable merchandise is the bane of all retail firms. Overstock can restrict cash flow, occupy valuable retail space and increase the risk of damage and theft. Sale remainders are often recalled or finally dumped (Subramaniam *et al*, 2004). Whether overstock will be returned to manufacturers and whether manufacturers will offer partial or full refunds is a matter that depends on the trading terms between manufacturers and retailers (Shulman *et al*, 2010). A manufacturer’s decision to take back returns depends on the marginal cost of production, the relative advantage in disposing unsold inventory and the scope to re-allocate products, among others (Kandel, 1996; Padmanabham and Png, 2004). ‘No fault found’ returns are usually linked to liberal return policies and may be taken back to grade A’ for re-sale stream, or sold at a significantly reduced price to jobbers or secondary markets if quality checks and repackaging required for the re-integration of products in the original supply chain prove uneconomical (DfT, 2004a). Browne *et al* (2005a) suggested that the use of consolidation centres for returns, inter-store transfers and stock-holding activities can optimise B2B (business-to-business) and B2C (business-to-customer) services and reduce the overall transport footprint.

2.3.3.3 Product Repairs

Under the '*Sale of Goods Act*', retailers are liable for any product faults developed in the first six months of purchase. In response, they are obligated to provide refund, replacement or repair services for defective goods. Repairs require the provision of after-sales services and the set-up of service networks especially in the case of consumer durable goods such as electronics (Wu and Dunn, 1995). Service networks are characterised by low visibility on service demand and increased requirements for storage space, special equipment and specialised staff to run gate-keeping and repair processes. Dependent on the location of gate-keeping and repair operations, lead-time for product repairs and the associated costs may increase significantly. McCollough (2009) suggested that as repair prices increase, the less attractive repairs become. This puts a challenge for reverse logistics systems to handle returned products as quickly and cost-efficiently as possible (Banomyong *et al,* 2008). Of particular importance is also the development of linkages with recycling or re-use markets for materials passing back up the supply chain (Stock, 1992).

2.3.3.4 Packaging

Except for customer returns, overstock, faulty items and end-of-life products (Section 2.4), the return flow can also include packaging materials (Kleindorfer *et al*, 2005). Packaging includes all materials used to contain, protect, handle, deliver or present products and can be returnable (e.g. pallets, roll cages, plastic boxes and trays) or single-trip (e.g. cardboard boxes, polythene materials and sacks). Lee and Lye, (2002) classified packaging into three main categories: 'primary packaging' which usually contains no returnable materials and is used to envelop products and hold them (e.g. polythene wrapping material and cardboard boxes), 'secondary packaging' which may include returnable or no returnable materials and is used to group primary packages together (e.g. cardboard and plastic boxes), and 'tertiary or transport packaging' which is normally returnable and is used for bulk handling, warehouse storage and transport shipping (e.g. pallets and roll cages).

The UK retail sector is a major consumer of packaging materials; as of 2009, more than 5.5 million tonnes of packaging waste came from commercial and industrial sources (DEFRA, 2011). The recovery rate increased from 34% in 1999 to 66.7% in 2009 (recycling 62% and energy from waste 4%) exceeding the 60% (55% for recycling) threshold set by the '*Packaging and Packaging Waste Directive [94/62/EC]*'. Paper accounted for 47% of total recycled packaging, glass for 25%, plastics for 9%, wood for 12%, steel for 6% and aluminium for 1%. The 2011-2012 strategy aims to attain even higher recycling rates (Table 4).

Table 4: UK recycling and recovery targets and achieved recovery rates for packaging waste. (DEFRA, 2010).

Packaging Type	% Packaging Total UK Recovery Target and Achieved Rates						
	2002	2008		2009		2010	2011-2012
	Achieved	Target	Achieved	Target	Achieved	Target	Target
Paper	59	67.5	79.8	68.5	83.9	69.5	69.5
Glass	34	78.0	61.3	80.0	61.7	81	81
Aluminium	22.1	35.0	34.6	38.0	41.3	40	40
Steel	42	68.0	61.7	68.5	57.8	69	71
Plastic	20	26.0	23.7	27.0	24.1	29	32
Wood	54	20.5	78.5	21.0	76.9	22	22
Recycling	**44.5**	**66.2**	**67**	**67**	**61.8**	**68**	**68**
Total Recovery	**50.4**	**72**	**65.7**	**73**	**66.7**	**74**	**74**

Many studies (e.g. Lockamy, 1995; Klevas, 2005; Hellstrom, 2007) have discussed the impact of the design of packaging on the logistics and environmental performance of supply chains. Packaging specifications influence the time required to package a product and therefore impact on the products lead time and due date performance (Hellstrom and Saghir, 2007). Reusable packaging presents reduced environmental impacts against single-trip packaging as it can make more trips in its lifetime and can considerably reduce the cube utilisation in the return trip if it is properly designed (e.g. fold or nest). On the other hand, longer journey distances tend to favour single-trip materials enabling the usage of the back-load vehicle capacity for further en-route deliveries and collections. In addition, the number of packaging items needed to maintain a re-usable packaging system is significantly high when considering the extra items required to allow for the time taken for return processes, cleaning, seasonal fluctuations in the volume of goods, damages and losses in the system (WRAP, 2010). Tsouflas and Pappis (2006) highlighted the importance of setting a policy in regards to the recovery of used products and the potential mileage savings gained through the co-location of return and distribution centres.

2.3.3.5 Product Recalls

Product recalls is another area which may result in the increase of the level of returns a firm has to manage. Recalls occur for a number of reasons: insufficient due diligence on product development processes (White and Pomponi, 2003), poor quality control processes, inadequate infrastructure (Teratanavat *et al*, 2005), and doubtful quality of goods produced in low-cost manufacturing countries (Delios *et al*, 2008; Teagarden and Hinrichs, 2009; Finstad, 2007). Product recalls are quite common in the auto-motive industry (Bates *et al*, 2007) mostly due to safety related issues such as tyre failures (e.g in the *Ford Explorer* model in 2000), problems in break pedals (e.g. in *Peugeot-Citroen* models in 2003), unintended acceleration incidents (e.g. in *Toyota* models in 2010) and fuel leak problems (e.g. in *Toyota Avensis* and *Lexus* in 2011). In the UK, the '*Vehicle and Operator Services Agency (VOSA)*' offers a database with notices on recalls and relevant consumer information (http://www.dft.gov.uk/vosa/). Recalls of pharmaceutical products have also become rampant in recent years due to issues relating to mix-ups, dosage and dubious composition, packaging malfunctions and manufacturing defects of medical equipment (Cheah *et al*, 2007). In the UK, the '*Medicines and Healthcare products Regulatory Agency (MHRA)*' is responsible for processing all pharmaceutical and medical devices recalls (http://www.mhra.gov.uk). Food recalls are also frequent and intend to remove food products from the market when there is suspicion or evidence that products are adulterated or misbranded, and can cause health problems or even death (Onyango *et al*, 2008). In the UK, the '*Food Standards Agency*' is responsible for the provision of alerts and information about the latest product withdrawals and recalls (http://www.food.gov.uk). Finally, toy recalls are widely reported (e.g. several recalls of *Mattel* toys since 1998) due to potential choking, burn, strangulation, ingestion, laceration hazards and other risks of injury. Such recalls are publicised by the '*British Toy & Hobby Association (BTHA)*' (http://www.btha.co.uk).

Moving product recalls back to the source can be a headache for retailers (Bowersox, 1991). The logistics involved in resolving a recall can be considerable (Kumar and Budin, 2005) and may constitute a costly source of loss in the supply chain (Tang, 2008). Smith *et al* (1996) suggested that firms should focus their efforts on policy and planning, product development, communication, logistics and information systems, along three stages: the problem discovery, the recall, and the follow-up phase. Farzan (2007) suggested that in order to develop a proactive approach to product recalls a company must first identify faulty products and then notify customers, ensure the availability of in-house or 3PL contractors fleet for collections, stop the supply of recalled products, provide detailed instructions to end users, ensure the move of recalled products to locations that minimise shipping costs and delivery times, and provide customers with replacement products. Several studies (e.g. Agrawal *et al*, 2006; Folinas *et al*, 2006; Kelepouris *et al*, 2007) have paid special attention to the use of RDIF systems in order to facilitate the organisation of product recalls.

2.3.4 Network Structures for Product Returns

Within the retail sector, two main mechanisms for returns management have been identified (Halldórsson and Skjøtt-Larsen, 2007). In the *centralised reverse supply chain*, one organisation has responsibility for collection, inspection, disposition and redistribution of returned items which could originate from many different retailers. Returned products and waste derived from such a centralised gate-keeping process are often grouped in one place and can be effectively managed. In the *decentralised reverse supply chain*, multiple organisations can be involved in this process, where individual sales outlets act as their own gate-keepers, checking returned product and deciding which re-use/disposition paths items should take. Where the gate-keeping function is taken on at the individual store level, local skills are needed in product inspection and testing. This is not a trivial undertaking and is a process which could lead to increased waste generation if not tightly managed and coordinated. As a result, there is often little coordination in terms of the treatment processes and contractors used between businesses. Four physical network structures for handling retail returns and the related waste outgoings have been identified (DfT 2004a):

- *Type A - Integrated Outbound and Returns Network*: Using a company's own fleet or their 3PL's vehicles, returns are 'back-hauled' from the retail outlets to a regional distribution centre (RDC) where the gate-keeping function is undertaken. Waste products generated by the gate-keeping process are onward managed from the RDC. This system works well in a supply chain where the frequency of delivery to stores is high, and the volume of returns is also high.

- *Type B - Non-Integrated Outbound and Returns Network*: In this case, a separate network is used for managing returns, typically operated by a 3PL provider who takes returns (on an 'as-and-when-required' basis) from stores to a separate location for gate-keeping, managed by the retail organisation. This system works well if the level of returns varies in volume but is generally low.
- *Type C - Third-Party Returns Management*: The total management of product returns is outsourced to a third-party contractor who undertakes all the gate-keeping processes. The contractor provides this functionality along with a complete returns management process, including supporting technologies, refurbishment and disposition/waste management programmes. Centralised gate-keeping processes have the potential to better manage the waste generated during the returns process and maximise re-use potential as they have greater visibility of the various refurbishment options. This has resulted in the emergence of 4PLs who undertake '*business process outsourcing*' to deliver fully comprehensive forward and reverse supply chain solutions, including refurbishment and disposition management (Mukhopadhyay and Setaputra 2006).
- *Type D - Return to Suppliers*: In this case, goods are returned directly to suppliers and exchanged for credit. Under these circumstances, retailers may have no gate-keeping responsibilities and little responsibility for returns. Such systems may have additional transport cost implications as the goods have to return to the individual supplier for the gate-keeping function before potential further travel related to refurbishment or disposition.

Many large retail companies (e.g. *Estee Lauder*) use centralised return centers (CRCs) to process product returns (Rogers and Tibben-Lembke, 1998; Schatteman, 2003). In CRCs employees assess the condition of incoming items and determine the best option for disposal (Section 2.3.5). CRCs are preferred because the savings from having fewer premises and smaller inventory far outweigh the additional costs of transporting goods longer distances (McKinnon *et al*, 2002). Other firms (e.g. *ASDA*, 2006) prefer the use of local hubs that allow local producers to pool their resources and reduce costs, cut carbon emissions and lower the overall environmental impact of

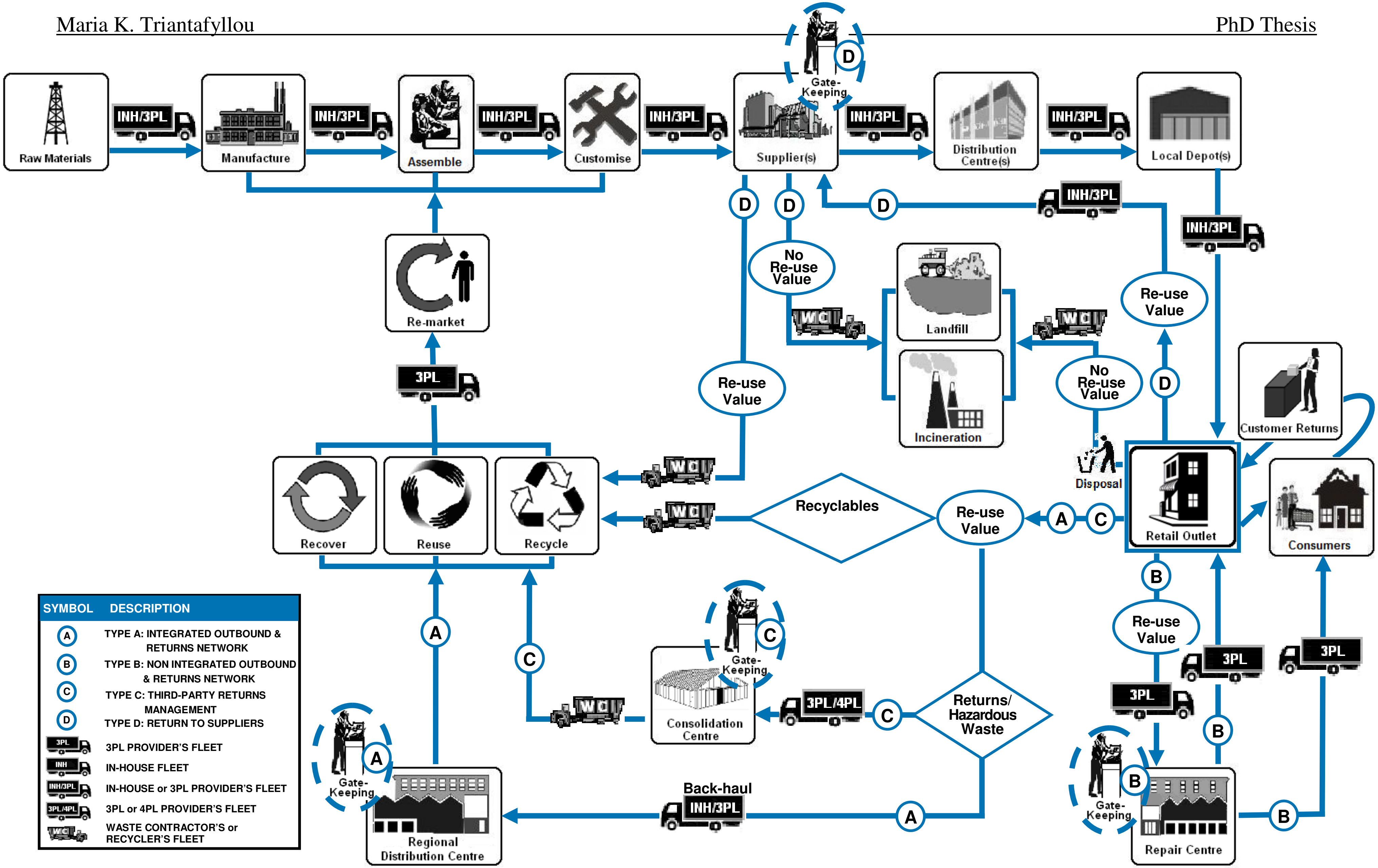


Figure 3: Physical network structures for recovery of retail returns and waste outgoings incorporated in the supply chain.

product distribution. A case-by-case examination is required to reveal what system is right for each business.

2.3.5 Disposition Routes for Product Returns

In response to emerging supply chain trends and legislative pressures, the retail industry channels product returns through a number of disposition routes (Thierry *et al* 1995; Srivastava and Srivastava, 2006):

- *Sell as New*: Non defective products returned at stores with all original packaging and accompanied by the receipt of purchase can be resold in the existing channel either at full or discounted price. No transport is involved unless products are transferred to other chain stores.
- *Return to Supplier*: Returns of defective, non conforming or overstock products may be sent back to suppliers in accordance with the terms of sale and the return acceptance policy. Dependent on the condition of the products, suppliers may re-distribute products across their customers base, sell to the secondary market or through the internet, repair, donate or dispose of.
- *Return to Manufacturer (Recovery/Remanufacture/Cannibalisation)*: Manufacturers receiving product returns may attempt to restore their utility by remanufacturing work parts. Products can thereafter be auctioned through the internet or redeployed to outlet stores. Alternatively, manufacturers may decompose products (e.g. cars and computers) and sell spare parts. One should consider though the sales losses in the primary products channel.
- *Repair/Refurbish*: Products under warranty and where a moderate amount of repairs and re-packaging can make them re-usable can be sent to a service/repair centre. From there, products may be returned to customers, or become available through the Internet and the secondary market.
- *Sell via Outlet (Secondary Market)*: Brand-sensitive companies (e.g. *Burberry*'s) prefer selling returns in their own highly profitable outlet stores rather than through alternative channels. Several other retail businesses may send returns to large outlets offering a merchandise mix (e.g. *T.K. Maxx*).
- *Sell to Broker*: Brokers are retail businesses that buy mass quantities of products at the end of their sales life at a very low price, and sell them at a

profit. Products can be channelled through the Internet, outlets or other discount stores (e.g. *Poundland*).

- *Donate to Charity*: Many retail businesses have teamed up with charities (e.g. *Marks & Spencer* with *Oxfam*) to help clear out unwanted stock, save money, reduce waste and raise money for weak and under-privileged social groups. Products can thereafter be sold through the internet, charity stores, recycled or even disposed of. In a study about the take-back schedules of a UK based global charity business (*Oxfam*), Cherrett *et al* (2010) identified that a large volume of donations were deemed un-sellable due to quality issues and were ending up in the waste stream. They suggested that the creation of strategic alliances with other charities and retail businesses would reduce the associated transport footprint.
- *Recycle*: Products not deemed suitable for re-sale, re-use, or recovery, but with a high recycling potential (e.g. paper) are sent to specialised companies.
- *Send to Landfill*: Disposal of products in landfills is the last option for retailers, due to green and cost considerations (e.g. the Landfill Tax).

In many cases, alternative routes to disposition are not explored as they add another level of complexity to the reverse logistics network which is often not geared up to manage multiple collections and transfers.

2.4 Reverse Logistics and Commercial Waste

Increasing government regulation coupled with the drive for greater environmental accountability has brought waste logistics to the forefront of supply chain strategies. The retail sector has had to collectively respond to this because of the responsibilities obligated on producers, suppliers and retailers putting products onto the market (Gonzalez-Torre *et al*, 2004). Retailers now have key responsibilities related to the collection, storage, treatment, transportation and disposal of end-of-life materials and packaging waste, as well as the development of customer take-back systems at the store level. At the same time, the increasing use of hazardous materials in servicing day-to-day retail activities and certain consumer products has meant that retailers are also bound to organise critical reverse logistics operations for the safe and efficient collection, storage, transitional treatment, distribution, recycling and final disposal of hazardous wastes. To do this effectively, retailers must develop cost effective strategies to optimise the collection processes and minimise the logistics demand associated with moving hazardous wastes.

2.4.1 Commercial Waste in the UK

According to the latest national survey of '*Commercial and Industrial (C&I)*' waste (DEFRA, 2011), the retail and wholesale sector, including out-of-town developments, retail parks, community shopping centres and department stores, as of 2009 produced an estimated 9.2 million tonnes of waste, presenting a 27.6% decrease since 2002 (12.7 million tonnes; Envirowise, 2002). Over a third of 2009 arisings (38.5%, 3.5 million tonnes) were classified as mixed waste, with most of the remaining (44.6%, 4.1 million tonnes) being non-metallic materials (e.g. paper, cardboard, plastic, glass). Statistics also showed that the percentage of the waste volume diverted from landfill grew from 33% in 2002 to almost 80% in 2009 and suggested the potential to treat up to an estimated 97.5% of total UK waste volume (Table 5).

Table 5: 2009 UK waste statistics about the volume and management type by type of waste (DEFRA, 2010).

2009 Waste Statistics for the UK Retail and Wholesale Sector (Volume: x 10^3 tonnes)									
By Waste Type			**By Management Type**			**Currently**		**Potentially**	
Waste Type	**Volume**	**%**	**Management**	**Volume**	**%**	**Volume**	**%**	**Volume**	**%**
Animal & Vegetable	328	3.6	**Landfill**	1,956	21.2	**Re-used**			
Chemical	291	3.2	**Land Recovery**	4	0.0	213	2.3	633	6.9
Common Sludges	2	0.0	**Incineration**	146	1.6	**Recycled**			
Discarded Equipment	308	3.3	**Thermal-Other**	170	1.9	5,275	57.3	7,676	83.3
Healthcare	402	4.4	**Non-Thermal**	615	6.7	**Recovered**			
Metals	169	1.8	**Transfer Station**	247	2.7	931	10.1	8,979	97.5
Mineral	57	0.6	**Recycling**	5,240	56.9	**Total Treated**			
Mixed	3,543	38.5	**Composting**	35	0.4	6,419	69.7	8,979	97.5
Non Metallic	4,112	44.6	**Reuse**	213	2.3	**Untreated/Other**			
			Unknown	586	6.4	2,793	30.3	233	2.5
Total	**9,212**	**100**	**Total**	**9,212**	**100**	**9,212**	**100**	**9,212**	**100**

The move away from landfill disposal was fostered in chief by the implementation of the '*Landfill Directive [1999/31/EC]*' that required the closure by 2009 of many older landfill sites not meeting its requirements (Section 2.4.2.6). This measure along with a fall in economic activity in 2008-2009 led to a 18% decrease in municipal, industrial and commercial waste ending up in landfill during this period and to an overall 45% fall since 2000 (Environment Agency, 2011). As of 2009, 134.4 million tonnes of waste were treated in regulated facilities in England and the Wales, 6.87% (9.2 million tonnes) of which consisted of commercial wastes. Of total arisings, 46.5 million tonnes (34.7%) were landfilled, 41.9 million tonnes (31.3%) were transferred prior final disposal or recovery, 27.4 million tonnes (20.4%) were treated, 13.2 million tonnes of metals (9.9%) were recycled, and 5.4 million tonnes (4%) were incinerated. These figures suggested a lower dependence of commercial waste on landfill and incineration compared to the treatment options selected for municipal, commercial and industrial waste as a whole. Following the *Landfill Directive*'s demands, as of 2010 the capacity of landfills presented a 19% decrease since 2000, with a 5% fall occurring only in 2009. Estimations based on 2009 outputs, suggested that at the time there were 614m³ of available landfill capacity providing nearly 8 years of landfill life left. Almost two thirds (68%) of the available capacity was destined for non hazardous wastes (Environment Agency, 2011).

Significant was also the role of the '*Waste Strategy for England 2007*' which was developed under the provisions of the '*Environment Act 1995*' (Section 2.4.2.6) to heavily endorse re-use, recycling and recovery as a more sustainable treatment option for a number of waste materials. The *Waste Strategy* was introduced to reform regulation and improve local, regional and national governance in relation to waste management, while reducing costs to compliant businesses and regulators, and stimulate investment in relevant infrastructure, markets and services for recovered materials (DEFRA, 2007a). The management of the return flow of waste by more sustainable ways was further urged by the increased costs to business considering that except for disposal covered the value of returns, damaged stock, discarded material, waste treatment operations and transport. Estimations by the Department for Transport (DfT, 2004a) determined that the total cost to businesses could be actually 5 to 20 times greater than that of disposal, with the contribution of logistics being particularly significant, especially when internalising the transport impacts on the environment (e.g. air pollution, noise, accident risk, vibration and visual intrusion).

2.4.1.1 Hazardous Commercial Waste in the UK

Hazardous materials are prevalent throughout our society. Whilst industry is a primary user of hazardous chemicals, the commercial sector also has a considerable take-up. Retail outlets and catering units use a range of items containing hazardous substances such as cleaning and maintenance products, fluorescent lighting tubes, batteries and electrical and electronic equipment (EEE) to support their day-to-day operations and customer services. A variety of hazardous waste can be produced and when added to the stream of hazardous end-of-life products returned to stores through customer take-back schemes, a considerable pressure can be placed on retailers to develop distinctly different handling protocols, treatment practices and disposal alternatives. These have to be achieved whilst still maintaining quality in customer services and adding economic value along the supply chain.

As of 2009, it was estimated that over 170,000 commercial businesses and industries in England and Wales produced 4.3 million tonnes of hazardous waste (Environment Agency, 2011). This represented a 17% reduction since 2004, mainly due to the reduction in liquid inputs in one treatment facility (Teeside). About a third (35%) of hazardous waste was treated, 23% was recycled, recovered or re-used, 22% was transferred before final disposal or recovery, 13% was landfilled, and 7% was incinerated. Estimations based on 2009 outputs, suggested that at the time there were 18 million m^3 of available capacity at hazardous waste only sites. In addition, out of the total 235,000 tonnes of waste exported from England and Wales, 9% consisted of waste containing hazardous heavy metals, 8% of lead-acid batteries and 7% waste mineral oils sent mainly to Germany, France and Belgium for recovery (Environment Agency, 2011).

The management of hazardous waste is more complex than non hazardous waste materials due to the considerable variation in contractual, business and operational practices that can be adopted in order to meet the considerable legislative requirements (Browne and Allen, 2007). This naturally works against collaborative working in the sector because of the variety of systems that can be used by retailers (Sheu, 2005). The variety in the material characteristics and properties of hazardous waste often dictate specific handling and treatment measures (control and separation) from the principal reverse waste flows to ensure safe, efficient and cost effective collection, transportation, treatment and disposal (Nema and Gupta, 1999; Wang *et al*, 2008).

The complexity of managing hazardous waste has been widely researched in previous studies on reverse logistics which largely focussed on optimising the location and use of treatment facilities in network planning. Areas well covered include private business costs minimisation (e.g. Peirce & Davidson, 1982; Hu *et al*, 2002) and transportation and/or disposal risk (e.g. Zografos & Samara, 1989). It appears though that relatively few theoretical and practical studies have been undertaken investigating cross-supply with regard to the management of hazardous wastes produced by different or rival businesses

2.4.2 The Drivers of Waste Management

Development in waste management throughout years has been led by six broad groups of drivers including concerns about public health, environmental protection and climate change, as well opportunities to utilise the resource value of waste, and increased public awareness and various institutional and responsibility issues, (Wilson, 2007).

2.4.2.1 Public Health

During the Middle Ages many attempts were made to remove waste away from UK city streets in order to reduce smell and the amount of waste obstructing access. 'Rakers' were periodically employed to collect resalable items and dumb or sell residue to farmers for use or compost (Girling, 2005). The aim was to increase income and reuse as many materials as possible as a measure against resource scarcity (Woodward, 1985). However due to the poor being more concerned with surviving and the rich objecting to pay for cleaning for the poor such attempts did not last. The first clear linkages between poor sanitation conditions and infectious diseases such as cholera were made around 1840 and followed with the introduction of the 1848 and the 1875 '*Public Health Acts*' that placed responsibility on householders to collect and store waste in movable receptacles and on Local Authorities to empty them on a weekly basis (Wilson, 2007). Disposal was though uncontrolled with most of the waste being dumped or burned. The main priority was to get waste 'out of foot' a concept similar to today's 'Not In My Back Yard (NIMBY)' attitude where people oppose to waste treatment developments close to them.

Since 1970s protection of public health became a factor taken for granted in developed countries. However, public health was recently used as the most important argument against the introduction of fortnightly collections in the UK. The frequency of collections generally depends on local circumstances, for this reason in hot climates residual waste is often collected on a daily basis (Wilson, 2007).

2.4.2.2 Environmental Protection

The emergence of environmental protection as a means to eliminate uncontrolled disposal came to the forefront of waste management strategies in early 1970s. This move was progressed through the gradual introduction of technical standards aiming to control leachate and gas from landfills, reduce dioxin and trace gases from incineration, eliminate odour from composting, reduce methane through the diversion of biodegradable waste from landfills, and recover energy from waste (Wilson, 2007; DEFRA, 2007b). Furthermore, climate change concerns along with targets set by the Kyoto Convention accelerated the introduction of clean development mechanisms including waste management practices in many developing countries.

2.4.2.3 Closing the Loop

The move from landfill disposal towards more sustainable treatment options has been invigorated by the notion of the ‘waste hierarchy’ which calls for the adoption of reduction, re-use, recycling and energy recovery with the aim to extract the maximum benefits from products and generate as little waste as possible (Wilson, 2007). Waste hierarchy was first introduced in 1977 in the E.U.’s ‘*2nd Environmental Action Programme*’ (CEC, 1977) and constituted the first step away from ‘end-of-pipe’ waste management concepts towards more integrated policies. ‘Closing the loop’ has meant that the realisation of sustainable waste management practices should look at environmental, financial, technical, institutional, political and social aspects at the same time and include greener disposal options along with sustainable design and consumption of products.

2.4.2.4 Resource Value of Waste

Recovering waste materials was always an important driver for the waste management industry. The initial aim was to minimise the use of raw materials and at the same time reduce waste disposal quantities and costs. Today, although in many cases the value of recovered materials does not cover treatment costs; many developing countries adopt recovery practices to meet statutory targets and ethical principles. Yet, many rapidly growing economies, such as those of China and India, import secondary raw materials to sustain their industries, while making a living by recovering waste materials is still a key driver in many poor countries (Wilson *et al*, 2006).

2.4.2.5 Public Awareness

As living standards increase, issues like environmental protection, climate change and resource and waste management present increasing importance and often appear in the public and the political agenda. Although the main focus in people's priorities is still in livelihood, shelter, food and security, waste turns into an issue when it poses a risk to public health or the environment (Wilson, 2007). Poor public perceptions on disposal practices (e.g. the NIMBY phenomenon) require public awareness and education in order to lead to behaviour change (Sharp, 2006).

2.4.2.6 Legislation

The concept that the flow of goods through a supply chain ultimately ends with the consumer has been challenged due to the European Commission's (EC) comprehensive environmental legislation and growing consumer awareness of recycling. Waste disposal, deposit, recovery and recycling in the U.K. is regulated under the provisions of a comprehensive set of European and domestic laws. All businesses that import, produce, carry, keep, treat or dispose of commercial waste have a '*Duty of Care*' to ensure that all it is safely contained and transferred to an 'authorised person'. This 'person' or 'body' can be either a holder of a 'Waste Management License' under '*Section 35 of the Environmental Protection Act 1990*', or a registered waste carrier under the '*Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations [S.I. 1991/1624]*'. Any transfer of waste from one party to another must be accompanied by a 'Waste Transfer Note' and copies must be kept by all parties for at least 2 years.

Under the wider 'polluter pays' principle, retailers are obligated to set up and manage material take-back schemes. An increasing number of corresponding regulatory frameworks (Tables 6 and 7) aim to ensure proper handling and disposal, while shifting waste management to producers to enforce them to re-design products in order to reduce the volume of the waste generated and increase the use of recycled materials (Marien, 1998). Especially, in the case of hazardous wastes that fall within the remit of the '*Hazardous Waste Regulations [S.I. 2005/894]*' in correspondence to the '*Hazardous Waste Directive [91/689/EC*]' and the '*Restriction of Hazardous Substances Directive [2002/96/EC]*' special provisions must be made. Classification of hazardous materials is made under the 'European Waste Catalogue (EWC) 2002' according to how they were produced (20 main categories and 650 codes). All controlled wastes must be deposited, disposed of, recycled or recovered at a suitably licensed site, or a site that is registered as exempt from waste management licensing as stipulated by the '*Waste Management Licensing Regulations 1994 [S.I. 1994/1056]*'. Waste management sites are classified into three categories according to the type of waste they receive (hazardous, non hazardous and inert) and are licensed by the Environment Agency.

Table 6: Main pieces of waste legislation in the UK.

<table>
<tr><th colspan="3">Main Waste Legislation</th></tr>
<tr><td rowspan="6">Waste Framework Directive</td><td rowspan="2">EU</td><td>Waste Framework Directive [2008/98/EC] & European Waste Catalogue</td></tr>
<tr><td>This Directive aims to ensure that all necessary measures will be taken ensuring that waste is recovered or disposed of without endangering human health and without using processes/methods that could harm the environment.
Polluter Pays Principle: It is a guiding principle at European and international levels. The waste producer and holder should manage it in a way that guarantees a high level of protection of the environment and human health.</td></tr>
<tr><td rowspan="4">UK</td><td>Environmental Protection Act 1990</td></tr>
<tr><td>This Act is largely concerned with changes to the legal and institutional framework for waste management. It provides for the establishment of EA as a Body Corporate, requires the production of a 'National Waste' and a National Air Quality Strategy' and introduces the Best Practicable Environmental Option (BPEO).</td></tr>
<tr><td>Environment Act 1995</td></tr>
<tr><td>This Act introduces integrated pollution control, places a Duty of Care to all those involved in the management of waste and sets standards and control responsibilities to enforcing bodies.</td></tr>
<tr><td rowspan="4">Landfill Directive</td><td rowspan="2">EU</td><td>Landfill Directive [1999/31/EC] and Pre-treatment Requirements</td></tr>
<tr><td>The aim of this Directive is to prevent or reduce as far as possible negative environmental impacts by setting maximum quantities for the landfill disposal of biodegradable municipal waste. Its 'Pre-Treatment Requirements' mean all waste destined for landfill disposal must first undergo treatment in the form of a physical, thermal or biological process. Commercial waste producers can meet these requirements by either separating different waste streams for recycling, or by making arrangements for waste contractors to treat the waste before disposing of it.</td></tr>
<tr><td rowspan="2">UK</td><td>Landfill (England and Wales) (Amendment) Regulations [S.I. 2005/1640]</td></tr>
<tr><td>This Directive was brought into force in the UK on June 2002 as the 'Landfill (England and Wales) Regulations 2002' and amended in 2005. The Regulations set out a pollution control regime by banning the co-disposal of hazardous waste with non-hazardous waste in landfills, and since 2004, accepting materials in hazardous and non-hazardous sites only when they are permitted by their licences. In addition, the directive bans liquid wastes, used tyres, healthcare and infectious clinical wastes, animal-by-products, explosive/corrosive/flammable/oxidising wastes and chemicals. It also brings with it tighter site monitoring and engineering standards.</td></tr>
</table>

Main Waste Legislation (continued)		
Packaging & Packaging Waste Directive	**EU**	**Packaging and Packaging Waste Directive [1994/62/EC]**
		The objective of this Directive is to increase recovery and recycling levels of packaging waste produced across the various commercial sectors including sales outlets. Packaging includes all products used to contain, protect, handle, deliver or present products and includes returnable and non-returnable units (boxes, pallets, plastic totes, bags, drums etc.). This legislation is harmonised in the UK through two regulations that obligate businesses to take back customers packaging when returned in stores and increase the level of re-usable containers used for the transport of their core goods, product returns and waste.
	UK	**Packaging (Essential Requirements) Regulations [S.I. 2003/1941]**
		The Regulations set design criteria and requirements for sales (primary and secondary) and transport (tertiary) packaging in such a way as to maximise its recovery, re-use and recycling potential whilst reducing the level of any hazardous materials to a minimum. The use of re-usable plastic crates and glass is legislated under the [1999/177/EC] and [2001/171/EC] *Commission Decisions* that define the physical properties and the requirements of recoverable packaging for treatment at the end of their life.
		The Producer Responsibility Obligation (Packaging Waste) Regulations [S.I. 2007/871]
		The Regulations oblige product sellers to reach specific recycling and recovery targets, set up systems for customers to return packaging and join a registered compliance scheme. They work on the basis of shared '*Producer Responsibility*' between businesses operating at different stages. Sellers should achieve 48% of recycling targets, while secondary providers and service providers should achieve 85% individually. Retail outlets are obligated if they have an annual turnover of greater than 2 million and handle more than 50 tonnes of packaging annually. If a business belongs to a group of companies, these requirements apply to the total amount of packaging handled by the group and its total annual turnover.
Hazardous Waste Directive	**EU**	**Hazardous Waste Directive [91/689/EC]**
		The Directive defines the waste that is harmful to humans or the environment on the basis of the '*European Waste Catalogue (EWC) 2002*' which classifies waste materials (20 main categories) according to how they were produced (650 codes). It places a requirement to identify and record such arisings and undertake appropriate measures to ensure that companies that dispose of, recover, collect or transport hazardous waste do not mix different categories or mix hazardous waste with non-hazardous waste. In the course of collection, transportation and temporary storage, waste shall be properly packaged and labelled in compliance with international law. For example, the following wastes are classified as hazardous: - Separately collected fractions excluding packaging waste and their mixtures (e.g. fluorescent tubes, other mercury-containing waste, non-edible oil and fat, detergents containing dangerous substances, cytotoxic and cytostatic medicines, batteries and accumulators, discarded EEE containing hazardous wastes). - Packaging including separately collected municipal packaging waste (e.g. packaging contaminated by dangerous substances and metallic packaging containing a dangerous solid porous matrix (e.g. asbestos) including empty pressure containers. - Wastes from natal care, diagnosis, treatment or prevention of disease in humans (sharps and other wastes whose collection and disposal is subject to special requirements to prevent infection, chemicals consisting of or containing dangerous substances, cytotoxic/cytostatic medicines and amalgam waste from dental care). - Batteries and accumulators (e.g. lead, nicelium-cadmium and mercury)
	UK	**Hazardous Waste (England and Wales) Regulations [S.I. 2005/894]**
		Retail outlets producing any type of hazardous waste classified under the '*List of Waste (England Regulations) (LoW)*' must pre-register with the *Environment Agency,* and 'consignees' must keep records of all consignments received. Any mixing of hazardous and non hazardous materials is prohibited. *LoW* is compiled in accordance with the '*European Waste Catalogue*' and the use of its codes is a legal requirement of the '*Duty of Care*' and must be included in the description of controlled waste in any waste transfer or consignment note.

The variety in the characteristics and properties of hazardous wastes demands the development of material-specific legislation which dictates how different waste streams should be managed and disposed of. Table 7 summarises the main legislative requirements for the most common commercial hazardous wastes.

Table 7: Material-specific hazardous waste legislation in the UK.

<table>
<tr><th colspan="3">Material-Specific Hazardous Waste Legislation</th></tr>
<tr><td rowspan="8">WEEE</td><td rowspan="4">EU</td><td>Waste Electrical and Electronic Equipment Directive (WEEE) [2002/96/EC]</td></tr>
<tr><td>This Directive aims to minimise the impact of EEE on the environment, by increasing re-use and recycling and reducing the amount of WEEE going to landfill. It seeks to achieve this by making producers responsible for financing the collection, treatment, and waste recovery and by obliging distributors to establish collection mechanisms at no cost to consumers. The Directive provides a list with 10 product categories having a voltage of up to 1000 volts AC or up to 1500 volts DC (large/small household appliances, IT & telecommunications equipment, electrical and electronic tools, lighting equipment, toys and sports equipment, medical devices, consumer equipment, monitoring and control instruments and automatic dispensers).</td></tr>
<tr><td>Restriction of Hazardous Substances Directive (RoHS) [2002/95/EC]</td></tr>
<tr><td>Its more recent (2008) version ‘RoHS^{2}’ restricts the use of 6 hazardous materials in the manufacture of various types of EEE (e.g. heavy metals as lead, mercury and cadmium, and flame retardants used in plastics). It covers the same scope of the ‘WEEE Directive’ (10 product categories) except for medical devices and monitoring and control instruments. It also excludes batteries and certain types of fluorescent lamps, tubes, and electronic components. In line with the ‘WEEE Directive’ retailers are duty bound to sell approved products and establish take-back schemes for WEEE.</td></tr>
<tr><td rowspan="4">UK</td><td>UK WEEE (Amendment) Regulations 2007 [S.I. 2007/3454]</td></tr>
<tr><td>The UK Department for Business, Enterprise & Regulatory Reform (BERR) is responsible for overseeing the passage of the ‘WEEE Directive’ into the domestic regulatory frame. Retailers and distributors selling EEE must:
▪ Store, collect, treat, recycle and dispose of WEEE separately from other waste.
▪ Obtain and keep proof that WEEE was given to a waste management company and was treated and disposed of in an environmentally sound way.
▪ Discharge WEEE for free if EEE was sold after 13/08/2005, was replaced by new equivalent EEE, or came from private households (separated and unmixed with other waste)
▪ Discharge WEEE at a cost when EEE was purchased before 13/08/2005, if it is impossible to trace the producer or its compliance scheme, or have made special arrangements with the producer to bear future costs.</td></tr>
<tr><td>Retailers must inform customers why they must separate WEEE from other waste, which are the environmental impacts of EEE and WEEE, how take-back schemes operate, and how WEEE can be safely deposited for proper treatment/recycling free of charge. There are generally 2 customer take-back systems offered by retail outlets: a) in-store where retailers must accept all WEEE types associated with EEE traded and record their amount before being removed through a producer compliance scheme; and b) through the provision of pre-paid mail order sacks or pre-paid label (dependent on appliance size).</td></tr>
<tr><td>Separate collections of large household appliances, gas discharge lamps, display equipment containing cathode ray tubes and all other WEEE must be made, however, if joint collections must be made due to restrictions on the size of containers, then different streams may be mixed up to 15% by weight of material in a single consignment as long as gas discharge tubes and display equipment containing cathode ray tubes remain separate from each other.</td></tr>
<tr><td rowspan="2">Lamps</td><td rowspan="2">UK</td><td>Energy Efficiency Requirements for Ballasts for Fluorescent Lighting Directive [2000/55/EC]</td></tr>
<tr><td>The Directive aims at reducing energy consumption for ballasts for fluorescent lighting by moving gradually away from less efficient ballasts towards more energy-saving ballasts that meet specific design requirements, bear the EC marking and ensure a high level of protection for both the environment and consumer.</td></tr>
</table>

Material-Specific Hazardous Waste Legislation (continued)		
Lamps (continued)	**UK**	**Energy Efficiency (Ballasts for Fluorescent Lighting) Regulations [S.I. 2001/3316]** Under the 'Hazardous Waste Regulations', fluorescent lighting tubes are classified as hazardous waste and their disposal in landfill is prohibited due to high levels of heavy metals (e.g. mercury). Although the tubes are safe provided they are not broken, mercury when released can be very damaging to health. Under the 'WEEE' and the 'RoHS' Directives, retailers are allowed to distribute certain types of lighting equipment and collect, store and dispose of end-of-life lighting tubes separately from general waste.
Batteries	**EU**	**Batteries, Accumulators and their Wastes Directive [2006/66/EC]** The Directive entitles members of the public to deposit, free of charge, all waste batteries at appropriate retail outlets. Retailers are only obligated to take-back batteries of a type they supply.
	UK	**Batteries & Accumulators (Placing on the Market Regulations) [S.I. 2008/2164]** The Regulations first specify the main technical characteristics of the batteries, accumulators (rechargeable batteries) or products that contain batteries or accumulators that fall within their scope. Any person placing such products on the market must ensure that batteries contain acceptable levels of mercury and cadmium, are labelled properly, and meet all design specifications. **The Waste Batteries and Accumulators Regulations 2009 [S.I. 2009/890]** Retailers putting less than 1kg of portable batteries on the market are exempted from the take-back duty and any other funding obligation regarding the collection, treatment and recycling of batteries; however they still have to register with the E.A. Retailers bound to take-back batteries have the right to join free of charge any compliance scheme as long as it ensures the collection of batteries within a reasonable time (21 days). Interim targets of collecting waste portable batteries are equivalent to 25% of sales by 2012 and 45% by 2016. In the past, batteries were removed according to the WEEE legislation and were included in declarations of weight of electrical and electronic products. Since January 2010 the weight of batteries is declared on the amount of batteries put in the market.
Clinical Waste	**EU**	**'07-01: Safe Management of Healthcare Waste' - Environment and Sustainability Health Technical Memorandum.** Waste produced as a consequence of health care activities in hospitals and community settings (e.g. retail outlets authorised to operate as surgeries) must be segregated and disposed of in accordance with the hazard it poses. Clinical waste (e.g. sharps, cytotoxic/cytostatic medicines and healthcare chemicals) must be classified under the EWC codes and stored safely prior to being moved to authorised treatment/disposal sites. Storage areas must be secure, accessible only by authorised staff, and sufficient in size to allow segregation and separate storage of waste of different classifications. Packaging items (e.g. bags, containers) must be approved, labelled and accompanied when in large quantities with appropriate documentation.
	UK	**'07-06: Disposal of Pharmaceutical Waste in Community Pharmacies' – Environment and Sustainability Health Technical Manual** On-site storage of pharmaceutical waste in community pharmacies or other specialised retail outlets either produced on-site or returned by patients does not need to be licensed by the E.A., unless more than 200kg of hazardous waste is produced by an outlet in total (including other hazardous waste produced such as fluorescent lighting tubes). Similarly to hospitals or other healthcare settings producing hazardous clinical waste, secure storage and authorised collection and transport must be ensured.
Cooking Oil	**EU**	**Animal By-Products Regulation - Guidance on Cooking Oil [2002/2774/EC]** Used cooking oil from catering units must not be poured down drains or sewers to avoid odour, blockage and pollution of watercourses. Instead, retailers are obligated to ensure proper storage and collection by authorised contractors transferring waste oil to authorised recovery or disposal sites. Since November 2004, cooking oils can no longer be used as calorie enhancers in animal feed, but can be used in the production of bio-diesel to power vehicles.
	UK	**Animal By-Products Regulations England [S.I. 2005/2347]** In accordance with the '*Duty of Care*' producers of waste cooking oil (e.g. restaurants and other catering units) must store cooking oil safely and ensure that it is collected by authorised contractors. 'Carriers' must be licensed and registered with the *Environment Agency*, and issue and retain for 2 years transfer notes accompanying consignments.

2.4.3 Types of Commercial Waste

Retail outlets and catering units have to deal with a wide range of waste materials either produced on-site as part of day-to-day operations (e.g. maintenance products, fluorescent lighting tubes, batteries and EEE), received by customers through take-back schemes (e.g. mobile phones), or generated as part of customer services (e.g. packaging). The ongoing introduction of environmental legislation has changed the way these waste streams must be treated and has set specific guidelines on how waste collection, transportation and treatment must be implemented in the UK. The following sections describe those requirements for some of the most commonly produced waste streams by the retail sector.

2.4.3.1 Packaging Waste

A large amount of single-use packaging, predominantly 'primary' or 'secondary' (Section 2.3.3.4), ends up in the waste stream. It consists of mixed waste (50%), paper and cardboard (20%), non metallic wastes (e.g. plastic and polythene) (9%), food waste (7%), metals (2%), oils and solvents (2%), discarded equipment (1%) and other (9%) (DEFRA, 2011). Although as of 2009 the recovery rates in the form of recycling and re-use (66,7%) exceeded the national target (60%), a greater potential to recover higher percentages lies into the recycling of biodegradable materials such as cardboard, paper, food and wood (DEFRA, 2009):

- *Cardboard*: It is made from cellulose fibres made from wood pulp. It is widely used as primary and/or secondary packaging in almost all product types (e.g. food products, electronics, cosmetics etc). To be recycled it has to be soaked and agitated to release the fibres before being re-pulped. This process can be repeated up to 5 times, as fibres shorten and disintegrate (Recycling Expert, 2011).
- *Plastics and Polythene*: There are many different types of plastics used for packaging purposes including bottles, crates, food containers, and film (polythene) among others. Plastics are used as packaging materials because they are flexible, lightweight, cost effective, durable and transparent. Under the 'packaging waste' legislation manufacturers must cut down the amount of plastics used in packaging materials, while retailers must ensure that they maximise re-use, recycling and recovery rates (BPF, 2011).

2.4.3.2 Waste Produced by Day-to-Day Retail Operations

Any business produces a variety of waste materials as part of its day-to-day retail and catering operations. The range of waste materials produced varies according to its trading activities (e.g. stores selling cosmetics may generate clinical waste), however there are some specific waste types that are produced by almost every single business (e.g. fluorescent lighting tubes and cleaning materials):

- *Fluorescent Lighting Tubes*: Currently, over 100 million fluorescent light tubes are scrapped annually in the UK, leading to approximately 20,000 tonnes of mercury and lead contaminated glass going to landfill. Of the 100 million tubes, only 12 million are recycled (PHS, 2009). Under the '*Hazardous Waste Directive [91/689/EC]*', lighting tubes are considered as hazardous waste and are legislated under the '*WEEE*' and the '*RoHS*' Directives, that prohibit their disposal in landfill due to the high levels of heavy metals, particularly mercury. Retailers must take all appropriate measures to separately collect, store and dispose of end-of-life fluorescent lighting tubes from the general waste to enable proper disposal. Collection of tubes from retail outlets and catering units must be made by registered waste contractors, and their disposal must be made in properly authorised sites. New technologies offer the opportunity to recycle all the components of a tube (glass, phosphor, mercury and metal end caps) in appropriate recovery sites.
- *WEEE*: EEE is a rapidly growing waste stream in the western world. It originates from either domestic end-users with household WEEE, commercial end-users with business WEEE or manufacturers, distributors and retailers with ex-lease products, excess inventory, customer returns and obsolete assets (Abu Bakar and Rahimifard, 2008). EEE appliances consist of a variety of components containing different hazardous, valuable and contaminating materials. For instance, a typical TV set contains 6% metal and 50% glass whereas a cooker is 89% metal and only 6% glass with the remaining materials being plastics, ceramics and precious metals. In addition, EEE contains a complex array of heavy metals, lead, mercury, flame retardants and other toxic substances such as arsenic and cadmium making WEEE difficult to manage (WasteOnline, 2005). Research by the Royal Society for the Encouragement of Arts, Manufactures and Commerce (RSA) suggested that

the average UK citizen throws away 3.3 tonnes of WEEE in their lifetime and therefore a total of 939,000 tonnes of WEEE are produced annually by the UK population and 6,500,000 tonnes across European (WEEEMan, 2006). Following the implementation of the '*WEEE Directive*' in 2007 UK retail businesses are obligated to register, mark and record all their WEEE products, and make arrangements of the collection, treatment and recovery through the use of specialist service providers (Bernon 2005). Retailers must store, collect, treat, recycle and dispose of WEEE separately from other waste, obtain and keep proof that WEEE was given to a registered waste management company and was treated and disposed of in an environmentally sound way. Proper collection and recycling of WEEE has a direct impact on landfill but the use of alternative recovery and recycling methods in its management adds a burden to the existing transport systems through the creation of more complex networks with more links and more vehicles. According to an initial assessment by the Department of Trade and Industry (DTI), the 'WEEE Directive' could create an additional 100,000 vehicle movements a year in the UK leading to increased emissions, noise and congestion (Bernon, 2005). In addition, recent studies have also suggested that as much as 60% of all WEEE costs will relate to the collection of discarded products (James, 2007) due to unnecessary handling and transportation stages in the reverse supply chain of WEEE (Lehtinen and Poikela, 2006). It is therefore paramount in planning corporate WEEE recovery and collection strategies to manage reverse logistics flows effectively and configure collection networks that deploy local recycling markets, maximise vehicle load carrying capacity and minimise the overall distances WEEE products have to travel in the network.

- *Clinical Waste*: Certain types of waste produced as a consequence of health care activities in retail outlets also operating as surgeries (e.g. laser eye surgery treatments), are classed as hazardous and can therefore pose a danger to the environment and human health. Clinical wastes must be properly segregated, stored in secure areas and packaged and labelled properly prior to being collected by registered clinical waste contractors. Dependent on the waste's characteristics, the treatment options differ. Cytotoxic and pharmaceutical wastes must be incinerated before disposal to landfill, while human body parts must be either incinerated or treated by chemical disinfection processes followed by shredding prior to being disposed in landfill in order to render the clinical and healthcare wastes safe. All these processes can involve additional transport and specialist contractors.

- *Waste Cooking Oil*: It is estimated that in the UK, catering premises produce more than 10,000 tonnes of used cooking oil every week. Approximately 200,000 sewer blockages and pollution incidents take place in England and Wales annually, 75% of which are directly related to deposits caused by fat, oils and grease (Water.org 2009). According to the '*Animal By-Products Regulation – Guidance on Cooking Oil [(EC) No. 1774/2002]*', proper storage and collection must be made by authorised waste contractors. To reduce dependency upon landfill sites, the European Commission strongly supports the recovery of waste oil, and waste collectors are expected to supply it to either producers of bio-diesel to power vehicles, incinerators to generate electricity, or the chemical industry.

2.4.3.3 Waste Collected Through Customer Take-Back Schemes

Any distributor of EEE is obligated to receive WEEE from private households free of charge either at stores or through 'Distributor Take-Back Schemes'. A characteristic example of customer take-back scheme is that of mobile phones:

- *Mobile Phones*: The mobile phone sector is one of the fastest growing industries in the world (Hanafi *et al*, 2008). In 2008 it was estimated that mobile penetration in the UK reached over 122% with 74.5 million subscribers. Annual sales of mobiles reached 18 million equating to 75% of the UK population upgrading or replacing their phone every 18 months (NetSize Guide, 2008). Under the requirements of the '*WEEE Directive*', customers may drop-off 'end-of-life' electronics in retail outlets either registered with a producer compliance scheme or having in place appropriate arrangements with registered or licensed waste contractors. Alternatively, customers may be provided with a pre-paid returns envelope to return their phone via the postal network. In a comparison of drop-off and mail-in collection methods, Hanafi *et al* (2008) concluded that due to the small size of mobile phones, the cost of mailing each product to the transfer/consolidation station was quite high in contrast with the cost of the drop-off method.

Mobile phones consist of a number of modular components having clear potential to be remanufactured and reused. Metals from batteries can be sent for recycling, plastic elements can be recovered through energy-from-incineration, while some plastics recovered from the outer body of recycled telephones can be granulated, reformed and reused in mouldings such as car wheel trims. In addition, a number of other useful parts including aerials, battery connectors, printed circuit boards (PCBs), connectors including gold-coated edge contacts on PCBs, integrated circuits (ICs), keyboards, lenses, microphones, phone housings and speakers can be recovered and re-used (Envocare, 2009). With increasing numbers of collections on each part of the take-back journey, the risk of valuable untreated waste components being illegally extracted or stolen becomes greater (Chan and Chan 2008). As a large proportion of the manufacturing activities related to mobile phones have moved to China with direct impacts on forward logistic costs, it is important to design effective reverse logistics that incorporate remanufacturing, reselling and repackaging activities to recover assets and add extra value, preferably at the local level.

2.4.4 Network Structures for Commercial Waste

Within the retail sector, two main mechanisms for waste management have been identified: the centralised and the de-centralised (Halldórsson and Skjøtt-Larsen, 2007). In a centralised model for waste collections, a single planner or organisation is acquainted with all system information including waste production levels, transportation capacities, recyclables sale prices, processing capabilities and disposal/treatment options for end-of-life products (Hong *et al*, 2008). Waste products derived from many different retailers are grouped in one place to enable efficient collection, inspection, disposition and redistribution (Figure 3). In contrast, a de-centralised collection system for commercial waste consists of multiple organisations involved in collection, sorting and distribution of returned items. It may be characterised by a vast amount of waste contractors, recyclers and other licensed logistics providers servicing individual businesses that operate in an urban retail setting such as a commercial high street or a shopping centre. The following variations in commercial waste service plans are identified:

2.4.4.1 Centralised Waste Collection Systems

This type of waste management system is usually noted in integrated retail structures where there are increased opportunities to coordinate centrally activities related to the collection of products discarded by a group of retail outlets (Figure 4). The application of this system enables high consolidation of waste at source resulting in reduced service visits and logistics footprint. Its success depends on the participation and synchronisation of retailers and requires clear definition of the rights and obligations of the landlord and the tenants through a consistent set of rules, regulations and contracts. The role of a 'logistics controller' is also very important as this central figure is responsible for the coordination of products and waste take-back operations using the delivery fleet or 3PLs in such a way to minimise the number of overall freight vehicle trips, the distance travelled and the number of less-than-vehicle loads generated. The logistics controller is also responsible for the integration of corporate strategic planning into day-to-day processes by looking beyond the organisation's processes, and finding and eliminating sources of waste to optimise collections (Melnyk *et al,* 1998). This person must identify the need of resources in terms of capital structure and human information, develop the technological and structural capabilities, modernise processes and actions and evaluate performance to identify the required adjustments (Ghisi *et al*, 2008).

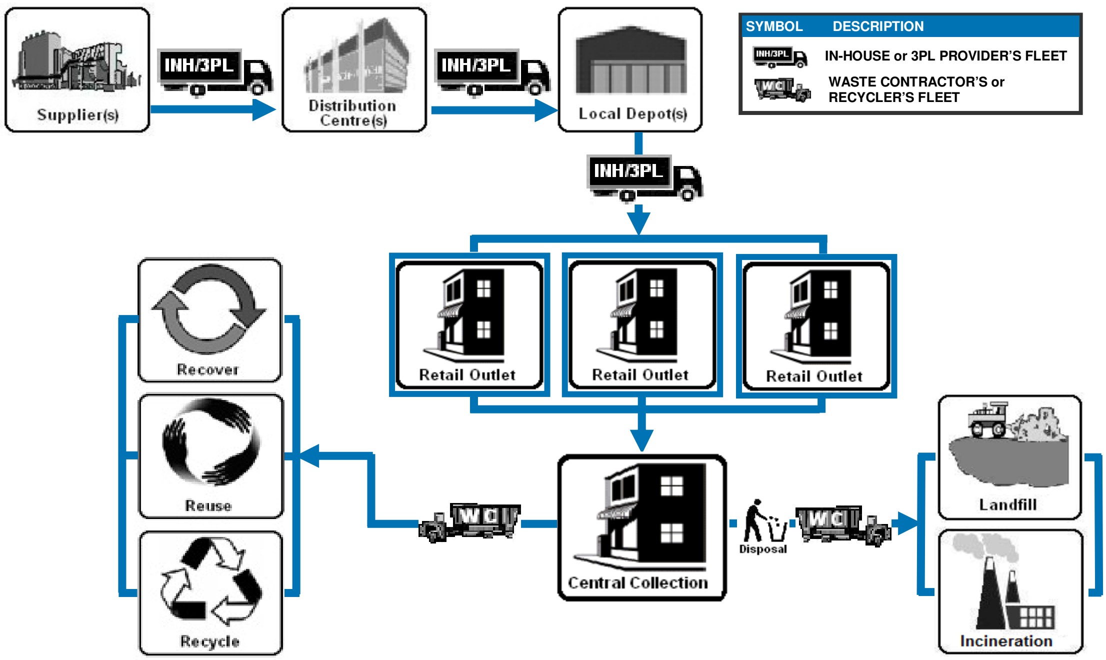


Figure 4: Centralised waste collections within an integrated retail structure.

2.4.4.2 Centralised Return Centres for Waste

The use of centralised return centres (CRCs) to process waste materials and recyclables (Figure 5) is usually adopted by large retail chains having the capital to make investments in processes that integrate environmental management into corporate strategic planning and resource productivity frameworks. This helps businesses increase their competitive advantage in a socially responsible manner. In logistical terms, this system utilises the back-load capacity of delivery fleet and therefore minimises the transport footprint. In addition the savings from having fewer waste collection premises usually outweigh the additional costs of transporting goods longer distances (McKinnon *et al*, 2002). However, the operation of CRCs has many implications in terms of time and workload both for staff involved in on-site waste management, and store managers being responsible for the organisation of waste take-back using in-house/contracted or 3PL fleet. The organisation of collection activities must be made in such a way to prevent waste from occupying valuable retail space and without impeding the system to deliver products in follow-up destinations or interfering with its capacity to process product returns. Coupled to these issues, the lack of equipment at stores needed to reduce waste volume prior collection, the need

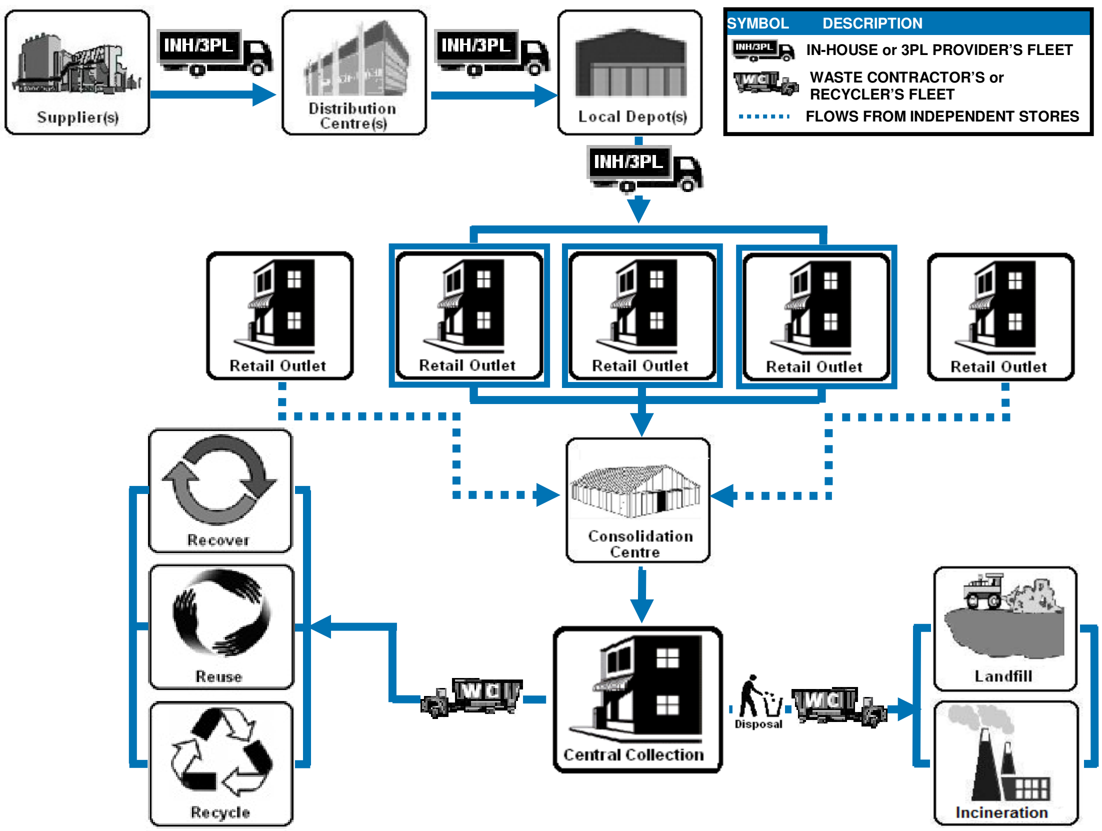


Figure 5: Centralised return centres (consolidation centres) for waste collections.

to transport re-usable or one-off packaging to ship waste, as well as the inability of the system to manage emergency collections are some of the issues a business should consider before embracing this type of waste collection technique.

In such a system one can distinguish between different coordination arrangements. For example the CRCs for waste collections may differ from the CRCs for products returns where employees assess the condition of each incoming item, and determine the best place to dispose of the item (gate-keeping operations). In addition forward and reverse distribution centres may differ because reverse CRCs are often more profitable for companies when outsourced (Beltran, 2002). On the other hand, a number of firms prefer the use of local hubs that allow local producers to pool their resources to reduce costs, cut carbon emissions and lower the overall environmental impact of product distribution and waste/returns collections. When products and waste are managed in the same centre then significant problems may arise in association with the mixing of the two flows. In those cases, operations related with the management of products to be delivered must precede the operations related with the management of waste. Finally locating a CRC for distribution or product returns has been the object of extended research with much of the focus being given on the optimisation of the location of hubs. Often researchers employ fuzzy goal programming in their models to examine issues such as capacity (Nie *et al*, 2009) and load allocation (e.g. Mujumdar and Vemula, 2004). In determining the siting of a CRC for waste and recyclables one should consider the local/regional recycling/disposal network along with the business branch network in order to eliminate the overall distances travelled. The optimal solution can be attained by case-by-case examination of the problem.

2.4.4.3 De-Centralised Waste Collections

The development of multiple waste contracts is often a result of the absence of centralised waste collection arrangements on site or over the branch network. In addition, the great variety in material characteristics and properties of waste/recyclates often dictate specific handling and treatment measures (control and separation) from the principal reverse waste flow (e.g. hazardous waste materials). Conflicting priorities, individual requirements including different collection time windows, incompatible waste types, different handling requirements, branding and privacy issues impeding retailers from exchanging information required to support integrated decision making, are some of the reasons why the retail industry has failed to drive innovation into the integration and coordination of system's–wide physical flows. On the other hand, McLeod *et al* (2007) concluded that when de-centralised returns networks take place, the existence of competent inspection, evaluation and disposition mechanisms for returns are essential in order for costs and vehicles kilometres to be minimised (Figure 6).

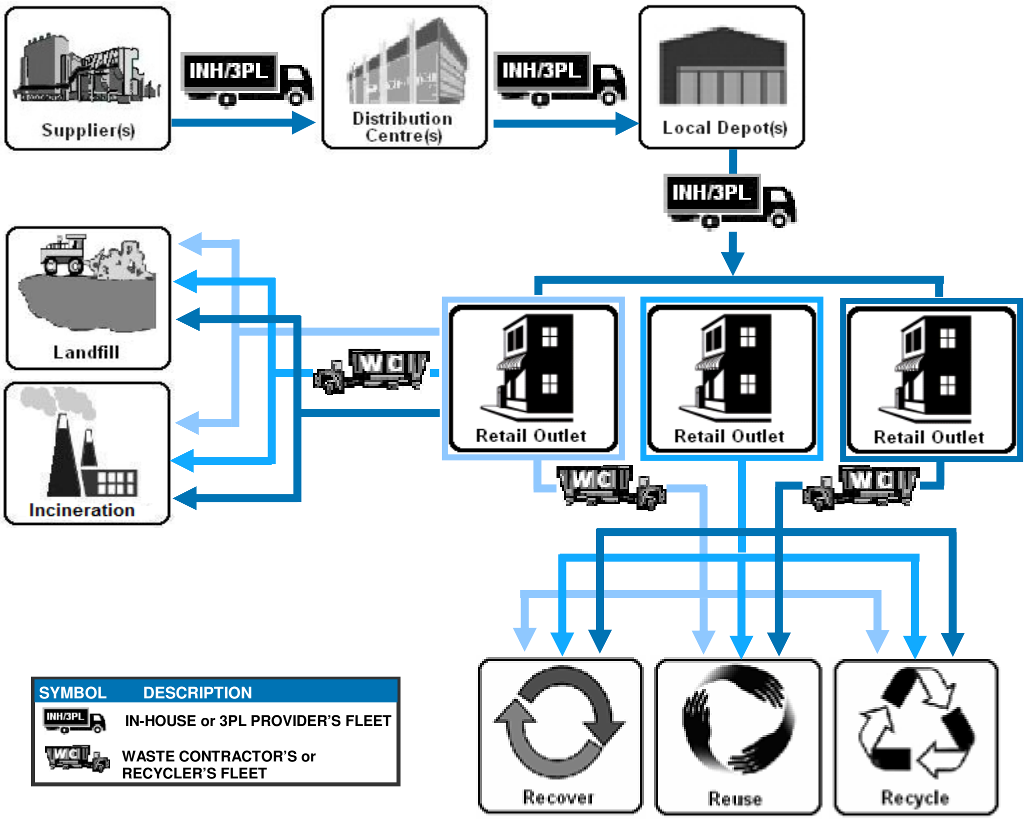


Figure 6: De-centralised waste collections within an integrated retail structure.

2.4.5 Transport of Commercial Waste

In order to overcome the operational complexities associated with planning and undertaking waste collections, many businesses outsource collection operations to specialised third parties who have the expertise and the tools to offer fully managed services which meet the clients legal obligations. Commercial waste can be collected by contractors, local authorities or through other routes (e.g. in-house management). Waste contractors may be national (*BIFFA*, *Sita, Onyx*, *Cleanway* etc) or local and offer flexible services at competitive prices. Larger retailers may use several different contractors to service their needs. Third party contractors can operate in a number of different ways (Rushton *et al*, 2010):

- Dedicated, exclusive service.
- Shared service.
- Specialised service.
- Multi-client distribution.
- Transit only.
- Joint venture between a 3PL and a client company.
- Occasional use in peak periods.

2.4.6 Disposition Routes for Waste Products

Typical waste disposition routes include recycling, re-use, energy recovery (incineration) and land disposal:

- *Recycling*: It is the conversion of waste materials into new products with the aim to reduce the consumption of raw materials, lower production costs, increase energy efficiency, reduce energy consumption in manufacturing, reduce land, water and air pollution and the associated disposal costs, and minimise reliance on imports. These benefits must be weighted against the costs of collection and treatment of wastes, the energy costs of reprocessing and the need to maintain quality in production (Roper, 2011).
- *Re-use*: It includes the repeated use of an item for the same function in order to save natural resources and reduce the amount of waste generated and ending up in landfills. Re-use can take place in the form of donation, re-sell or trade and may require an additional step: repair. In order to determine whether a product has a re-use potential and requires repair, it has to undergo the gate-keeping process (Section 2.3.3.1) where a number of faults are rectified in order to return the product to useful service (Barker and King, 2007). Re-use is often considered better than recycling as the latter requires increased resources, energy, time and money to process waste products into new usable items. However, re-usable items must be more durable than single-use products, while they often present increased cleaning and transport demands with direct impacts on the overall environmental footprint (Morgan, 2009).

- *Recovery*: It is the use of waste for the replacement of non waste materials with the aim to conserve natural resources (Environment Agency, 2010a). Recovery may include wholly or partly repair of end-of-life products, re-use, recycling, energy recovery and land recovery among others. The latter pertains to the use of waste materials for the reclamation, restoration or improvement of land (DEFRA, 2011).
- *Incineration (Energy Recovery)*: This can take three forms: a) Energy from waste which is the combustion of waste under controlled conditions with the aim to generate electricity or heat (e.g. steam or hot water) for beneficial purposes. Ash produced can be recycled into aggregate or used in the construction industry, while a limited quantity of residues produced as part of the flue gas cleansing are considered hazardous; b) Pyrolysis which is the thermal decomposition of wastes into gaseous or liquid fuels which need further treatment; c) Gasification which is thermal decomposition which transforms waste into fuel gas. All three methods result in major reductions in the waste volume (around 90%) reducing significantly the follow-up transport requirements (DEFRA, 2011).
- *Land Disposal*: It is the placement of waste in or on the land when other sustainable options, such as recycling and re-use, are not possible (Environment Agency, 2010a). There are three types of landfill: non-hazardous, inert and hazardous. One of the advantages of land disposal is that landfills receive mixed waste, therefore it is easier to enable higher consolidation and vehicle fill rates. On the other hand, the resource capacity of waste is not exploited, large land areas are required and the gases and liquids produced by the rotting rubbish can pose a threat to human health and the environment if they are not properly captured and treated (DEFRA, 2011).

As of 2009, there were in total 3,591 transfer stations, 1,381 treatment facilities, 2,411 metal recycling sites, 94 incinerators and 497 operational permitted landfills in England (Environment Agency, 2011).

2.4.7 Differences between Forward and Reverse Logistics

Fleischmann *et al* (1997) highlighted that reverse logistics is '*not necessarily a symmetric picture of forward distribution*'. Tibben-Lembke (2002) mentioned that a reverse logistics flow is much more reactive, with much less visibility as firms have to respond to actions initiated by consumers or downstream members. They suggested that the logistics systems associated with the return of goods present several disadvantages compared to a forward distribution of goods:

- Difficulty in forecasting the timing and quantities of returns because reverse logistics are initiated by individual customers.
- Movement of returns from many origins to one destination unlike the forward distribution of goods that takes place from one origin to many destinations.
- Doubtful quality of returned products and their packaging.
- Not uniform and varying quality and price of returned goods.
- Difficulty in determining the next destination (e.g. broker, recycling facility, back to market) and routing of a good returned to a central depot.
- Different levels of urgency in terms of 'gate-keeping' dictating the end-value of returns (e.g. electronics must be resold the soonest possible to avoid obsolescence or damage, while clothes may be stored until next season).
- Lack of storage space for returns and gate-keeping provisions at a store level.
- Differences in the nature and visibility of costs:
  - Higher transportation costs (smaller shipments, more frequent stops, and limited cube utilisation of trucks).
  - Higher handling and labour costs inside facilities due to potential repackaging and gate-keeping operations required.
  - Lower inventory costs unless the value of returned products has declined due to obsolescence, damage, out of season or bad repackaging.
- Inconsistent inventory management affected by seasonal accounting deadlines.
- More complex product lifecycle issues such as marketing changes (products phased out, replaced, out of season or out of production).
- More complex negotiations due to the varying quality of product returns.
- More marketing difficulties (e.g. brand equity and inconsistent supply).
- Lower visibility of the entire process for returns (e.g. lack of I.S. resources).

In addition, Bernon (2005) identified key differences between managing retail returns and end of life products mainly due to the far higher residual value of product returns when compared to end-of-life products passed into the waste stream.

2.5 Environmental Impacts of Freight Transport

The transport sector is the fastest growing source of greenhouse gases (GHG) in the UK. Although overall UK GHG emissions are decreasing, those generated from road transport increase steadily. Between 1990 and 2008, road transport GHG emissions increased by 5.8% to 118.4 million tonnes of CO_2 equating to 18.9% of total GHGs produced. The contribution of Heavy Good Vehicles (HGVs) in total UK GHG emissions increased from 3.1% in 1990 to 3.8% in 2008, while emissions from Light Good Vehicles (LGVs) presented a more radical increase (64%) since 1990 from 9.6 million tonnes of CO_2 (1.2% of total UK GHG emissions) to 15.8% million tonnes (2.5%) in 2008 (DfT, 2010d).

Although these statistics present the significant contribution of freight transport in overall UK GHG emissions, McKinnon (2007b) identified significant discrepancies between the different estimates in assessing the carbon footprint. He suggested that the opportunities to reduce carbon footprint should be systematically reviewed through the use of an analytical framework (Figure 7) that shows the relationship between the carbon intensity per tonne of freight moved in terms of seven key ratios:

- *Handling Factor*: It converts the weight of goods into freight tonnes-lifted considering that products are loaded on vehicles several times as they move through the supply chain. It is a crude measure of the links in a supply chain.
- *Average Length of Haul*: It converts the tonnes-lifted into tonnes-kilometre.
- *Transport Intensity:* It is the amount of freight movement generated for every tonne of goods produced/consumed. Its value arises from the first two measures.
- *Modal Split*: It shows the proportion of tonne-kilometres carried by different transport modes.
- *Average Payload on Laden Trips:* It indicates the load carried in tonnes.
- *Proportion of Kilometres run Empty*: It indicates the proportion of vehicles per kilometre that run empty. Along with the average payload on laden trips, this ratio is used to determine the amount of freight traffic needed to move the tonnes-kilometre.
- *Fuel Efficiency*: It shows the quantity of fuel consumed and depends on traffic conditions at particular times of the day on particular roads.

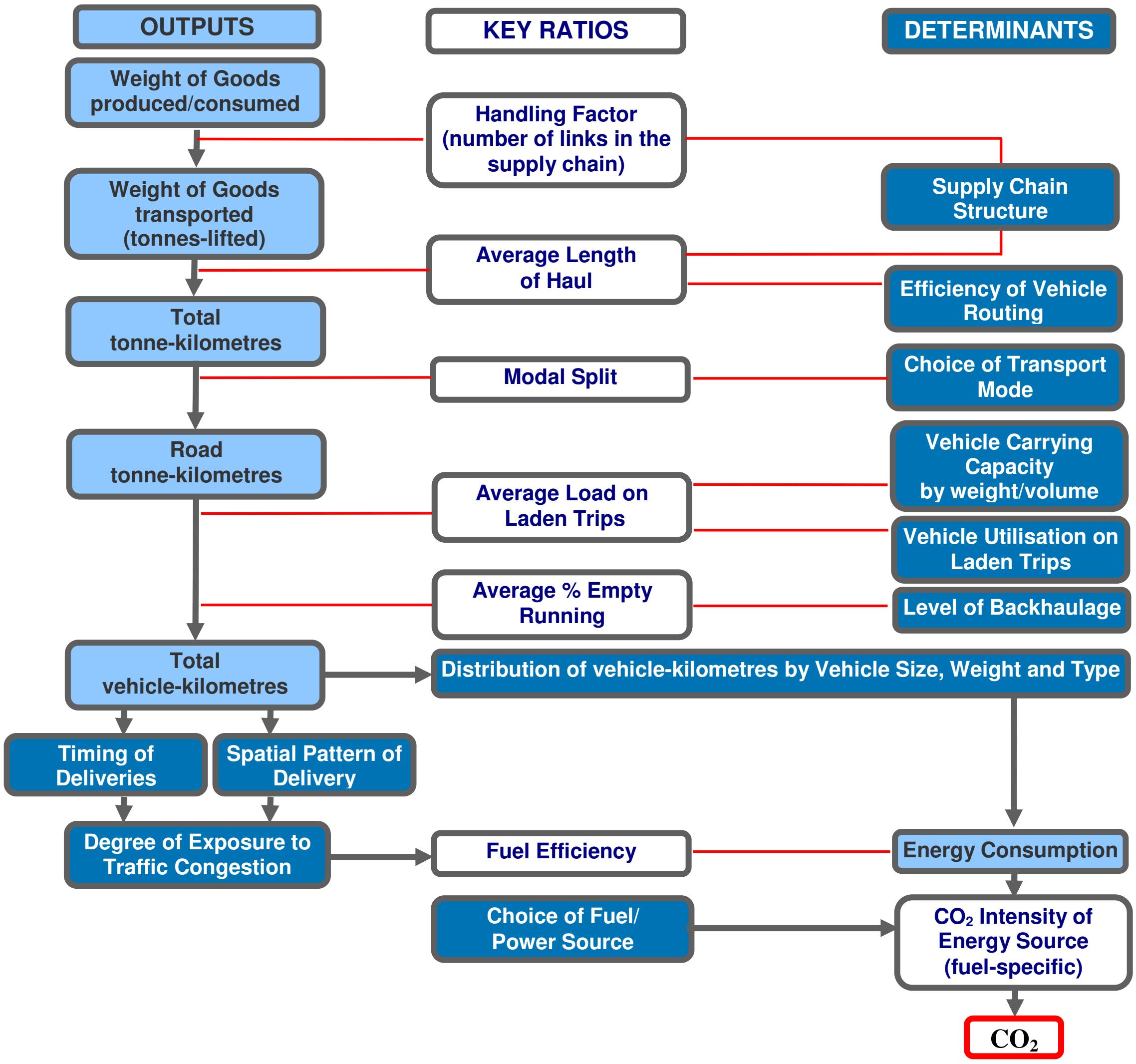


Figure 7: Framework for analysing opportunities for CO2 reduction (source: McKinnon, 2007b)

These ratios differ among different industry types, distribution systems, and vehicle modes, among others. In addition, the carbon footprint of different fuel types depends on the nature of raw materials, the efficiency of distribution systems and the production of fuels however the fuel consumption to CO_2 emissions is fixed for specific fuel/power sources (McKinnon, 2007b).

2.5.1 Carbon Footprint

A 'carbon footprint' measures the total GHG emissions caused directly and indirectly by a person, organisation, event or product (CarbonTrust, 2010). It considers all six of the Kyoto Protocol GHGs (CO_2, CH_4, N_2O, HFC_S, PFC_S and SF_6) and is measured in tonnes of carbon dioxide equivalent (CO_{2e}) allowing the different GHGs to be compared on a like-for-like basis relative for one unit of CO_2. CO_{2e} is calculated by multiplying the emissions of each of the six GHGs by their 100 year Global Warming

Potential (GWP) through the use of established conversion factors. Two main types of carbon footprint exist: one referred to all the activities across an organisation and one referred to the whole life of a product or service. The main characteristics of the six principal GHGs are summarised in Table 8:

Table 8: Main characteristics of the six Kyoto greenhouse gases forming the 'carbon footprint'

GHGs	Description
Carbon Dioxide CO_2	CO_2 is the most widely known of the GHGs contributing to global warming. It is a colourless, odourless gas which is a natural constituent of air and is also formed by natural processes and the combustion of fuels containing carbon (DECC, 2010). Its atmospheric lifetime is in the range of 50-200 years (ONS, 2009). It is released in direct proportion to fuel consumption, with differences in the amount of emissions by fuel type (TRB, 2006). As of 2008, CO_2 accounted for 85% of all GHG emissions in the UK (weighted by GWP) and made up 98% of all GHG emissions from domestic transport (DECC, 2010; DfT, 2010a). In total, freight transport was responsible for 16.8 mega-tonnes of GHGs of which 16.6 mega-tonnes (98.4%) were in the form of CO_2 (DfT, 2010b).
Methane CH4	CH_4 is a significant GHG with a much greater warming effect on the climate than CO_2. It has a GWP equal to 21 and a relative small atmospheric life of about 12±3 years (ONS, 2009; IPCC, 1996). It is a light, colourless and odourless pollutant that forms the main constituent of the most natural gas. The major sources for CH_4 are agriculture, waste disposal, coal mining and leakages from the gas distribution system. For road modes, CH_4 production is low and not proportional to fuel consumption, but affected by vehicle emissions control technologies, as well as the vehicle and fuel types used (TRB, 2006). As of 2007, CH_4 emissions accounted for about 8% (weighted by GWP) of the UK's GHG emissions (DECC, 2010). However, as of 2008 only 0.1% (18.9 kilo-tonnes of CO_2e) of GHG emissions from freight transport was attributable to CH_4 (DfT, 2010b).
Nitrous Oxide N_2O	N_2O is a powerful and long-lived GHG that has a GWP of 310 and an atmospheric lifetime of about 120 years, but with a relative small contribution to global warming (AEA, 2010; ONS, 2009). It is a colourless non-flammable gas produced by natural and human-related sources such as agricultural soil management, sewage treatment and the use of catalytic convertors in cars. Dependent on the technology used, the latter may result to up 20 times more N_2O than produced by non-catalytic cars (GHG Online, 2010). As of 2008, N_2O emissions accounted for about 5% (weighted by GWP) of the UK's man-made GHG emissions (DECC, 2010). In terms of freight transport, N_2O was responsible for 176.1 kilo-tonnes of CO_2e (1% of overall UK freight GHG emissions) (DfT, 2010b).
Hydro-Fluorocarbons HFCs	HFCs are synthetic chemicals not found naturally in the environment (Environment Agency, 2010b). They have very high GWP that range from 140 for HFC-152a to 11,700 for HFC-23 with varying lifecycles lengths, usually smaller than 15 years (EPA, 2010a). They are colourless, odourless and chemically unreactive gases, primarily replacing ozone damaging chlorofluorocarbons (CFCs) and hydrochlofluorocarbons (HCFCs) used in vehicle air conditioning and refrigeration systems (TRB, 2006). HFCs emissions are far smaller than those of CO_2 and represent only around 2.2% of total UK global warming contribution (Environment Agency, 2010b). As of 2008, freight transport accounted for 83.3 kilo-tonnes of HFCs in terms of CO_2e (0.5% of overall GHG emissions from UK freight transport) (DfT, 2010b).
Per-Fluorocarbons PFCs	PFCs are man-made chemicals, with very high GWPs usually ranging from 5,000 to 10,000, and very long atmospheric lifecycles that in most of the cases equal thousands of years (Environment Agency, 2010b). They are colourless, odourless, non-flammable and unreactive gases primarily used in production of aluminium and in fire extinguishing systems (EPA, 2010a; Environment Agency, 2010b), as well as replacements of CFCs and HCFCs in vehicle air conditioning and refrigeration systems (TRB, 2006). They are only released in relatively small amounts and their concentrations represent only around 0.1% of UK global warming contribution (Environment Agency, 2010b). The contribution of freight transport in the production of PFCs emissions is negligible (DfT, 2010b).
Sulphur Hexafluorides SF_6	It is a man-made chemical, an unreactive, non-toxic heavy gas with no colour and no smell (Environment Agency, 2010b). Among the GHGs it has far the highest GWP (23,000) and has an about 3,200-year atmospheric lifetime (EPA, 2010a). It is widely used as electrical insulation medium in the magnesium industry and in the manufacture of training shoes and vehicle tyres (AEA, 2010). SF6 is released in small amounts and represents only around 0.2% of the total UK global warming contribution (Environment Agency, 2010b). Its generation as a result of freight transport activities is negligible (DfT, 2010b).

Due to the low quantities of the three industrial GHGs (HFCs, PFCs and SF_6) produced by freight transport activities, these compounds are not included in reporting GHG emissions from freight transportation. An overview of the gases assessed by the most common GHG analysis techniques for transportation projects in USA and the UK is provided in Appendices B1 and B2.

2.5.2 Carbon Footprint Assessment Methods

Freight transport contribution to airborne emissions is difficult to estimate and requires a number of assumptions (e.g. average vehicle load and speed and selection of gases to examine) to interpret emissions data. Currently, there is a range of methods, emissions factors and functions, for use in estimating the carbon footprint of transport and other activities.

2.5.2.1 Classification of Carbon Footprint Assessment Methods

Greenhouse emissions can be measured either by recording emissions at source by continuous monitoring (input-based measures) or by estimating the amount emitted using activity data (e.g. fuel consumption) and applying relevant conversion factors (output-based measures). These factors allow the conversion of activity data (e.g. litres of fuel consumed and number of kilometres/miles driven) into kilograms of CO_{2e} (DEFRA, 2010).

- *Input-Based Measures*: these are based on estimates of the fuel purchased by/supplied to companies in particular sectors. These are industry-specific and confined to the country a business is registered. However, as many businesses operate in more than one country, emissions from freight transport operations are not confined to operations taking place in the country of registration. For example, the EMEP/CORINAIR provides a fuel consumption based approach for the estimation of emissions (Appendix B2).
- *Output-Based Measures*: these are derived from estimates of the amount of freight movement, expressed either in tonne-km or vehicle-km. They are activity- or mode-specific and not confined to the operations taking place in the country of registration.

Emissions factors may be either only available for direct emissions of gases at the point of use of a fuel/energy carrier or for indirect emissions factors (known as fuel cycle or Well-to-Tank emissions factors) associated with the production and disposal stages of fuels to enable the estimation of life-cycle emissions (DEFRA, 2010).

- *Direct Emissions Assessment Tools*: These tools calculate emissions emitted at the point of use of a fuel/energy carrier.
- *Indirect Emissions Assessment Tools*: These tools calculate emissions emitted prior to the use of a fuel/energy carrier (upstream processes) e.g. as a result of extracting and transforming the primary energy source (e.g. crude oil) into the energy carrier (e.g. petrol), and also subsequent to the use of a fuel/energy carrier (downstream processes) e.g. crude oil disposal.

Another distinction of GHG assessment tools/methods can be made on the basis of the type of application (calculation, strategy analysis and forecasting). According to a report prepared for the Transportation Research Board (TRB, 2006) reviewing the strengths, limitations and applicability of available GHG analysis techniques for transportation, 17 available tools were classified under 3 main categories (Appendix B1):

- *Transportation GHG Calculation Tools*: GHG emissions are calculated on the basis of a range of activity levels (e.g. VTM or fuel consumption) and vehicle fleet inputs (e.g. vehicle fleet mix and age). Such tools include EPA's MOBILE6, SIT, MOVES and GREET models.
- *Transportation/Emissions Strategy Analysis Tools*: Travel and emissions impacts of specific types of transportation strategies are estimated on the basis of strategy parameters (e.g. strategy type) to assess travel impacts and emissions. The CO_2 calculations are relatively simple without accounting for complex implications of vehicle operating characteristics on emissions. Such tools include the U.S. COMMUTER and IDAS models.
- *Energy/Economic Forecasting Tools*: Energy consumption is estimated on the basis of economic factors such as economic growth and fuel prices. An example of such tools is the U.S. NEMS model.

In addition, the '*2006 Intergovernmental Panel on Climate Change (IPCC) guidelines*' requires the development of transparent, complete, consistent, comparable and accurate inventory tools. On this basis, Bader and Bleischwitz (2009) discussed the assessment of GHGs at a local level using either local or national inventory tools. Often though, such inventory tools refer to the overall GHG emissions generated in a territory and not only to those induced by transport activities.

- *Local Inventories (Bottom-up Approach)*: Emissions at a local level are estimated using geographical source data with local datasets and appropriate emissions factors. This provides the most reliable indication of the magnitude and spatial distribution of emissions but requires high workload and time commitment. For example, LAEI is a database with information on emissions from all sources of air pollutants in the Greater London area (Appendix B2).
- *National Inventories (Top-Down Approach)*: Data used for local studies are scaled from national GHG inventories. Such data reflect the national average for a certain emission source and not necessarily the actual local emissions. This approach is preferred when the relevant data are difficult to obtain at a local level, the workload is very high and data are not expected to represent a great share of overall emissions. For example, NAEI is the UK's national atmospheric emissions inventory (Appendix B2).
- *Mix of Bottom-Up and Top-Down Approaches*: In practice, individual inventories often use both bottom-up and top-down methodologies as cities face a trade-off between compiling an inventory as accurate as possible on the one hand and limiting the time needed for the undertaking on the other hand.

2.5.2.2 UK Types of Carbon Footprint Assessment Methods

McKinnon (2007) identified two types of estimate:

- *Input-based measures*: these are industry specific measures based on estimates of the fuel purchased by/supplied to companies in particular sectors and apply only to UK-registered companies. The *United Kingdom Environmental Accounts*, maintained by ONS, contains data on CO_2 emissions for HGVs freight of companies whose main activity is transport [EA code 67].

- *Output-based measures*: these are activity- or mode-specific measures derived from estimates of the amount of freight movement (tonne-km or vehicle-km) and are not confined to UK-registered companies operations. In UK there are two measures for HGVs: the '*Continuing Survey of Road Goods Transport*' (CSRGT) data and the combined '*National Road Traffic Survey*' (NRTS) and (CSRGT) data which makes possible to disaggregate emissions by road type and location. There is also a measure for vans, based on the '*2004 Survey of Van Activity*' and assuming that vans account for only 35%.

McKinnon and Piecyk (2009) identified four approaches adopted in the UK to estimate CO_2 emissions from road freight transport on a territorial basis:

- *CSRGT-based estimation of CO_2 emissions from British-registered operators*: CO_2 emissions are estimated on the basis of total fuel consumption using the standard conversion ratio for diesel fuel (2.63kg of CO_2 per litre of diesel fuel). Fuel consumption is calculated by multiplying the average fuel efficiency and the average annual distance travelled by different classes of trucks running on UK roads by British operators only. These data are obtained by the CSRGT.
- *Combination of traffic flow estimates of truck-km with survey-based fuel efficiency estimates*: This approach integrates the count-based truck-km data derived from the NRTS with survey-based fuel efficiency estimates derived from the CSRGT. It requires gross weight classes (CSRGT) alignment with axle numbers for rigid and articulated HGVs (NRTS) and assumptions made about the fuel efficiency of foreign operators running their trucks in the UK. Since 2007 this approach is adopted to derive CO_2 estimates for HGVs in the UK National Atmospheric Emissions Inventory (NAEI).
- *Combination of traffic flow estimates of truck-km with fuel efficiency estimates based on vehicle test-cycles*: The NRTS database is used in a much more disaggregated form, taking into account of the classes of road on which HGVs travel and the average speeds attained on these roads. Speeds are associated with the speed-fuel efficiency ratios derived from test-cycle analyses to obtain fuel estimates according the pattern of the HGV movement and the nature of the road infrastructure.

- *Estimate of total fuel sales to HGVs multiplied by the CO_2 conversion factor*: Diesel engine road vehicle (DERV) sales are apportioned retrospectively among vehicle types to match with the supply of diesel fuel to the UK market. Fuel consumption by HGVs is published in the Digest of UK Energy Statistics (DUKES). These are identical to the NAEI statistics following a normalisation process in order to provide CO_2 estimates.

A detailed description of the method selected in order to assess the carbon footprint from examined freight activities in this study was made in accordance with the guidance provided by DEFRA (2010) and is described analytically in Chapter 4.

2.6 Freight-Related Studies and Research Needs

This section reviews a number of previous freight-related projects to bring into the surface specific data requirements, data collection and analysis methods.

2.6.1 Major UK and European Freight Projects

The course of the logistics sector in the last two decades has been reflected in major European and UK research projects. A considerable focus was given on the use of cleaner vehicles and fuels (e.g. CIVITAS projects), the efficient, competitive and more sustainable urban transport systems (e.g. NICHES), the use of technologies to improve urban freight and logistics operation (e.g. BESTUFS), the optimisation of vehicle load capacity and improvement of trans-shipment operations (e.g. FIDEUS), the collection and dissemination of logistics best practice knowledge across Europe (e.g. BESTLOG) and more innovative concepts in reducing the environmental externalities of logistics activities, while achieving a more sustainable balance between economic, environmental and social objectives (e.g. GREEN LOGISTICS).

The following table provides a brief description of the most relevant to the study freight-related projects. Further information can be gathered from projects websites, the '*Transport Research Knowledge Centre*' of the *European Commission*[2] and the '*UK Engineering and Physical Sciences Research Council (EPSRC)*'[3].

[2] Transport Research Knowledge Centre, Directorate-General for Mobility and Transport, European Commission (http://www.transport-research.info/web/)
3 UK Engineering and Physical Sciences Research Council (EPSRC) (http://gow.epsrc.ac.uk/ChooseTTS.aspx?Mode=TOPIC&ItemDesc=Transportation+Operations+and+Management)

Table 9: List of the most important UK and European projects pertinent to this study.

Name	Description	Duration	Funded by
CIVITAS CIVITAS PLUS CIVITAS II CIVITAS I	The CIVITAS Initiative helps cities to achieve a more sustainable, clean and energy efficient urban transport system by implementing and evaluating an ambitious, integrated set of technology and policy based measures. http://www.civitas-initiative.org/	2008-2012 2005-2009 2002-2006	European Commission
NICHES NICHES PLUS NICHES	The mission of NICHES is to promote innovative measures for making urban transport more efficient and sustainable and to move them from their current "niche" position into a mainstream urban transport application. http://www.niches-transport.org/	2008-2011 2004-2007	European Commission
BESTUFS BESTUFS II BESTUFS I	BESTUFS aims to identify, describe and disseminate best practices, success criteria and bottlenecks with respect to City Logistics Solutions (CLS) http://www.bestufs.net/	2004-2008 2000-2003	European Commission
FIDEUS	FIDEUS aims to provide a complementary set of vehicle solutions to support an innovative approach to the organisation of urban freight transport, in line with political strategies to safeguard the "liveability" of cities, while being compatible with efficient logistics. http://www.cvisproject.org/en/links/fideus.htm	2005-2008	European Commission
BESTLOG	BESTLOG aims to collect and disseminate logistics best practices through the development of a dissemination and promotion platform. http://www.bestlog.org/	2006-2010	European Commission
GREEN LOGISTICS	GREEN LOGISTICS examines ways of reducing environmental externalities and achieve a more sustainable balance between economic, environmental and social objectives. http://www.greenlogistics.org/index.htm	2006-2010	EPSRC (UK)

2.6.2 Freight-Related Establishment Studies

As part of the Green Logistics project, Allen *et al* (2008) have reviewed over 160 freight surveys undertaken across the UK, EU and USA since 1960. The majority of these studies has been funded by either local, regional or national government departments, research bodies or through other public sector agencies and has used business establishment surveys as their main data collection medium. Nearly 50% of these have taken place in the UK with the aim to collect information about core goods delivery and service vehicle visits, origin-destination movements and other supply chain characteristics. Studies were either confined to retail outlets and catering units, such as in a number of studies in Winchester (Edwards, 1997; Cherrett *et al*, 2002; Cherrett and Hickford, 2005) or were combined with freight operator, driver or more general traffic count surveys, many of which have taken place around London (TTR, 2007) using relatively small sample sizes (usually between 50 and 100 establishments). In addition, a small number of more recent studies (e.g. Browne *et al*, 2005a; Lewis *et al*, 2007; Campbell *et al*, 2010) examine the establishment of urban consolidation centres as a way to address the last-mile issue (Chapter 7).

2.6.3 Data Collection Methods and Issues in Freight-Related Establishment Studies

One of the main challenges faced in previous studies was the selection of the data collection method and the survey technique in the case of interviews. A review on the survey techniques employed in freight related establishment surveys (Allen and Browne, 2008) identified mail/fax/email questionnaires, telephone and face-to-face interviews as being the most commonly used data collection techniques. Higher average response rates were achieved in interview surveys (59%) compared with self-completion surveys (25%) providing also better quality and more detailed information. However, the frequent uncertainty of respondents regarding the vehicle types used, the origins of vehicles/goods and the loading/unloading times and the locations has meant that combinations of techniques were often required for different groups of players within the supply chain.

In addition, Van Binsbergen and Visser (1999) noted the lack of general-use classification of retail establishments in urban freight research. This was further confirmed by Guy (1998) who highlighted the lack of any universally applicable classification system, even within one geographical area and time period. As a result most urban studies have developed unique methodologies to enable comparison between different businesses and studies. In a review of UK urban freight studies, Allen *et al* (2008) identified that classifications are made on the basis of business types, floor space data, employee characteristics, product ranges and packaging types. Guy (1998) suggested that for most purposes, classification based on types of goods was deemed most appropriate, but often should be accompanied by a second dimension such as ownership type or size. However, several difficulties were often experienced in the collection of floor size and employee data and the classification of products and packaging due to lack of standardisation. This has turned attempts at comparisons difficult if not impossible (Allen *et al*, 2008). To this end, Cherrett *et al* (2009) suggested that the '*UK SIC 2007*' should be used wherever possible to enable cross-survey comparisons. In their Winchester study, attempts were also made to link retail activity to the number of employees or stores sales turnover however these turned out to be unsuccessful due to lack of data. Instead, freight activity was linked successfully to retail activity (floor area) and the types of supply chain (centralised, de-centralised or hybrid). The latter classification was also identified in previous studies in London and Norwich (Allen *et al*, 2000).

2.6.3.1 Businesses Classification under SIC 2007

The '*UK SIC*' was first introduced in 1948 for use in classifying business establishments and other statistical units by the type of economic activity in which they are engaged (SIC, 2007). The classification provides a framework for the collection, tabulation, presentation and analysis of data and its use promotes uniformity across business and economic statistics. The introduction of *SIC 2007* represents the first major revision of the SIC system since 1992 (TSG, 2010). It is a hierarchical five digit system divided into 21 sections (1 digit), each defined by the next breakdown – 88 divisions (2 digits) which in turn are broken down into groups (3 digits), then into classes (4 digits) and, in several cases, into subclasses (5 digits).

SIC classifications are determined according to the principal activity of a business considering the value added to it (SIC, 2007). This refers to a business' core competencies, namely the type of main core goods (MCGs) and/or services traded (e.g. in Maynard and Cherrett, 2010). These products/services are usually the first products the company created and sustained from its founding which are central to its performance and make the most money that sustain the business. For example, in the case of the stores selling electronics MCGs are computers, mobiles phones and other electrical goods, while in restaurants MCGs are food products and drinks.

A business may perform more than one economic activity which may fall under any other SIC category than the principal one. Such activities are called secondary and refer to secondary core goods (SCGs) and/or services. Secondary activities are not central to the company's performance and make a smaller contribution to a company's financial condition than that of the principal activity (SIC, 2007). For example, in stores principally trading clothing, SCGs may be jewellery and footwear. The SIC code also makes a distinction between principal and secondary activities, on the one hand, and ancillary activities, on the other. Ancillary activities are considered as all service activities needed to carry out the principal and secondary activities (e.g. repair and maintenance, cleaning and sales promotion). For the purposes of this study, the products needed to carry out ancillary activities are called service products (SPs). Such products are essential for day-to-day operations, but not destined for sale purposes and may include promotional materials (e.g. graphics), stationery, packaging (e.g. carrier bags, boxes) and cleaning materials.

2.6.3.2 Businesses Classification by Store Size

Currently there is a great variation in the size of retail businesses as a result of the establishment of big multi-product chains, the formation of super-centres, the reduction of large downtown establishments and the local businesses shrinking in size (Dunne and Lusch, 2005). Coupled to the current economic turmoil, further changes in the usage of commercial floor areas occur as a result of the decline in the demand for commercial property, the rise in the amount of available floor space and the significant reductions in property rents (RICS, 2009). Moreover, businesses face increased economic strains in terms of growing stocks of unsold products. These trends influence the need for storage capacity and transport of products back to distribution centres, suppliers or secondary markets. As a result, commercial floor sizes are now bigger or smaller than their counterparts in the past as a means of trying to ‘kill’ the fierce competition.

Although one might assume that larger stores are responsible for more freight activity, this may not be the case when considering the type of the adopted distribution/ collection systems. Often larger stores use larger delivery vehicles, consolidate loads more and/or are served by centralised distribution or return consolidation centres, while smaller stores receive more deliveries from a range of suppliers using smaller vehicles (Cherrett *et al*, 2009). The nature of products and the location of the relevant gate-keeping operations also determine whether unsold and defective products are treated at stores or elsewhere. Such decisions are interlinked to the need for and the availability of storage capacity. For instance, many restaurants use fresh products for cooking increasing the need for onsite storage (e.g. fridges/freezers), businesses selling clothing may store out-of-season unsold clothes in stock rooms if available, otherwise ship them back to distribution centres re-stocking stores in the next sales season, while businesses selling electrical equipment may have to send faulty products to repair centres, suppliers or manufacturers unless they have the capacity in terms of experts, equipment and floor area to run gate-keeping and repair operations in-store. To better reflect the situation, in most cases a combination of variables such as product turnovers, product ranges and goods supply systems is also needed to relate the number of deliveries/collections with floor space (Allen *et al*, 2008). Due to the complexity involved though, only few studies such as the ones in Ealing (MVA, 2004) and Wallington (MVA, 2005) have managed to collect this information.

Classification by size can be problematic in several ways, including decisions about the selection and usage of the sales or the total floor area and the availability and/or provision of the relevant data. In a study about classification systems commonly used in retail outlets, retail areas and shopping centres in the UK and North America, Guy (1998) concluded that the sales area was more indicative of the volume of the merchandise in a store. One should consider though the difficulties in measuring sales areas from large-scale maps and the implications in selecting the arbitrary size boundaries of classes especially in the case of stores varying significantly in nature or in the case of international comparative studies. The study concluded that classification by size can be constructive when the relationship between the business sizes and the parameter(s) researched (e.g. number of shopping trips) was clear and when there was a balance between comprehensiveness and simplicity. Such a system should always consider the applicability and feasibility of the selected classes and boundaries as the case may be.

2.7 The Way Forward

Organisations can effectively adopt the waste hierarchy principles for product disposition, by adopting the following management approaches: integration, collaboration and evaluation (Figure 8).

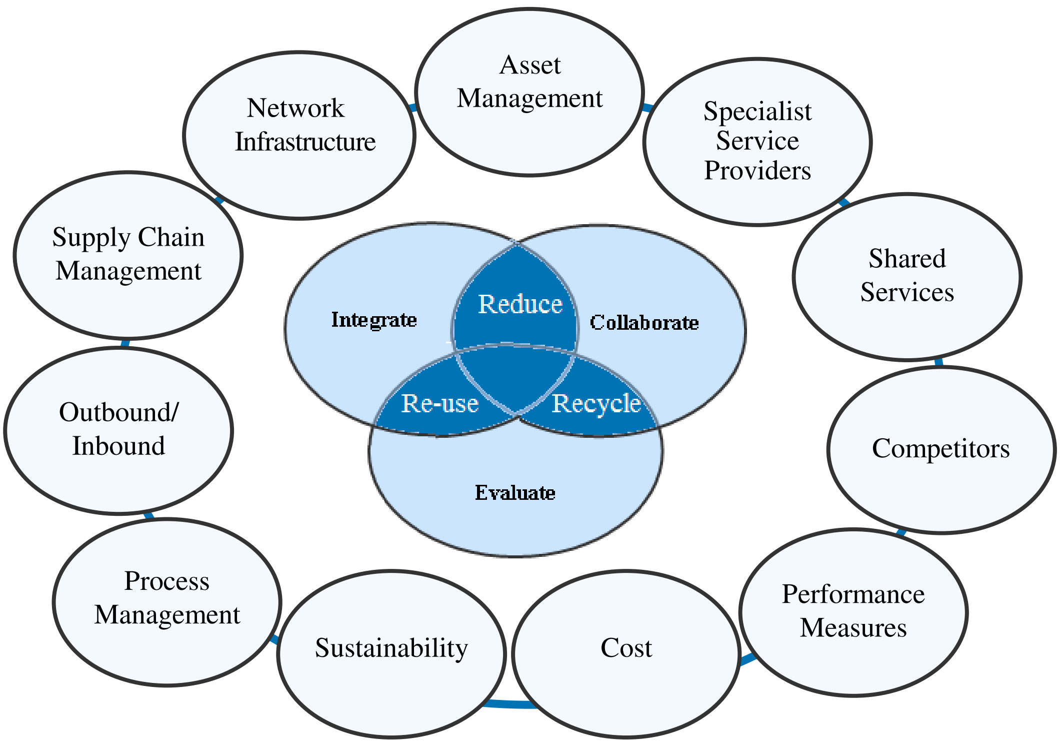


Figure 8: The way forward for managing returns (source: DfT, 2004a)

Further opportunities to reduce the transport impacts of the collection of product returns and waste materials, lie on the development of back-haul operations, freight consolidation and synergistic alliances among different actors of the supply chain.

2.7.1 Back-loading

Back-loading, the utilisation of delivery vehicles spare capacity to carry loads on return journeys is an operational tool that can be used to reduce the number of empty-running trucks on road, alleviate traffic congestion, combat environmental impacts and improve efficiency (Shakantu *et al*, 2002). Reverse logistics gives scope for the back-load of returned components, waste/recyclables and re-usable packaging from the consumer or the retailer out to the points of disposal. Back-loads '*logistics against the flow*' create opportunities for businesses to minimise double handling and create cost savings through higher vehicle and driver utilisation, as well as lower fuel requirements (Freight Best Practice, 2005).

Often the development of backhauling practices is inhibited by a number of factors. In trying to increase vehicle utilisation, an individual company is often constrained by the activities of its suppliers, distributors and customers. Significant problems also may arise from the mixing of the two flows of goods, one heading to consumers and one heading backwards (Elliot and Wright, 2004). This may happen when delivery vehicles stop at multiple stores and any previously returned merchandise must be offloaded first to allow for new products to be offloaded. There is also a great temptation for personnel, both at a store and at a depot level, to be redirected to work on the 'more important' area of distribution, the forward or the backward, dependent on the demand experienced (Tibben-Lembke and Rogers, 2002). The integration of individual logistics operations into a 'network system' requires the formation of closer synergistic alliances between suppliers and distributors overcoming any variances in working practices, any mistrust between partners, the absence of organisational framework to jointly review operations and the lack of consistent data on transport efficiencies (Freight Best Practice, 2005).

2.7.2 Consolidation

To combat environmental impacts and minimise costs, logistics managers are looking towards the reduction of the number of transits through the consolidation of freight movements. Logistical management decisions involving freight consolidation and backhaul management may increase the load balance to help reduce the number of empty trucks on the road, alleviate traffic congestion and cut down pollutants emitted (Shakantu *et al*, 2002).

When intensive use of consolidation operations takes place as part of supply transportation services in a network-wide scale the complexity of each type of operation, the relationships and trade-offs between these operations and the associated economic and service productivity measures and decision criteria turn the tactical planning into a particularly difficult process for firms and organisations. In addition different paths for product returns including transfers from consolidation centres to locations where products are refurbished or re-distributed and spare parts/accessories are resold add legs of freight introducing even more risk for freight-related expenses. Accumulating and consolidating products can reduce freight carrier expense, but the product is also depreciating while it waits on dock (Mehrmann, 2008). Therefore a thorough examination of a system's characteristics must be made to find the best match between the resources used and the level of service provided. Chapter 3 provides a thorough insight into the concept of urban consolidation through the examination of a number of existing consolidation schemes in the UK context.

2.7.3 Collaboration

To ensure successful reverse logistics management a crucial aspect is the notion of collaboration, where potentially rival businesses band together to share the burden and exploit any synergies that might arise from using an interlinked network, rather than a series of disparate operations (Elliot and Wright, 2004; Gardner, 2005). This concept is forming around the consensus that businesses can tackle their legislative obligations using their existing systems without investing in rather costly, made-to-measure reverse logistics systems when dealing with specialist contractors on a stand-alone basis or relying on municipal facilities. Mutual cooperation and good communication between the actors of the network and between different producer co-operatives (Lehtinen and Poikela, 2006) such as retail businesses, logistics providers, waste contractors, local authorities, community groups and the public (Read, 1999; Pitt, 2005), set out the changes needed to deliver more sustainable development.

The development of collaborative strategies among retailers has been impeded so far by a general lack of coordination among cross-supply chains. Sharing information to support integrated decision making is often difficult due to privacy issues and retailers needing to maintain their market position. Data sharing, publicity and protecting brand image issues add to current practical restrictions limiting more cross-supply chain coordination. Multiple container types, multiple delivery time windows, different priorities for different customers/suppliers, limited fleet sizes (Archetti and Speranza, 2005) incompatible waste types and different handling requirements challenge businesses and require a careful and proper case-by-case consideration of individual requirements in order to link and coordinate reverse operations.

Strategic partnerships and alliances among leading edge businesses have proven successful in driving change within a particular service or sphere of operation (Pitt, 2005). Individual companies can follow this example and gain significant benefits through coordinated collection processes and integrated decision making overcoming any privacy and market position issues impeding the development of such collaborative strategies. Supply chain integrators that have experience managing multiple operations and relationships may play a pivotal role (Elliot and Wright, 2004). As far as shopping centres are concerned, such coordinated action requires liaison and partnership with the retail units and the suppliers, while shopping centre managers can contribute directly by improving centralised opportunities for the re-use and recycling of waste produced by tenants (Pitt, 2005).

2.8 Need for Research

The integration of environmental concerns into the network design of supply chains first appeared in 1990s as a result of a series of new transport policies. The degree of research on green logistics at the time was characterised as ‘small but expanding’ (McKinnon, 1996b). Rogers and Tibben-Lembke (2001) justified the absence of both pertinent literature and knowledge on the potential of logistics to reduce environmental pollution as a result of a general lack of information systems (IS) resources and recognition of the reverse logistics importance. The rapid growing interest in the ‘greening’ of logistics provides plentiful excellent opportunities for additional empirical research on the relationship between environmentalism and logistics management (Murphy and Poist, 2003).

At the same time, the industry had developed very narrow and specific interests (Rodrigue *et al*, 2001) mainly relating to the financial implications of logistics activities. Recently, certain firms have begun to benchmark return operations and include reverse logistics as part of their management strategy (Beltran, 2002). Some individual centres do perform well, however the sector as a whole does not show a decrease in the level of waste production despite the introduction of various environmental regulations (Pitt, 2005). Especially in the case of hazardous waste materials more in-depth investigation is warranted due to the variety of hazardous waste characteristics and the diverse environmental regulations in place requiring specific solution measures such as control and management of reverse logistics (Wang *et al*, 2008).

To improve the performance of the retail sector and to link and coordinate key elements of reverse logistics, such as returns and their disposal into a closed-loop supply chain, it is not enough to focus research on the end result of reverse logistics and consider it an isolated process. A holistic view must be taken to reduce material in the forward system, increase re-use and recycling of both the product and its packaging (Beltran, 2002) and evaluate the impact on the environment (emissions assessment). Paramount to accomplish this is understanding the trade-offs between environmental impacts and optimal supply chain efficiency (Wu and Dunn, 1995) and determining the most appropriate way to combine, adapt, generalise and modify reverse logistics practices, such as cooperation of interest groups (Geroliminis and Daganzo, 2006).

To help individual logistics firms and logistics managers find the best match between environmental considerations and profitability (Rodrigue *et al*, 2001) additional spatial, sectoral or temporal empirical research in green and comparative logistics must be made (Murphy and Poist, 2003). McKinnon (1996b) proposed that the following research areas should be further covered:

- Survey-based analysis to improve knowledge and understanding in reverse logistics trends.
- Development of retails logistics technologies including software, co-ordination of IT systems, mechanisation/automation of sortation, development of new reusable handling equipment and control systems. Impact studies to

assess the effects of socio-economic, infrastructural and environmental developments on retail logistics.

The organisation of logistics networks is determined by current supply chain trends that include the spatial concentration of production and inventory, the development of peripheral trans-shipment and hub systems, wider geographical sourcing of supplies and distribution of finished goods, timed delivery systems, reverse logistics and online shopping, among others (Lehtonen, 2008). These systems are characterised by decreased inventory levels, increased service frequency, decreased production costs, longer distances between producers and retailers, smaller size of consignments, and accuracy and consistency in deliveries (Zografos and Giannouli, 2003). In addition, reverse logistics networks are characterised by irregular flows, random assortment and diverse quality of returned goods and waste (Wyld, 2006). As the supply chain management discipline continues to develop, there are significant issues that researchers need to address (Stock *et al*, 2010). Radical changes in online shopping, for example, have changed and will further change the way businesses build their logistics mechanisms (e.g. distribution networks, warehouses, fleet). Xing and Grant (2006), and Fernie *et al* (2010) highlighted the significant increases in the volume of goods and returns transported, the demand for new distribution centres, larger vehicle fleets, faster, more reliable and timely deliveries, and changes in the geographical pattern of home deliveries (Section 2.3.2.4).

Gate-keeping planning is another area that deserves more consideration and involves finding ways to reduce the number of items entering the return flow by screening return merchandise (Rogers and Tibben-Lembke, 1998; Section 2.3.3.1). More research is needed to investigate the possible ways in which environmental decisions can be incorporated as part of value-added activities such as door-to-door and just-in-time deliveries (Section 2.2.2.4), after-sales services and technical support. Only few studies (e.g. Christopher *et al*, 2009; Edwards *et al*, 2010) have investigated the last-mile issue, considering that emissions in the final leg of distribution (between home and store for conventional shopping and depot and home for online shopping) account for a large proportion of overall emissions. Finally, only few studies (e.g. Browne *et al*, 2005a; Lewis *et al*, 2007; Campbell *et al*, 2010) have examined the establishment of urban consolidation centres as a way to address the last-mile issue (Chapter 8).

2.9 Summary

This chapter depicted the rapid development of logistics in the second half of the 20th century and documented the gradual shift of its focus from warfare to business and from cost-minimisation to customer value-oriented processes. It recorded the breakthrough of environmental policies and explored various legislative, financial and operational challenges facing retail businesses. The aim was to identify ways to optimise existing logistics processes to reduce congestion, costs and emissions. To this end, a number of previous freight-related projects were reviewed to bring into the surface specific data collection and analysis needs that would enable the assessment of logistics and environmental externalities under a number of operating scenarios.

Focusing on the forward flow of materials, the review of the literature suggested that the real importance of logistics is to maintain sufficient material supply of businesses while providing customers with superior services such as quality products, low damage rates, on-time deliveries and order cycle time reliability. A description of the current legislation placing producers, retailers and carriers abide by numerous responsibilities was made and various socio-economic factors that have led into significant innovations in the design of forward channels for different supply chains, types of premises and products were discussed. This section also highlighted the shift from inventory-based to replenishment-based logistics and witnessed the prevalent use of HGVs in long-distance trips and vans in urban areas in order to increase overall fill rates and reduce empty-running vehicles performing JIT deliveries. In further, it presented the outsourcing of distribution activities to 3PL providers, the introduction of hub-and-spoke and intermodal transhipment centres, the adoption of factory gate-pricing network systems and efficient loading and packaging methods for products.

Concerning reverse flows, the review of the literature revealed that product returns are generated either from the government through a set of legislative provisions, the industry interested in recycling/re-using obsolete, over-stocked, out of season, after sales or unwanted stock in order to gain generous refunds while promoting a philanthropic and green profile, or the customers returning products that fail to satisfy minimum statutory requirements. It also highlighted the need to develop different return mechanisms for different types of returns giving special attention to emergency product recalls, e-sales and the location of gate-keeping operations. It revealed the critical role of short disposition cycle times for fast-moving products and pointed out that shorter lead times could reduce the likelihood of products entering the waste stream. It unveiled the complexities related to the low visibility on service demand for repairs and highlighted the increased requirements for storage space, specialised equipment and staff running gate-keeping and repair operations. Insights were also given on the operational and logistics benefits that could arise from the use of consolidation centres for returns, inter-store transfers and stock-holding activities.

Current collection, transport and treatment requirements for solid and hazardous materials produced as part of day-to-day operations, customer returns and take-back schemes were also reviewed to identify how environmental legislation, disposal, treatment and transport costs, and environmental and public health concerns impact their implementation and how these could be made by more sustainable means. The examination of numerous case studies exhibited the variety in the characteristics and properties of wastes and the role of material-specific legislation on the way different waste streams should be managed and disposed of. In reviewing the network structures for waste collections, two different mechanisms were identified; one often developed in integrated retail structures where waste is consolidated on-site and managed centrally and another in large retail chains where waste is consolidated centrally but at a regional/national scale. In both cases it was found that collections were implemented using the backload capacity of the delivery fleet or by outsourcing waste management collection and treatment services to specialised waste contractors.

Overall the review of the literature highlighted the considerable mileage, environmental and cost savings that could arise from the optimisation of logistics operations and the integration of supply chain processes. In the case of deliveries, such gains could be generated through the operation of consolidation centres and milk-runs, the use of low-carbon vans in urban areas and larger vehicles in long-haul trips, and the use of improved scheduling and communication tools. Businesses could further shrink their logistics costs and increase the agility of their supply chains by using centralised return centres and local hubs to process product returns. Regarding waste collections, such savings could arise from the co-location of distribution and waste management facilities, the adoption of more efficient back-loading practices and the development of cross-supply synergies controlled by a logistics co-ordinator.

Chapter 3: Freight Consolidation

3.1 Introduction

Freight consolidation is a comparably new concept in the logistics and supply chain management that is strongly tied to the wider green movement focusing on the reduction of unnecessary freight traffic in urban centres. This objective can be achieved through the provision of facilities, viz urban consolidation centres, situated close to commercial districts, shopping centres or construction sites, at which part loads are grouped together and delivered to the target area reducing the total number of lorry journeys. Of utmost importance is the selection of an appropriate vehicle type used that can offer a high level of load utilisation on the last-mile of the delivery trip.

Freight consolidation has been widely investigated in transportation science with a focus on the use of analytical tools and simulation models. Higginson and Bookbinder (1994), for instance, used simulation to analyse freight consolidation systems, Higginson and Bookbinder (1995) utilised a Markov decision process (modelling decision-making when outcome is partly under the control of decision-maker and partly random), Higginson (1995) used marginal analysis (allocation of scarce resources to maximise the benefits of the outputs produced), Cetinkaya and Bookbinder (2003) used the renewal theory (branch of probability theory that generalises Poisson processes for arbitrary holding times), and Zhou *et al* (2011) examined the effects of two different alliance structures (strategic alliance and full collaboration) in distribution. Furthermore, a number of studies have been conducted by local authorities or other commercial entities concerning the development of urban consolidation centres (e.g. in Bristol, Heathrow Airport and Norwich; summarised in Section 3.3), while other studies have been carried out to identify lessons learned from previous, current or recently operating consolidation centres in the UK or abroad (e.g. Browne *et al*, 2005b; Klaus, 2005; Lewis *et al*, 2007; Campbell *et al*, 2010).

The main objective of this chapter is to review a number of existing consolidation schemes in the UK and abroad with the aim to identify the potential demands and benefits of the establishment of two different forms of consolidation activities in *WestQuay*'s context (Sections 8.2 and 8.3). The purpose in both cases is to identify the potential mileage and environmental impacts under a number of operational regimes. To identify potential strengths, weaknesses and risks a preliminary evaluation of the different forms (e.g. types, categories, classes) and characteristics (e.g. location, size, beneficiaries, modes used) of existing consolidation schemes is required (Section 3.2).

3.2 Freight Consolidation

Freight consolidation involves grouping of individual consignments or part-loads that are destined for the same locality at a consolidation centre so that a smaller number of full loads are transported to their destination (Lewis *et al*, 2007). Its main aim is the increase of the load balance to help reduce the number of empty trucks on the road, cut down pollution, alleviate traffic congestion and ameliorate intra-modal conflicts in urban areas (Shakantu *et al*, 2002). In further, logistics managers are looking into the minimisation of costs, to free-up of sales floor at shops and have better availability of stock and services (Browne *et al*, 2005). Such practices can motivate retail staff and prioritise the delivery of customer-focused services at shops, while offering retailers the opportunity to undertake value-added activities (Campbell *et al*, 2010).

Lewis *et al* (2007) identified two main forms of freight consolidation. The first concerns the development of vertically integrated supply chains in terms of individual businesses, predominantly large retail groups and parcel/pallet networks, consolidating consignments through regional or national distribution centres. Goods from individual suppliers form full loads destined to the various end recipients with the aim to minimise the long distance 'trunking' mileage (Figure 9, Type B).

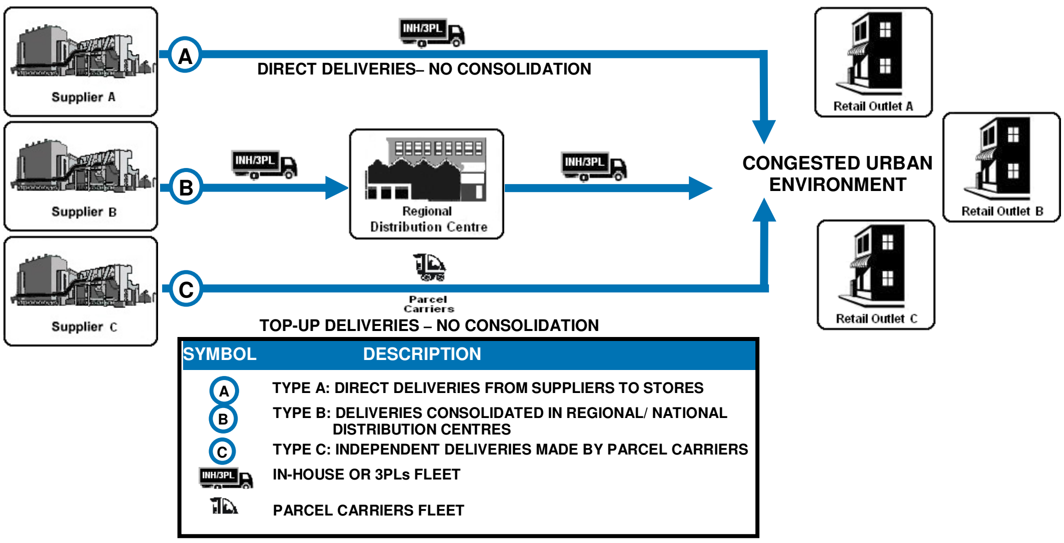


Figure 9: Typical retail centre goods supply channels.

The second form includes an additional step in the supply chain to enable further consolidation of all parts destined for a common destination (Figure 10). This is performed through urban freight consolidation centres (UCCs) which are logistics facilities situated in relatively close proximity to the geographic area that they serve (e.g. a city centre, an entire town or a specific site such as a shopping centre) (Browne *et al*, 2005). Dependent on the potential application and the split of involvement of the public and private sectors, their concept may include public distribution depots, central goods sorting points, single- and shared-user urban trans-shipment centres, freight platforms, cooperative delivery systems, consolidation centres, urban distribution centres, city logistics schemes, logistics centres, pick-up drop-off locations, and off-site logistics support depots (Huschebeck and Allen, 2005).

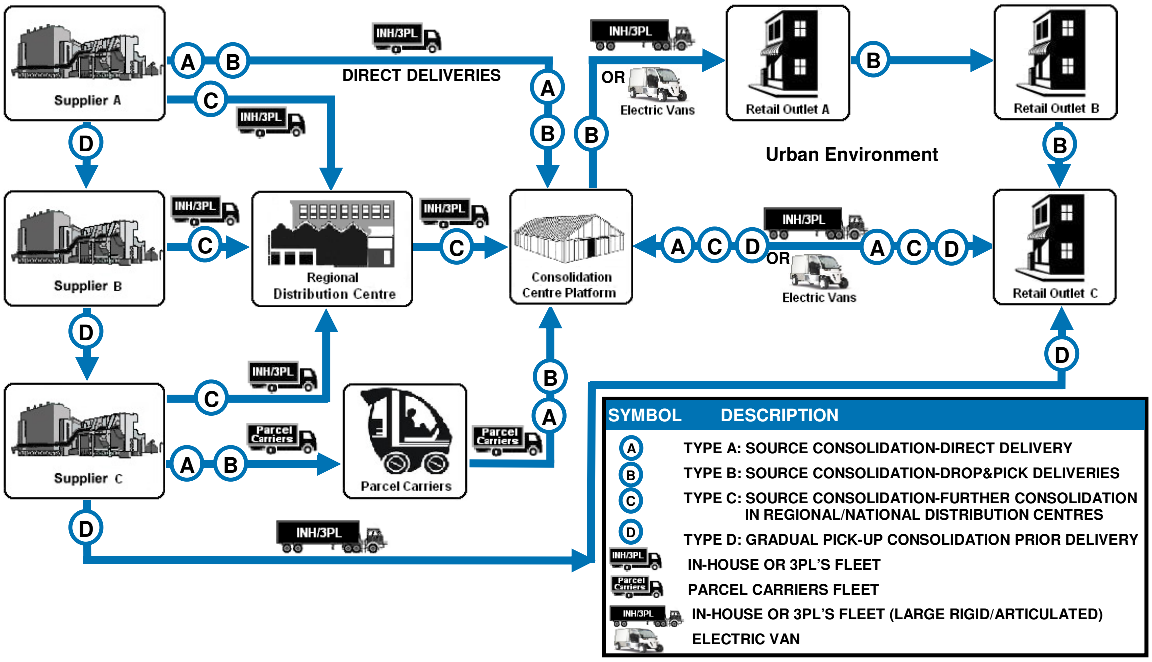


Figure 10: Different forms of urban consolidated delivery approach to supply channels.

On this basis, Crainic (1999) identified four sub-categories of urban freight consolidation used for deliveries, spare parts and waste/recyclables (Figure 10):

- *Type A*: Consolidation with other loads prior to being all shipped to the destination terminal using one of the available direct transport services.
- *Type B*: Consolidation with other loads prior to being all shipped to the destination terminal using one of the available transport services that stop at one or several other terminals to drop and pick up traffic.

- Type C: Consolidation with other loads prior to being all shipped to an intermediate terminal where load is reclassified and consolidated with other loads originating from various other terminals, and finally being all transferred to the destination terminal.
- Type D: Consolidation with other loads in terms of using a dedicated transport service (road or train) carrying other loads, when special contractual agreements exist and load volumes are considerable.

3.2.1 UCCs Classification

In a review of existing UCCs in the UK and Europe, Browne *et al* (2005) divided UCCs into three main categories:

- *Site-specific*: These are developments controlled by a single entity, usually a commercial organization such as a shopping centre or an airport, or other non-retail developments such as construction sites. In both cases, participation in the scheme may be voluntary or compulsory and its operation may be partly or fully self-financed through rent structures and handling fees. Examples of commercial schemes include *Meadwhall shopping centre* in Sheffield and Heathrow airport, while examples of non-retail schemes include the construction sites in Hammerby in Stockholm and Heathrow airport.
- *Co-operative City Logistics Schemes*: Freight transport companies working in the same urban area work together to share collection and delivery services. Goods destined for a single address or a certain geographical area, are consolidated at a common or individual business depot and are shipped in a single full-loaded vehicle. Such a scheme was established in Fujuoka City in Japan in 1994 under the co-operation of 36 freight transport operators and the support of the public sector, resulting in significant reductions in the number of freight vehicles (65%), local freight vehicle kilometers (87%) and environmental impacts (OECD, 2003). In Europe, characteristic examples include the schemes in Aachen, Bremen, Essen, Frankfurt am Main, and Regensburg in Germany (Browne *et al*, 2005).
- *Community Collection and Delivery Points*: These include points between shops and residential properties used to consolidate goods purchased by customers from surrounding shops, deliveries destined for local stores, or

goods ordered remotely by customers. Goods from these points are transported with a single well-loaded goods specialist or customers' private vehicle replacing several vehicle trips (OECD, 2003).

Besides, several studies have produced classification systems based on a selection of UCC schemes. For example, Kohler (2001) classified six fundamental co-operation forms for German UCC schemes in which distribution companies shared their depot and vehicle capacity. Klaus (2005) classified German inner city cargo logistics initiatives under three types including milk round-type schemes for single retailer, city logistics schemes and schemes using telematics and alternative transport technologies (Browne *et al*, 2005). The French Ministere de l'Equipment (2002) classified UCC models under the Monaco, the Dutch and the German models on the basis of the public support given to projects and to some extent their financing (Benjelloun *et al*, 2009). As part of the BESTUFS project (www.bestufs.net), three forms of freight platforms were identified including single-company UCCs, multi-company UCCs and freight villages (Egger and Ruesch, 2002).

Further independent classifications were made by Nemoto (1997) and Browne *et al* (2005). Nemoto (1997) distinguished between UCCs receiving direct deliveries by poorly loaded vehicles replaced by better loaded vehicles, and UCCs receiving direct deliveries by large goods vehicles replaced by smaller vehicles (typical trans-shipment type of operation). Browne *et al* (2005) on the other hand, drew a distinction between commercial UCC schemes operating under the partial or full financial public financial support. Of much interest is the case of the *Broadmead* shopping centre in Bristol. The scheme was initially set up in 2002 as a pilot demonstration and free of charge to retailers, under the 4-year support of the EC VIVALDI project. Since then, the scheme has been mainstreamed and has secured financial support from the City Council using funds from the EC START project (http://www.southwestiep.gov.uk). Today, the scheme seeks for a 40% contribution to the costs by participant retailers using value-added services (Campbell *et al*, 2010).

3.2.2 Main and Value Added Activities

Campbell *et al* (2010) outlined the typical services offered by a UCC, together with the main benefits to retailers.

- *Consolidation*: Multiple daily deliveries, from a single or multiple suppliers, are consolidated in a single load to minimise empty–running, transport emissions and costs, while increasing productivity.
- *Cross-Docking*: Deliveries can be made to a UCC at a time to suit suppliers, with onward deliveries at a time to suit retailers. This can reduce transport and staff costs.
- *Stockholding*: Short-time storage can reduce delivery lead times, improve product availability and customer service. Seasonal or peak storage can free-up space at retail outlets for additional retailing footage.
- *Replenishment*: Big unmanageable deliveries can be split in smaller regular deliveries throughout the day to increase response to customer needs and therefore eliminate lost sales.

Whereas the primary focus of a UCC is to consolidate loads in the inbound journey, many UCCs also offer a range of additional value-added logistics and retail services, including (Campbell *et al*, 2010; McLeod *et al*, 2008; Browne *et al*, 2005):

- *Inventory Monitoring and Information Collection and Analysis linked to In-store Systems*: Inventory monitoring can increase the visibility of the supply chain leading to better availability and service levels.
- *Pre-retailing*: Pre-merchandising activities such as quality and quantity checks, consignment unpacking, preparation of products for display and price labelling can be carried in the UCC to reduce time and space requirements upon final delivery.
- *Returns Management*: Suppliers may use UCCs to consolidate returns into a central stream ideally using the available backload capacity. This may reduce the amount of empty-running and present an opportunity for freight companies to utilise their transport resources more efficiently.
- *Gate-keeping Operations*: Screening of delivered and returned products at a UCC can help alleviate some of the problems associated with the quality of product returns and reduce unnecessary transport.
- *Packaging/Waste Collection/Recycling*: UCCs may be used as storage, trans-shipment and/or treatment facilities of waste and recyclables produced by retailers participating in the scheme.

- *Business-to-Business (B2B) and Business-to Customer (B2C) Services*: UCCs may be in a position to offer B2B and B2C services within their catchment area, including inter-store transfers, home delivery or customer collection of products purchased in town or by mail and online orders.
- *Staff Training Facilities*: Training develops and strengthens the technical and practical skills of all those engaged in the operation of the UCC scheme, such as UCC staff, retail staff and drivers. It enables correct implementation of activities and greater consistency of performance across the network.

3.2.3 Main Beneficiaries of UCC Schemes

UCCs are likely to be more effective in some types of goods and vehicle movements than others. Huschebeck and Allen (2005) and Lewis *et al* (2007) demonstrated a number of cases where UCCs are most likely to be successful:

- Retailers receiving low vehicle loads and poorly or not at all consolidated deliveries (e.g. Figure 9, Types A and C). These retailers are usually prioritised in the recruitment process (e.g. in *Broadmead* shopping centre).
- Transport operators making multi-drop deliveries, whose size is disproportionate to the location, parking and unloading time.
- Retailers receiving large, shared-user and low-cost deliveries, albeit geographically spread, causing significant delays in the urban delivery part of the operation.
- Retail premises receiving non-perishable goods when the UCC is designed to handle the wide range of packaging (e.g. roll cages, pallets, boxes and hanging rails for textiles) handled by retail outlets.
- Specific and clearly defined geographical areas, such as historic town centres and districts, which are either undergoing a ‘retailing renaissance’, presenting a high incidence of small traders/outlets that are not part of a regional/national business with a dedicated and sophisticated supply chain, or suffering from delivery traffic congestion.
- New and large retail/commercial developments (e.g. shopping centres) or non retail developments (e.g. construction sites), offering the opportunity to consolidate all the goods/materials within a dedicated part of the complex/site as part of the total design.

- Potential UCC schemes attracting widespread interest from a group of potential users with common interests and objectives.

Huschebeck and Allen (2005) and Lewis *et al* (2007) also demonstrated a number of cases where businesses are not envisaged as being beneficiaries of UCCs:

- Businesses receiving highly time-sensitive products (e.g. perishable food and newspapers).
- Businesses receiving products that require specific distribution and storage due to their nature (e.g. medicines and fresh food) or their high-value (e.g. jewellery).
- Businesses receiving dedicated visits of full vehicle loads. Several studies (e.g. in Heathrow airport) have shown that intercepting fully-loaded vehicles brings no benefit and merely results in additional costs.
- Major supermarkets, department stores or freight transports companies and some wholesalers who operate their own regional/national stock or in-house consolidation centres and achieve high vehicle utilisation by the use of appropriate vehicle sizes to minimise the number of journeys.
- When shared-user consolidated deliveries are made to businesses not located in areas of sparse population, but in major cities where it is difficult to create an attractive financial proposition and the road mileage saved is relatively small (ECR-UK, 2007)

3.2.4 UCCs Location

Locating a consolidation centre is of primary importance for the reduction of unnecessary transport movements, the minimisation of administration and transportation costs and the reduction of vehicle emissions (Tan *et al*, 2003). Huschebeck and Allen (2005) discussed about the potential benefits arising from the relative distance of a UCC from its target market. They determined that transport and environmental impacts are minimized when a UCC is located several miles from the target area as vehicles do not need to enter into the urban area at all, as long as environmentally friendly vehicles are used for the longest leg of the delivery trip (from suppliers to the UCC). However, benefits as such may be mitigated to some degree by the use of small vehicles in the final leg of the delivery trip (from the UCC to the stores serviced) due to increases in the number of vehicle trips and kilometres travelled (Browne *et al*, 2005). In choosing the optimal location of a UCC, key determinants are the existence of access roads of appropriate capacity, well-linked to the national highway network, and the availability of existing distribution facilities with potential to incorporate freight consolidation services as part of their existing operations (Lewis *et al*, 2010).

3.2.5 UCCs Size

The scale of a UCC is determined by the volume and spread of traffic processed each day. Lewis *et al* (2007) reviewed the size of a number of UCCs in the UK in order to identify some indicative parameters for the potential scale of typical UCCs. They identified, that the Heathrow consolidation scheme presented the highest ratio (r) of UCC area to number of businesses served (5,200 m^2 serving 220 retail outlets, r=23.6) and at the other end of the scale they positioned the *Broadmead* facility (660 m^2 serving 60 retail outlets, r=11). Allowing for the inclusion of areas for security scanning, off-site stock holding and facilities for chilled and frozen foods as found in the former, they suggested that 10 m^2 per retail outlet served would be appropriate. Browne *et al* (2005), on the other hand, highlighted the need to keep the initial cost base low and suggested that the use of a part of an existing building (with expansion potential) would be strategically expedient. They underlined the considerable cost and complexity of specialist cool-chain and frozen facilities as well and suggested that such facilities should be developed over time.

3.2.6 Vehicle Types Used

Deliveries processed through UCCs can be made by a wide range of different vehicle types. According to Nemoto (1997) there are two mechanisms for the operation of UCCs: deliveries made by small vehicles replaced by larger vehicles, and vice versa. Browne *et al* (2005) and later Lewis *et al* (2007) reviewed a number of UCCs in continental Europe and identified that the most common modes used in the final leg of the delivery trip (from the UCC to the stores serviced). In both studies, it was found that rigid lorries were most commonly used (25-40%), while other used vehicles included articulated vehicles and vans, both in the range of 17-25%. The data showed that rigid lorries were the most used due to the opportunity to balance out the usage of the maximum available delivery volume and ease of use in urban areas. Both rigid lorries and vans were appeared marginally more common when deliveries were part of a multi-drop delivery round (Lewis *et al*, 2007). Currently many schemes make use of low-emission vehicles such as electric vans. Their use has been promoted by tax incentives (e.g. in Tokyo in Japan), special grants (e.g. in the UK), the establishment of environmental zones (e.g. in Sweden) and traffic restrictions on certain road sections (e.g. in Germany) (OECD, 2003).

3.2.7 Key Elements of the Evaluation Framework of UCCs

Browne *et al* (2005) identified a lack of consistency in comparing 'before' and 'after' situations in previous studies and highlighted the importance of deciding upon the boundaries of the evaluation process, establishing the base situation, standardising the data collection between the 'before' and 'after' phases and undertaking the evaluation in as controlled an environment as possible (e.g. consider urban access restrictions). They summarised a number of measures examined in previous evaluations and suggested that these should involve measurement of the change in vehicle operations through comparisons of 'before' and 'after' schemes for vehicle operations in the urban area and outside it, as well as the overall impact of change in the urban area.

- Changes in the number of vehicle trips.
- Changes in the number of vehicle kilometres.
- Changes in the number of vehicles.
- Changes in travel time.
- Goods delivered per delivery point.
- Vehicle load factor.
- Changes in parking time and frequency.
- Changes in total fuel consumed.
- Changes in vehicle emissions.
- Changes in operating costs.

3.2.8 Critical Success Factors and Risks for UCCs

According to Bristol City Council (2011) the critical success factors for the operation of the *Broadmead* shopping centre's consolidation centre included securing stakeholder support, establishing genuine public/private partnership between the City Council and the logistics provider, and utilising EC support to provide initial funding.

To ensure retailer participation, apart from stakeholders support; access restriction measures for non-consolidated deliveries, priority measures for consolidation vehicles, financial incentives by the landlord of the centre, and even a mandatory participation regime were considered as key determinants. To develop a sustainable business model, significant cost savings can be achieved through the provision of added-value activities generating additional revenue and the integration of the development into the planning phase or a wider business model such as a multi-functioning warehouse operation.

On the other hand, potential risks include the lack of funding and participation. Mehrmann (2008) stated that the complexity of network-wide operations for the different participants may turn tactical planning into a particularly difficult process for businesses. Browne *et al* (2005) stressed that organisational and contractual problems may act as major barriers especially for businesses aiming to maintain competitive advantage rather than share expertise and systems. In addition, Mehrmann (2008) emphasized the potential risk to increase the level of empty-running due to the difficulty to secure return trip, and the possible need to add legs of freight, especially in the case of product returns. Furthermore, concerns regarding the loss of control of the supply chain, additional costs and poorer service standards can lead to a general apathy to the scheme (e.g. in *Norwich* consolidation centre). It is therefore necessary to find the best match between the resources used and the level of service provided.

3.3 Review of existing UCC Schemes in the UK

The main elements of existing commercial consolidation schemes in the UK are summarised in the following table (Table 10). The relevant information was collected from material published either on the official websites of the consolidation schemes or in official reports of the involved Local Authorities and logistics companies. However as many operational elements of the schemes change over time these data should be considered only as indicative and their validity should be revised for future references. The blank fields indicate the lack of availability of the relevant data.

Table 10: UK Operational retail consolidation schemes.

Operational Retail Consolidation Schemes in the UK									
	UCC	**Manchester Airport**	**East Midlands Airport**	**Heathrow Airport**	**Regent Street**	**Broadmead Shopping Centre Cabot Circus Shopping Centre Bath City Centre (future)**	**Bluewater Shopping Centre**	**Meadwhall Shopping Centre**	**Snetterton in Norwich City Centre**
Basic Operational Characteristics	**Location**	Bury Greater Manchester	Locally	Stockley Park	Brimsdown, Enfield	Bristol	Greenhithe	Sheffield	Norfolk
	Distance			10miles (16km)		10miles (16km)		0.25miles (0.4km)	20miles (32km)
	Time					25 minutes			30 minutes
	Terms of Use	Voluntary	Compulsory	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary
	Status			Permanent			Permanent	Permanent	
	Size			56,2,325 m^2		500 m^2 (1,524 m^2) (5,000 ft^2)	6,500 m^2	3,159 m^2	(240,000ft^2)
	Area Served	Site Specific	Site Specific	Site Specific	District	Site Specific (Future: Town-wide)	Site Specific	Site Specific	District
	Logistics Operator		Exel (DHL)	Exel (DHL)		DHL Exel Supply Chain	Exel (Tibbett & Britten Plc)		Foulger Transport Ltd
	Funding Source					Shopping centre, City Council, EU			
	Customers Charge					After termination of EU funding			✓
	Initiated	2007	2000	2000		2004	2002		2007
	No of Participants					62	28 (2004)		3
	Fleet			3 artics+3 rigid		1	1x7.5t		68 electric vans
	Min Response Time						3 hours		
AddedValue Services	**Stockholding**					✓	✓		✓
	Inventory Mgt						✓		
	Pre-retailing					✓	✓		
	Waste/Recycling			✓		✓	✓		
Measured Savings	**Number of Trips**			60-65%		50-75%			
	Vehicle Km Savings			130,000km		42,772 km a month			
	CO2 Savings			134,000kg		600kg a month			
	NOx Savings			12,000kg (2008)		100kg a month			
	Delivery Time Savings					20min			

3.4 Summary

This chapter illustrated the concept of consolidation centres which has been particularly embraced by the retail and the construction sector as a means to reduce business costs, increase the load balance of transport and cut down urban traffic and emissions. A review of numerous UK and international consolidation schemes was made and two main forms of freight consolidation were identified. The first concerned regional/national consolidation usually developed across vertically integrated supply chains of large retail groups in order to minimise the long distance ‘trunking’ mileage. The second form concerned urban consolidation of part-loads generated by different supply chains with the aim to address the last-mile issue.

In reviewing the activities undertaken in existing UK commercial consolidation sites, it was found that these included goods consolidation, cross-docking, stock-holding and replenishment activities. Several schemes offered additional value-added services such as inventory monitoring and data analysis, pre-retailing, returns management, gate-keeping operations, waste collection and recycling, store transfers and staff training. Further operational characteristics (e.g. location, scale, vehicle modes) were examined to identify the potential strengths, weaknesses and risks of a consolidation scheme. It was suggested that a consolidation facility should be located in an area well-linked to the national highway network and serviced by access roads of appropriate capacity to increase its operational efficiency and organisational effectiveness. Its exact size should be determined by the number of businesses serviced and the spread of the traffic processed however experience from existing UK schemes suggested that on average 10m² per retail outlet served would be appropriate for basic activities. Any further specialist facilities should be built over time to avoid increased cost and operational complexities during the initial planning stages, so the selection of an existing building with expansion potential would be strategically expedient. In addition, a UCC facility should be designed to receive both large delivery vehicles running long-haul trips and smaller vehicles such as low-emission vans running the last-mile.

Consolidation schemes were deemed successful for retailers receiving low vehicle loads, for transport operators making large, shared-user, multi-drop but geographically spread deliveries, for specific and clearly defined geographical areas such as historic town centres and districts, and for new large retail developments such as shopping centres. On the other hand, they were not regarded as beneficial for retailers receiving highly time-sensitive and high-value products, businesses already receiving full vehicle loads, major supermarkets and department stores already being serviced by regional distribution centres, and businesses already receiving shared-user consolidated deliveries. In addition, stakeholder support, establishment of public/private partnerships between the City Council and the logistics provider and initial external funding were included among the most critical success factors for the operation of a consolidation centre. On the other hand, barriers impeding the successful operation of UK schemes included the lack of funding and participation.

The characteristics of commercial consolidation schemes identified in this chapter will be form the basis for the examination of two best-case examples: a) the recent establishment of *Waterstone*'s national distribution centre servicing the company's national branch network (Section 8.2) and b) an under-planning UCC in Southampton to service a number of *WestQuay* businesses (Section 8.3). In the following chapters, a description of the background to the main case study (*WestQuay* shopping centre) will take place (Chapter 4), followed by a detailed outline of the methodology applied and the analysis processes used (Chapter 5) to examine inbound core goods flows (Chapter 6) and outbound waste/return flows (Chapter 7) in order to assess the performance of *WestQuay* consolidation scheme under a number of operational scenarios (Chapter 8).

Chapter 4: Case Study Background

4.1 Introduction

The focus of this study is to investigate potential opportunities to improve existing delivery mechanisms in urban centres in order to optimise the reverse flow systems for product returns and waste and minimise the overall freight activity and emissions. To this end, a dedicated shopping centre (*WestQuay*) located in Southampton UK was used as a case study example to examine forward and reverse supply chain activities developed by tenant businesses and explore the potential logistics and environmental benefits arising from the establishment and use of a consolidation centre in the outskirts of the city.

This chapter consists of two main sections. The first part outlines the background to local and regional urban and economic development and sets out the elements and the objectives of the local transport strategy. The second part describes *WestQuay*'s business profile and presents the components and the priorities of its environmental, and more particularly, waste management policy.

4.2 Local and Regional Development

The city of Southampton is located in the South Hampshire, the largest urbanised area in the south of England outside London. South Hampshire is home to almost 1 million people and boasts excellent transport links by air, road, rail and sea to the rest of UK and beyond. Its economy is strong in the sectors of business services, manufacturing, logistics, marine and aviation industries (TfSH, 2010). Southampton's economy is inextricably linked with that of South Hampshire with the city positioned as a hub for tourism, finance, business and distribution related industries. The city is particularly renowned as UK's cruise capital and a major commercial port currently having four cruise terminals (PUSH, 2010).

4.2.1 Local Retail Development

Following a steady rise in town centre activity throughout the 1990's, the opening of *WestQuay* shopping centre in 2000 reinforced Southampton's position in the UK retail map. Southampton was previously ranked 27th in the UK as a regional city in terms of retail space and with *WestQuay*'s opening it rose to number 13 (*WestQuay*, 2009). The complex was one of the first of a new wave of inner city regional shopping centres, a move that reflected a strongly urban regeneration-led focus of UK cities pioneering the link between retail and urban regeneration as a central component of development and promotion strategies. Lowe (2005a; 2005b) examined *WestQuay*'s impacts on the urban milieu of the city during the first 5 years of its operation and identified the fundamental impact of the centre on the built form and urban identity of the city and its vital contribution to Southampton's survival as the south coast's leading regional centre. At the same time though, *WestQuay* shifted the city's retail centre of gravity affecting more small and medium enterprises (SMEs) that lacked manpower, finance and knowledge available to their *WestQuay* competitors. Apart from dislocating district shopping functions and marginalising several businesses, its development also restricted public access to a large physical area after 6-8pm at night (Lowe, 2005a).

The current role of retailing as one of the most notable areas of domestic economic activity has attracted further investment from the retail, property and venture capital industries. As part of it, *WestQuay* developed and granted permission for extension plans ('*Watermark WestQuay*', also referred to as '*WestQuay* Phase III', Figure 11).

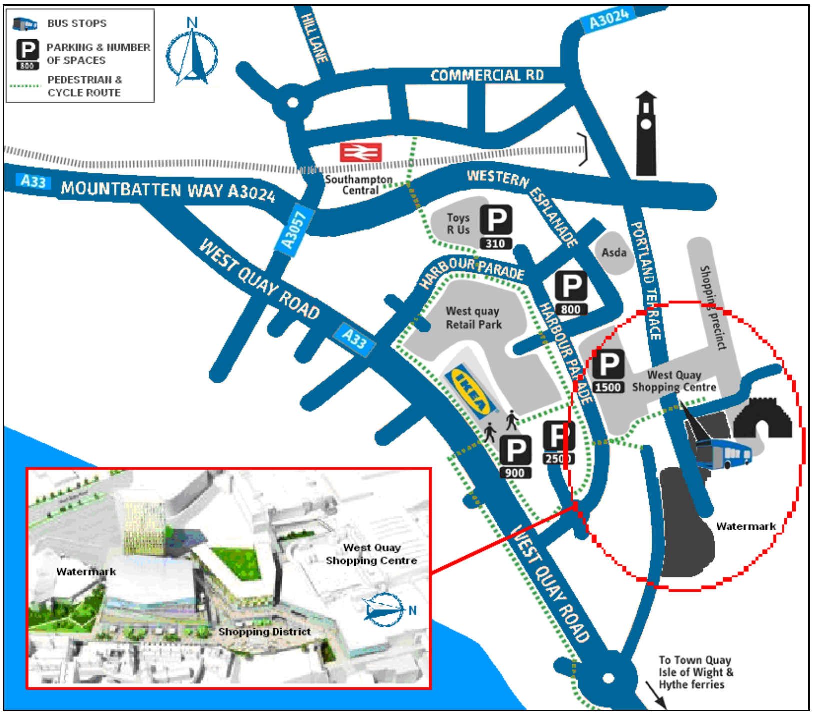


Figure 11: Southampton's commercial district (produced using images from: www.southampton.gov.uk/visitors/traveltransport/ikea.aspx and www.thisishampshire.net)

Extension plans include a £150 million development with shops, restaurants, cafes, cinema, 150-bed hotel and a block of 200 flats on a 5.4 acre site (4,050 m²) next to *WestQuay*. This project has though been delayed due to the current economic climate. *IKEA*'s opening in February 2009, on the other hand, was not affected by the 'credit crunch' in global banking, but raised numerous objections by *Hammerson*, *WestQuay*'s anchor tenant *John Lewis, Associated British Ports (ABP)* and public members on the grounds of increased traffic problems. In response, *Southampton City Council* carried out widening works on three key junctions and constructed a new enhanced pedestrian link into *Harbour Parade* (Citylocal, 2009). These were followed by numerous other infrastructure works to the wider Southampton area, such as rail gauge enhancements and road improvements, to improve accessibility and help the network cope with expected higher levels of passenger and freight activity.

4.2.2 Local Transport Strategy

The existence of an efficient and effective transport network in Southampton is vital to the City's continued development. Under the '*Transport Act 2000 [2000 c.38, §108]*', Southampton's City Council is required to deliver a Local Transport Plan (LTP) that contains its vision, policies and programmes over the next five years. Currently, the Council has issued the second Local Transport Plan (LTP2) that covers the period 2006-2011. LTP2 sets out how the City intends to improve accessibility, reduce congestion, improve road safety and enhance air quality. It considers a range of challenges and opportunities for Southampton such as its increased role as a retail centre, the implementation of 80,000 new residential units by 2026 (South East Plan), the enhanced role of the port in UK's freight and passenger traffic, and the procurement of sufficient funding. In addition, a great focus is given to the protection and amelioration of the city's environmental quality, a subject that has risen up the agenda in the last few years, as a result of the declaration in 2005 of six Air Quality Management Areas on the basis of excessive levels of NO_2 resulting from traffic (Southampton City Council, 2006).

Sustainable freight distribution is an area attracting growing attention over the course of LTP2. The Council seeks to ensure the development of sustainable measures both in the short-haul sector (e.g. home deliveries made by vans replacing several individual car trips) and the long-haul sector (e.g. the introduction of trans-shipment depots where goods are transferred from larger to smaller vehicles for more local distribution). Thus, a lorry routing network has been developed taking account the City's strategic road network, the locations of the principal generators of freight movements and the places of residential areas. In addition, it takes account of *ABP*'s wish to have two alternative routes to the port available for use (Figure 12).

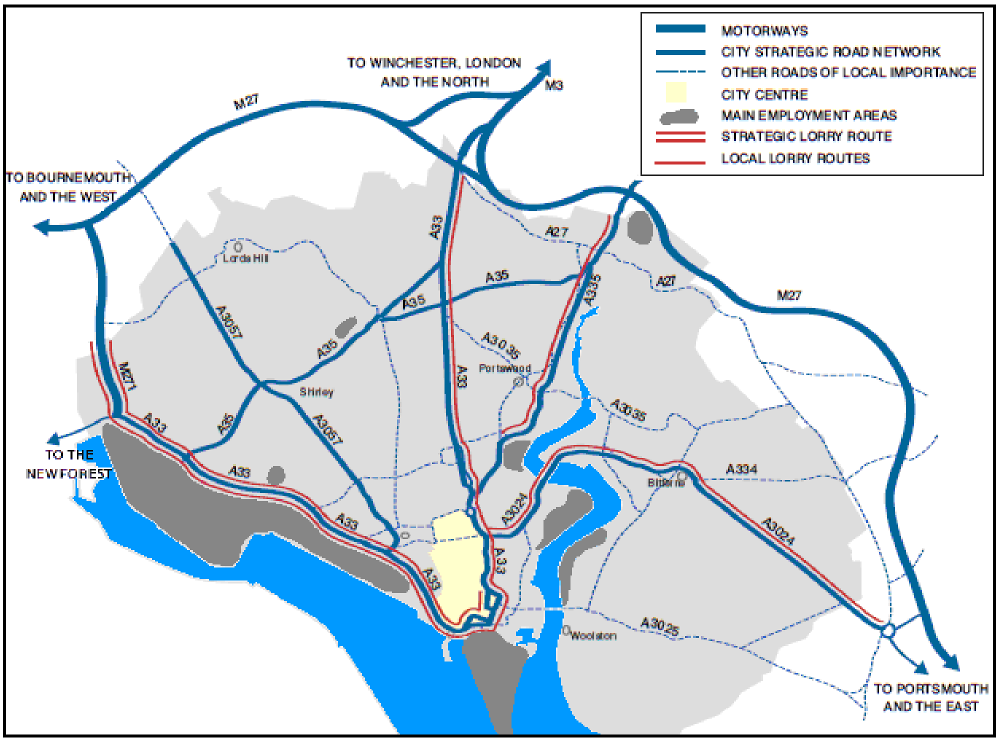


Figure 12: Southampton's lorry network.
(source: Southampton City Council, 2006 based on Orchance Survey material)

To help drivers that deliver goods to the city centre follow the most suitable routes and avoid unnecessary mileage and delays, the City Council in association with haulage groups has developed a system of directional signs. These show a lorry symbol and a letter indicating the group of delivery areas. More local signs also show the delivery area number, while colour coded backgrounds indicate the north, the west and east of the city (Figure 13). *WestQuay* is being served by three delivery areas (service yards: A2, A3, B2). Access is permitted to a business or person that owns an operator licence when transporting goods on a commercial basis using a vehicle which, when fully loaded, weights more than 3.5 tonnes (Southampton City Council, 2006).

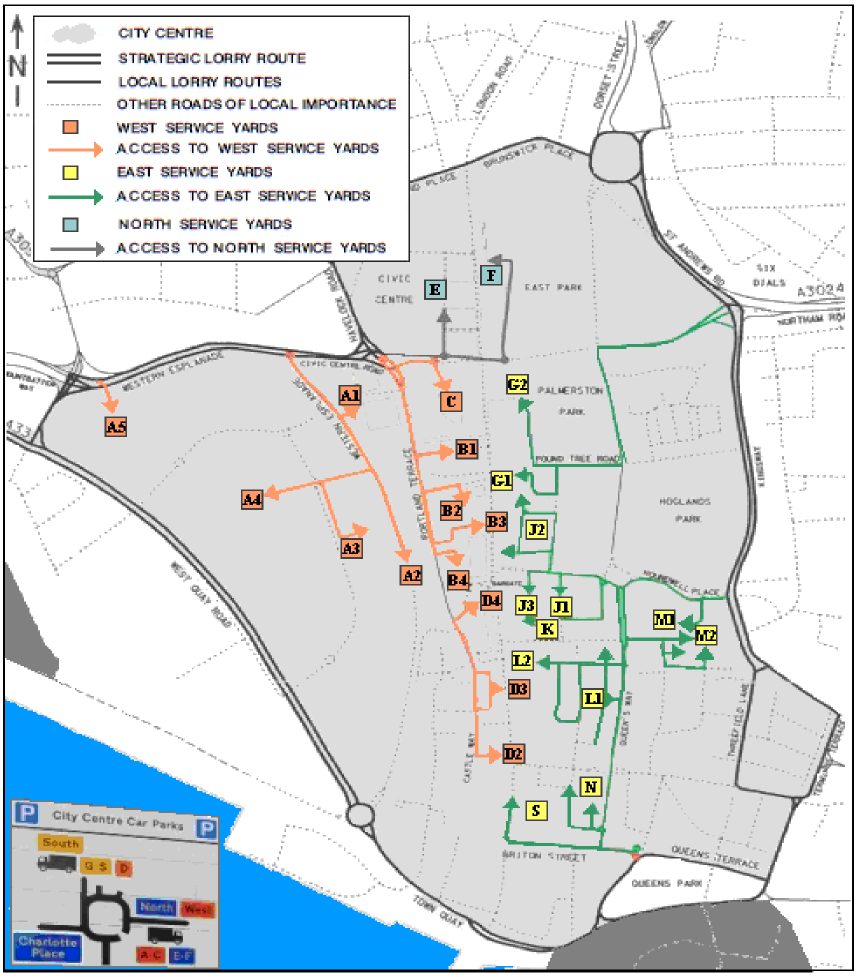


Figure 13: System of directional signs for freight deliveries made in Southampton's city centre (source: http://www.southampton.gov.uk).

Currently, Southampton's City Council is developing the *'Local Transport Plan 3'* which will guide development of the transport network within the city until 2031 (Southampton City Council, 2010). As part of it, the main vision of *Transport for South Hampshire (TfSH)* authorities is to create: '*A resilient, cost effective, fully-integrated sub-regional transport network, enabling economic growth whilst protecting and enhancing quality of life and environment*'.

4.3 Case Study: *WestQuay* Shopping Centre

WestQuay (Figure 14) is a £295 million development in Southampton, jointly owned by *Hammerson UK Properties* and *GIC Real Estate*, and solely managed by *Hammerson*. Opened in 2000, the retail complex covers 74,500 m^2 (800,000 ft^2) on a 33 acre (4,047 m²) site and incorporates almost 100 retail outlets and catering units across two floors and an additional catering level (*WestQuay*, 2010a).

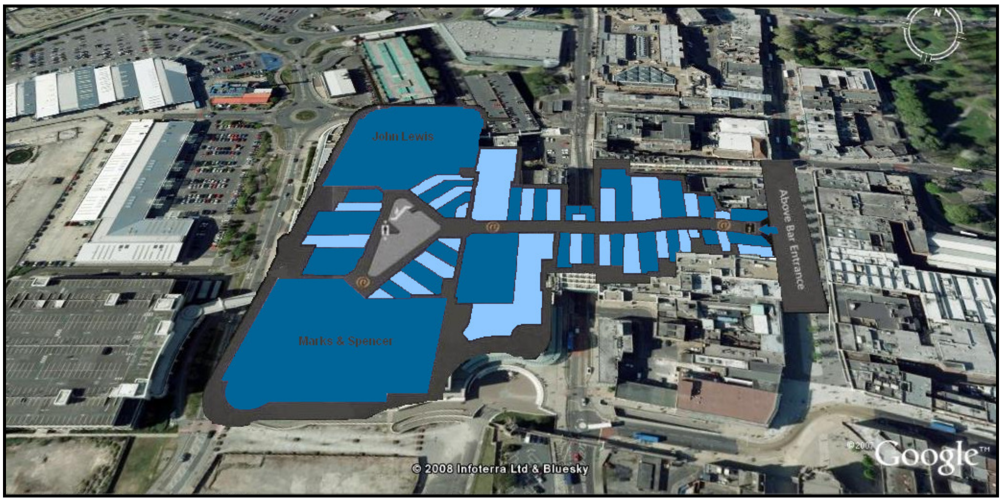


Figure 14: *WestQuay*'s setting in Southampton's city centre.
(source: produced using '*Google Earth*' and image from http://www.west-quay.co.uk).

WestQuay neighbours a retail park, a commercial high street, and a swimming and diving complex, all supported by public transport facilities and parking areas. In total, there are 7,000 car parking spaces within a 5 minute walk of the complex; 4,000 of those provided by *WestQuay* for its customers. In addition, the complex is served by numerous buses during peak times and a free link service to the train station and the ferry terminal. *WestQuay*'s catchment area (Figure 15) encompasses 2 million people living within a 60 minute drive of Southampton which includes Salisbury, Winchester, Portsmouth and Bournemouth. In the first year of its operation (2001) more than 16 million people visited the retail complex, and by the beginning of 2010 the total number of visitors is estimated to have risen to 120 million (TSE, 2010).

Figure 15: *WestQuay*'s catchment area (source: http://www.west-quay.co.uk)

*4.3.1 WestQuay***'s** ***Business Profile***

WestQuay contains a great range of top fashion and lifestyle brand stores, as well a number of restaurants and cafes. *WestQuay* businesses were classified according to the type of their economic activity under the '*UK Standard Industrial Classification of Economic Activities (SIC) 2007*' to examine freight activity per type of business. A further classification was made on the grounds of the average store size per business category to reveal any possible linkages between freight activity (e.g. frequency and size of deliveries) and the size of stores. Of particular interest was to examine whether smaller stores were receiving smaller and more frequent deliveries than larger stores due to lack of sufficient floor area and storage space, and vice versa.

4.3.1.1 *WestQuay* Businesses Categorisation under 'SIC 2007'

The study identified that as of the time of the interviews with tenant retailers (April-May 2008), 74 stores selling a variety of goods (clothing, footwear, electrical products, jewellery, games, sports goods, books, stationery and optical equipment), another 20 catering units (restaurants, confectioneries and cafes) and 2 department stores were operating in the shopping centre. *WestQuay* businesses were classified under 12 main SIC categories considering the type of the main core goods (MCGs) traded (Table 11). Due to the small number of art galleries (n=1) and travel agencies (n=1) though, these 2 business groups were put under a general group called 'Other' to simplify analysis. In general, it was found that food and drink retailers had a considerable presence in the complex (n=20, 21%) as did clothing stores (n=34, 35%).

In addition 47 businesses were found to trade one or more SCG (Secondary Core Goods) ranges. The vast majority were clothing businesses (n=31, 91.2% of total clothing businesses) also selling jewellery, footwear and accessories. On average, each of the 47 businesses traded 1.7 SCG ranges, making up a total of 80 secondary activities being undertaken. For example, although there were only 8 stores selling footwear/leather goods as their main activity, an additional 31 businesses trading other types of MCGs, were also selling footwear as part of their secondary activities. It should be noted that due to the wide range of MCG and SCG activities undertaken by the 2 department stores, these were only considered under the 'Department Stores' class. MCG and SCG activities of *WestQuay* businesses are summarised in Table 11 which presents the breakdown of retailers according to the *UK SIC 2007* code.

Table 11: *WestQuay* business classification under the 'UK SIC 2007' (n = number of businesses).

Business Type	UK SIC 2007		Activities (n=96)			
			As Main		As Secondary	
	Code	Description	n	%	n	%
Clothing	47.71	Includes articles of clothing, fur and accessories such as gloves, ties, braces and excludes textiles (fabrics, knitting yarn, haberdashery, materials for rug, tapestry or embroidery making).	34	35.4	5	5.2
Footwear/ Leather Goods	47.72	Includes footwear (except special sports equipment footwear such as ski boots), leather goods and travel accessories of leather and leather substitutes.	8	8.3	31	32.3
Catering Units (Restaurants/Cafes)	56.10	Includes licensed and unlicensed restaurants, cafeterias and fast-food restaurants (except for concession operation of waiting facilities), as well as take-away food shops and mobile food stands.	20	20.8	1	1.1
Electrical Equipment	47.41 47.42 47.54	Includes computers, peripheral units and software, telecommunications equipment, mobiles telephones, audio and video equipment and electrical household appliances.	7	7.3	0	0
Games/ Sports Goods	47.64 47.65	Includes games and toys, made of all materials (except for video games consoles and non-customised software) and sports goods, fishing gear, camping goods, boats and bicycles.	3	3.1	2	2.1
Jewellery	47.77	Includes watches and jewellery.	9	9.3	22	22.9
Medical Goods/ Cosmetics	47.75	Includes perfumery, cosmetic and toilet articles.	4	4.2	4	4.2
Bookstores/ Stationery	47.61 47.62	Includes books of all kinds (except for second-hand or antique books) and newspaper and stationery, such as pens, pencils, paper etc.	4	4.2	1	1.1
Opticians goods	47.78/2	Includes spectacles, contact lenses etc by dispensing opticians, optometrists, ophthalmic opticians etc.	3	3.1	14	14.6
Art Galleries	47.78/1	Includes new art goods and related activities.	1	1.1	0	0
Travel Agency	79.1	Includes the activities of agencies primarily engaged in selling travel, tour and accommodation services to the general public and commercial clients.	1	1.1	0	0
Department Stores	47.1	Includes a large variety of goods, such as food products, beverages or tobacco, several other lines of merchandise such as wearing apparel, furniture, appliances, hardware, cosmetics etc.	2	2.1	0	0
Total			**96**	**100**	**80**	

The absence of charity shops and banks from the shopping centre was noted when compared with the breakdown of the businesses operating in Wichester High Street as of the same year (Maynard and Cherrett, 2008). This comparison also suggested the stronger presence of catering units and stores selling clothing in the shopping centre.

4.3.1.2 *WestQuay* Businesses Categorisation by Store Size

In order to investigate the relationship between freight activity and the size of *WestQuay* stores, detailed data about the total shop and the dedicated storage floor area of individual businesses were provided by *Hammerson*. In some cases, some of the total shop area was not used for customer sales because it included staff rooms, offices and other private areas. Often the floor area was also used for stock management, especially in the case of businesses lacking dedicated storage rooms. As this kind of detail was not available to the study, analysis was made on the basis of the total shop area. Some additional analysis was made for the few businesses having designated store rooms (n=24, 25%). Businesses were classified under 3 floor-size classes (small: A<200m², medium: 200m²<A<500m² and large: A>500m²). Due to lack of guidance in the class boundaries (discussed in Section 2.6.3.2), the selection of these classes was made on the basis of a balanced distribution of the number of small- and medium-sized businesses into the first two classes (n=41 and n=39, correspondingly), and the formation of a separate class for businesses with much larger floor sizes. The following table shows the breakdown of retail business types operating in *WestQuay* in terms of total floor space.

Table 12: *WestQuay* business classification based on floor area.

Floor Area (A) / Business Type	Stores Number	Floor Area A (m²)					Number of Businesses n with					
		Mean	Min	Max	St.Dev.	Total	A<200		200<A<500		A>500	
	(n_{tot})	A_{mean}	A_{min}	A_{max}	A_{stdev}	A_{tot}	n	%	n	%	n	%
Clothing	34	670	21	3,211	803	22,780	7	21	18	52	9	26
Catering Units	20	183	18	936	221	3,660	16	80	2	10	2	10
Books/Stationery	4	456	155	817	310	1,822	1	25	1	25	2	50
Footwear/ Leather Goods	8	284	174	485	113	2,268	2	25	6	75	0	0
Optical Goods	3	260	14	495	241	780	1	33	2	67	0	0
Electrical Equipment	7	256	16	800	264	1,793	4	57	2	29	1	14
Jewellery	9	185	34	371	111	1,665	4	44	5	56	0	0
Medical Goods/ Cosmetics	4	76	13	181	77	304	4	100	0	0	0	0
Toys/Games	3	254	172	372	105	762	1	33	2	67	0	0
Department Stores	2	17,60	9,29	25,92	11,76	35,208	0	0	0	0	2	100
Other	2	182	96	268	121	364	1	50	1	50	0	0
Total	**96**	**743**	**13**	**25,92**	**2,81**	**71,341**	**41**	**43**	**39**	**40**	**16**	**15**

(n: number of businesses, %: percentage out of total number of stores per business category).

4.3.2 Hammerson's Guide and Requirements on Tenants Sustainability

Hammerson (www.hammerson.com) has a lead role in working with tenants to incorporate principles of sustainable development and helping them meet their responsibilities to address environmental issues. Through the provision of guides and sustainable design principles, *Hammerson* enables its tenants to maximise efficiency in terms of the use of resources, reducing energy consumption and minimising waste production. As part of tenants' commitment to efficient energy use, specific targets for operational power and lighting loading, ventilation, air distribution, cooling, hot water and storage systems must be met by all occupiers. In addition, retailers are obliged to:

- maximise recycling so that 80% of their waste stream is recycled,
- develop effective long-term waste minimisation strategies,
- reduce their use of single-trip packaging including carrier bags,
- replace packaging materials with reusable/recyclable/compostable alternatives,
- introduce green travel plans for employers and employees.

Hammerson also supports partnerships between small tenants to organise cost-effective site-wide recycling solutions and provides a levied waste collection and disposal service to retail units during their fit out.

In 2007, *Hammerson* introduced a green clause in its standard UK lease contract as part of a wider programme to engage and work with its occupiers. This forms a formal legal structure for increasing environmental accountability and creating a shared commitment from both property owner and occupier towards greater energy, water and waste efficiency. The owner and occupier agree on an energy and waste management plan and appoint representatives to implement and monitor the plan. It includes guidelines on maintaining data on energy and resource consumption, ways to improve energy efficiency, participation in waste management initiatives and ensuring that appropriate metering systems are available (Hammerson, 2009).

4.3.3 WestQuay's Environmental Policy

The transition of *Hammerson*'s sustainable strategy into *WestQuay*'s environmental policy is made through the commitments of *WestQuay*'s managers and tenants to minimise their environmental impacts through effective management of energy, water and waste by integrating environmental considerations into day-to-day operations. In addition, as part of its environmental campaign '*Pamper the Planet*' *WestQuay* promotes sustainable travel to the centre (*www.westquay*.co.uk).

4.3.3.1 Energy Saving

WestQuay already takes energy supply from the local geothermal plant (*www.westquay*.co.uk) for all heating and cooling in the complex, and research on renewable technologies such as the use of solar, wind and ground sources is ongoing to reduce the future demand for electricity. In addition *WestQuay* collaborates with regional stakeholders, such as the *Southampton's City Council* and the *University of Southampton*, in projects researching the effective management of operations, facilities and systems to reduce its overall environmental impact.

4.3.3.2 Sustainable Waste Management

In 2008 (data collection year), *WestQuay* recycled over 434 tonnes of waste, while the remaining waste was sent to an *Energy Recovery Facility* and used to produce electricity to power around 100 homes. *Hammerson* aims to improve their recycling rate every year by introducing new waste streams for recycling, working more closely with those retailers struggling to comply with their obligations and ensuring that they maximise the efficiency of their own waste management systems. To this end, in 2007 they launched a course of '*Retailer Waste Co-ordinator'* training sessions in which each retailer sent a representative to learn more about waste management within the centre and how to improve their retail unit's performance. The training is since offered on an annual basis to keep retailers up-to-date with the schemes that are in operation. More detailed information on waste arisings and recycling rates are provided in Sections 7.3 and 7.4.

4.3.3.3 Sustainable Water Usage

During 2008 the centre installed equipment and sanitary ware to start capturing data relating to water usage. In addition, it ran studies to assess the feasibility of alternative technologies such as rain and grey water harvesting and reviewed the ways water was used for watering and cleaning with the aim to make these procedures more efficient.

4.3.3.4 Sustainable Visitors Travel

The centre encourages its visitors to make use of public transport (train and bus) and/or bike/walk to the centre whenever possible. For example, in 2008 *WestQuay* was providing three 'pay the hour' rental low-emission and low-cost cars in the multi-storey car park in collaboration with a private company (www.whizzgo.co.uk). The company was providing a network of low emission cars at a low monthly registration fee and hourly cost in dedicated parking bays across 12 towns and cities in the UK.

4.3.4 WestQuay Operating Plan for Product Deliveries and Waste Collections

Vehicle access for the delivery of goods and the collection of product returns and waste is made to one of the three service yards (A2, A3, B3) servicing *WestQuay* dependent on the location of each retail/catering unit (Figure 16). Deliveries can be accepted between 05:30 and 20:30 on weekdays, 05:30 and 19:30 on Saturdays and 09:00 and 17:30 on Sundays, or 24 hours a day prior agreement with *WestQuay* management. Directional signs in each service yard show the way towards each retail unit, while drivers along with staff members are expected to remove products from service yards using private or *WestQuay*'s roll cages and pallets as soon as possible (*WestQuay*, 2008).

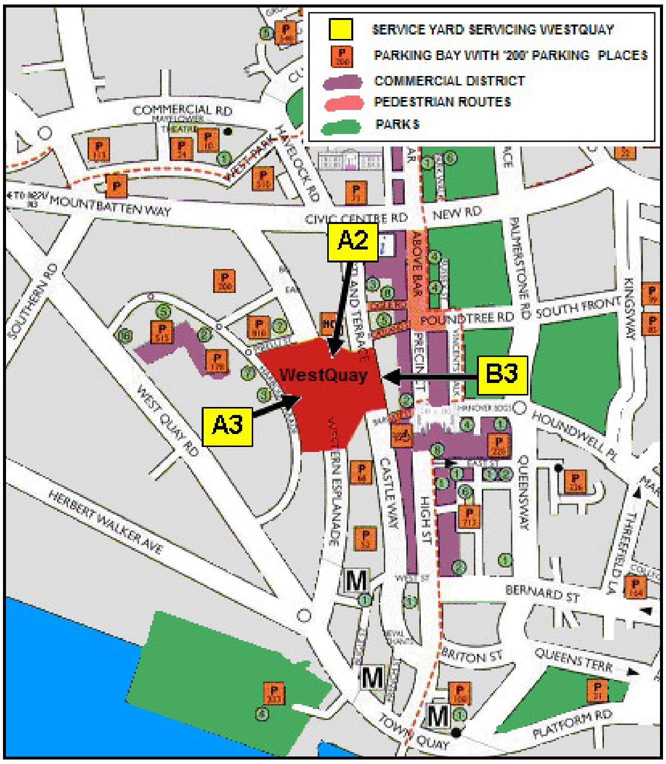


Figure 16: Siting of service yards servicing *WestQuay* businesses (source: *WestQuay,* 2008).

With regards to waste produced by retail outlets and catering units, *WestQuay* offers a centralised collection for non-hazardous materials (described in Chapter 7), joined by the vast majority of tenants. Waste materials produced by stores/catering units are initially consolidated at 28 collection points at the back of the stores. Mixed waste is disposed of in 1,100 litres bins, while flattened cardboard boxes and other recyclables in sacks are placed in roll cages. Two vehicles owned by *WestQuay* empty receptables twice a day and transfer waste materials to one of the three service yards. There, waste is further processed (e.g. baled) prior being collected by appointed waste contractors.

4.4 Summary

Following an overview of the literature on logistics and supply chain management, this chapter presented *WestQuay* shopping centre located in Southampton UK which served as the case study employed in this research. The use of *WestQuay* as a case study example was made to demonstrate how current policy agendas and institutional arrangements across UK retail businesses influence the strategic planning for deliveries and collections, and to investigate potential opportunities to better utilise the existing delivery mechanisms in order to minimise freight activity and emissions in urban centres. The following chapter presents the methods used to collect data and the tools applied to estimate the transport and environmental impacts of alternative forward and reverse logistics practices.

Chapter 5: Research Methodology

5.1 Introduction

This chapter discusses the conceptual framework and the practical elements involved in examining the forward and reverse supply chain operations in *WestQuay* shopping centre. Using qualitative and quantitative methods, the aim of the study was to identify best practice examples and investigate the scope for more sustainable logistics operations with regards to the management of core goods, product returns and waste/recyclate produced by tenant retailers. Qualitative research in the form of interviews was undertaken to understand current policy and organisational frameworks related to supply chain management operations. Quantitative analysis of the freight activity of the businesses operating in *WestQuay* as recorded by *Hammerson* and individual retailers verified the supply chain trends suggested by the qualitative analysis and provided relevant statistical data needed to determine the associated logistical and environmental impacts.

To this end, this chapter is divided into four key sections. The first part outlines the data collection activities required for the development of an origin-destination dataset on products and waste produced by the respondent businesses. It includes detailed information about the interviews conducted in 2008 with tenant retailers and selected carriers, waste contractors/recyclers and head offices (qualitative analysis). The second section describes the mapping of origin-destination data to enable the estimation of the distances travelled using a standard routing tool. The third section gives an overview of the method applied to measure the carbon impact of established and proposed freight movements under a series of operating scenarios. The last section describes the examined operating scenarios with regard to the operation of a suburban consolidation centre in the outskirts of Southampton.

5.2 Data Collection Plan

Based on a number of previous establishment and transport surveys (Sections 2.6.2 and 2.6.3) it was deemed necessary in this research to develop a multi-stage survey technique to accurately quantify and verify the wide range of logistics activities undertaken. A four-stage survey-based analysis (Figure 17) was therefore adopted to obtain all the spatial, sectoral and temporal information required for the design of an origin-destination based logistics assessment model used to quantify the environmental feasibility of numerous 'share-based' logistics scenarios.

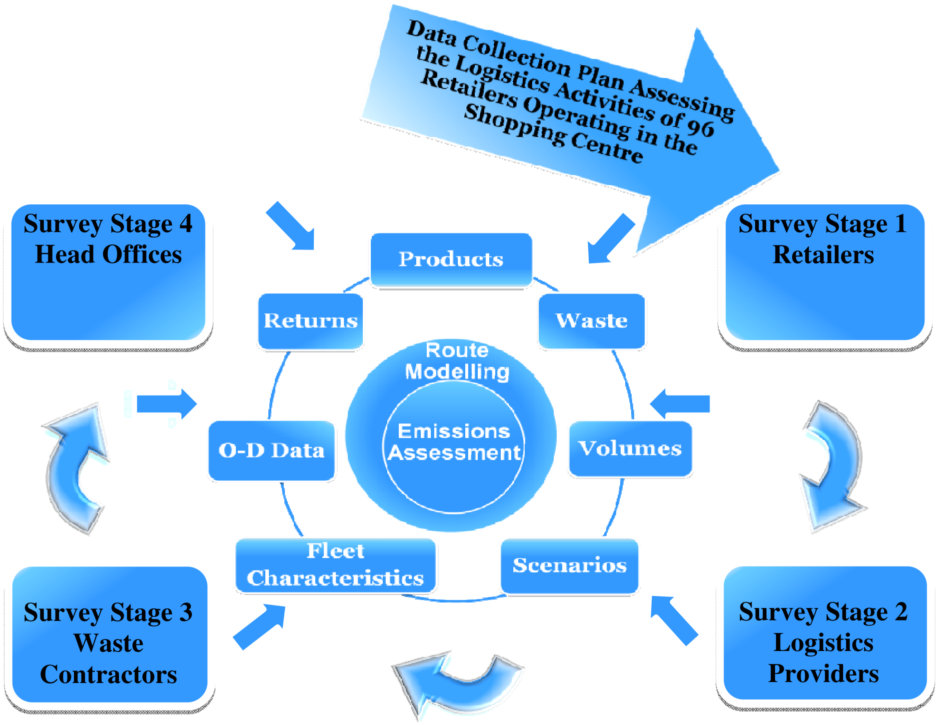


Figure 17: Four-stage data collection used in route modelling to assess environmental impacts of reverse logistics activities within a multi-face retail environment.

The requirements of the data collection plan included:

- Core goods deliveries and service vehicle visits to retailers.
- Quantification of core goods delivered, products returned and waste/recyclate produced per product category and by volume and weight.
- Origin-destination data for all inbound and outbound logistics activities.
- Current practices applied to handle waste/returns (collection contracts, product testing issues), system capacity (equipment, storage space) and inefficiencies.
- Fleet characteristics (technology, size, fuel type, ownership).
- Supply chain characteristics.

5.2.1 Survey Stage 1: Interviews with Retailers

As part of this study, interviews with the managers of 96% (92 out of 96) of the retail outlets and the catering units operating in *WestQuay* (Table 13) were held to gather information on individual waste management and logistics operations in order to quantify current logistics practices, identify specific problems and potential solutions.

Table 13: Survey response rate of businesses operating in *WestQuay* (n = sample)

Business Type	Number (n) of Businesses (Main Activity)	Response Level (%)	Activity			
			Main		Secondary	
			n	%	n	%
Clothing	34	97	33	35.8	5	5.4
Catering Units	20	100	20	21.7	1	1.1
Bookstores	4	100	4	4.4	0	0.0
Footwear	8	100	8	7.6	30	32.6
Opticians	3	100	3	3.2	6	6.6
Electronics	7	100	7	7.6	0	0
Jewellery	9	89	8	8.7	20	21.7
Cosmetics	4	100	4	4.4	3	3.3
Games	3	100	3	4.4	3	3.3
Department Stores	2	0	0	0	0	0
Other	2	100	2	2.2	0	0.0
Total	**96**	**95.8%**	**92**	**100**	**78**	

An interview approach was adopted to gather data from retailers due to the detailed nature of the data being sort and the complexity of the form completion which would be off-putting to managers if a pure postal approach was taken. A structured interview questionnaire [Appendices A1 and A2] was designed after examining previous similar studies (e.g. Edwards, 1997; Cherrett *et al*, 2002; Cherrett and Hickford, 2005) to create a mixture of qualitative and quantitative questions. Questions were grouped in three different categories (deliveries of core goods, collection of product returns and waste/recyclables). Although questions were closed and respondents were asked to choose from a list of options, multiple responses were available and the interviewer could make additional explanatory notes at any stage. Flow questions in the form of tables were also used to connect questions consequent upon earlier answers.

The interview questionnaire was piloted in a local commercial high street in order to identify problems and inefficiencies. The trials revealed the need to carefully distinguish between retailers who used largely centralised distribution systems with from one to three logistics providers supplying goods from a central distribution point [Appendix A1] and those having many separate suppliers visiting their premises [Appendix A2]. Also, the need to record inter-store transfers and return destinations were added to the final version.

The survey population consisted of all store managers operating in the shopping centre. Respondents initially received a cover letter from *WestQuay*'s Sustainability

Manager describing the background to the research and the need for them to participate in the survey. Follow-up phone contacts and visits were made to ensure availability and to schedule interviews. During the conduct of the survey it emerged that 15% of the stores were under new business management since the initial approach. In total, 96% (n=92) of the retailers operating in the retail complex were interviewed during a 5 week period between April and May 2008. An attempt to contact managers from the two non-responding retail units was made however due to a change in the management team at the time of the surveys in the first case and lack of available time to participate in the second case, interviews were not undertaken. In addition, initial contacts with members of the staff from the two department stores were made however attempts to reach upper management to receive approval for the surveys failed. Information gathered from *WestQuay*'s managers and online resources provided strong evidence that the two department stores have developed their own waste management systems at a national level. As a result the study sample was limited to 92 businesses.

During the interviews some key problems and challenges in the survey design arose which highlighted the need to corroborate certain responses from other sources (logistics providers, head offices or waste contractors). The main issues concerned:

- The confidential nature of the data being requested especially where high value products were concerned.
- Lack of knowledge about location of intermediate depots and uncertainty about origin-destination data and multi-drop services.
- Confusion concerning distribution centres used and returns destinations.
- Lack of knowledge concerning secondary or service deliveries especially when these were arranged by Head Offices or suppliers.
- Selective or random data collection when main suppliers numbered more than seven.
- Difficulty in quantifying average delivery consignments when the size varied between different delivery days or different types of packaging.
- Lack of knowledge concerning the fleet types used, as a result of the out-of-hours deliveries and collections or logistics activities in remote service bays.

- Difficulty quantifying goods by weight. Volume estimates provided were just an approximation.
- Lack of knowledge about past statistics due to new management teams or recent store openings.

5.2.2 Survey Stage 2: Interviews with Logistics Providers

Following the completion of the first survey stage it was deemed necessary to contact selected logistics providers servicing *WestQuay* in order to verify and supplement data obtained from the interviews with retailers. Due to the dispersed location of haulage companies, a phone interview survey was commissioned to verify the integrity of the data already collected and still gather a series of additional pertinent information. Hence logistics providers were asked to state the frequency of their visits to *WestQuay* by day of the week and by type of deliveries/collections (e.g. MCG, SCG, SP). Carriers were also asked to specify the types of vehicles servicing *WestQuay* businesses (van, articulated or rigid lorry) and provide additional information about the fuel requirements of the fleet used. Origin, destination and intermediate stops along delivery and return trips were recorded to determine a full routing description. This information was used to identify opportunities for joint deliveries and collections, detect available back-loads and set a baseline for measuring the logistics and environmental performance of a number of alternative collection scenarios.

5.2.3 Survey Stage 3: Interviews with Waste Contractors

WestQuay has developed a centrally coordinated waste collection and disposal service for non-hazardous wastes such as cardboard, polythene and paper. During the first survey stage it was determined that all businesses had joined *WestQuay*'s scheme, with the exception of the two department stores and one retail outlet. With reference to hazardous wastes, a number of retailers stated that they were producing an array of different waste streams (e.g. 11-WEEE, 10-batteries, 1-clinical waste, 87-fluorescent lighting tubes and 3-cooking oil) which were processed through individual mechanisms. The surveys suggested that the collection arrangements for hazardous waste and the waste produced by the three retailers varied significantly from business to business (described in more detail in Chapter 7). Waste loads were predominantly processed by dedicated waste contractors and on rare occasions by using the back-load capacity of delivery vehicles. Wastes were either returned to distribution centres, head offices or other specialised treatment facilities. The wide variation in waste management processes necessitated the conduct of additional interviews with hazardous waste collectors to help address the main operational and logistical issues related to particular collection methods.

The interview process included phone contacts with hazardous waste contractors selected on the basis of their specialism. Initial contacts were made with a number of them however only four waste contractors (managing WEEE, used cooking oil, medical waste and fluorescent lighting tubes) were finally interviewed. Further contacts were made with recyclers and logistics providers involved in several treatment stages to complete a full picture of the waste collection and treatment processes in the examined case studies. Due to the different specialisms of the waste companies, it was deemed necessary to produce different versions of a structured questionnaire to reflect the variations in the handling protocols for disparate waste streams [Appendices A3 and A4]. The spectrum of the issues covered included waste pre-treatment requirements (e.g. storage and packaging), collection arrangements (e.g. quantities, frequency and type of vehicles), treatment details (e.g. treatment methods such as recycling, recovery or disposal; stages and locations) and final disposal practices (e.g. remarket of recyclables or landfill disposal). This information was used to investigate the scope for coordinated collection strategies potentially using local treatment facilities.

5.2.4 Survey Stage 4: Interviews with Head Offices

The study identified that a small number of *WestQuay* businesses belonged to the same company and therefore shared the same Head Office. In total 84 individual Head Offices were identified for the 92 respondent businesses. In the final stage of the survey, some of these Head Offices were approached to cross-check and supplement data obtained from the interviews and seek views on general policy and attitudes towards potential cross-supply chain returns management scenarios. Where in-house fleets were used for the delivery of goods and the collection of return flows, Head Offices were asked to provide information similar to the data gathered from interviews with logistics providers (Survey Stage 2). Further information about the fleet used was gathered from online resources.

5.3 Routing Model- Microsoft MapPoint

In order to evaluate the overall environmental loss/gain incurred by established and proposed reverse logistics practices within the case study, it was necessary to use a routing tool (*Microsoft MapPoint*) to map all origin-destination data collected throughout the four survey stages. This model was used as a basis for evaluating potential collaborative scenarios among retailers with regards to the use of a consolidation centre located on the outskirts of Southampton.

Mappoint is a software program created by *Microsoft* that allows users to view, edit and integrate maps and calculate distances, travel times and costs. It is designed to facilitate the geographical visualisation and analysis of either included or custom data. Its main capabilities include trends analysis, statistics production and collaboration with other softwares in data sharing and import/export operations (MapPoint, 2010).

5.4 Emissions Assessment

With respect to the appraisal of the environmental impacts of the established and the proposed collaborative logistics activities among *WestQuay* retailers, potentially using an urban consolidation centre in the outskirts of Southampton (Chapter 8), the study adopted an emissions assessment methodology developed by the *UK Department of Food and Rural Affairs* (DEFRA). Details about this methodology are provided in the annex document '*2010 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting*' (DEFRA, 2010). This document describes the estimation of six distinct conversion factors differentiated on the basis of direct (CO_2, CH_4, N_2O, total), indirect (fuel production) and total (lifecycle) emissions. Emissions were determined using conversion factors that represent the rate at which different types of HGVs and LGVs emit greenhouse gases (GHGs) according to the distance travelled. This rate depends on the vehicle's fuel efficiency (distance travelled per unit of fuel consumed) which in turn is determined by the vehicle size and the loading of goods (tonnes-kilometre).

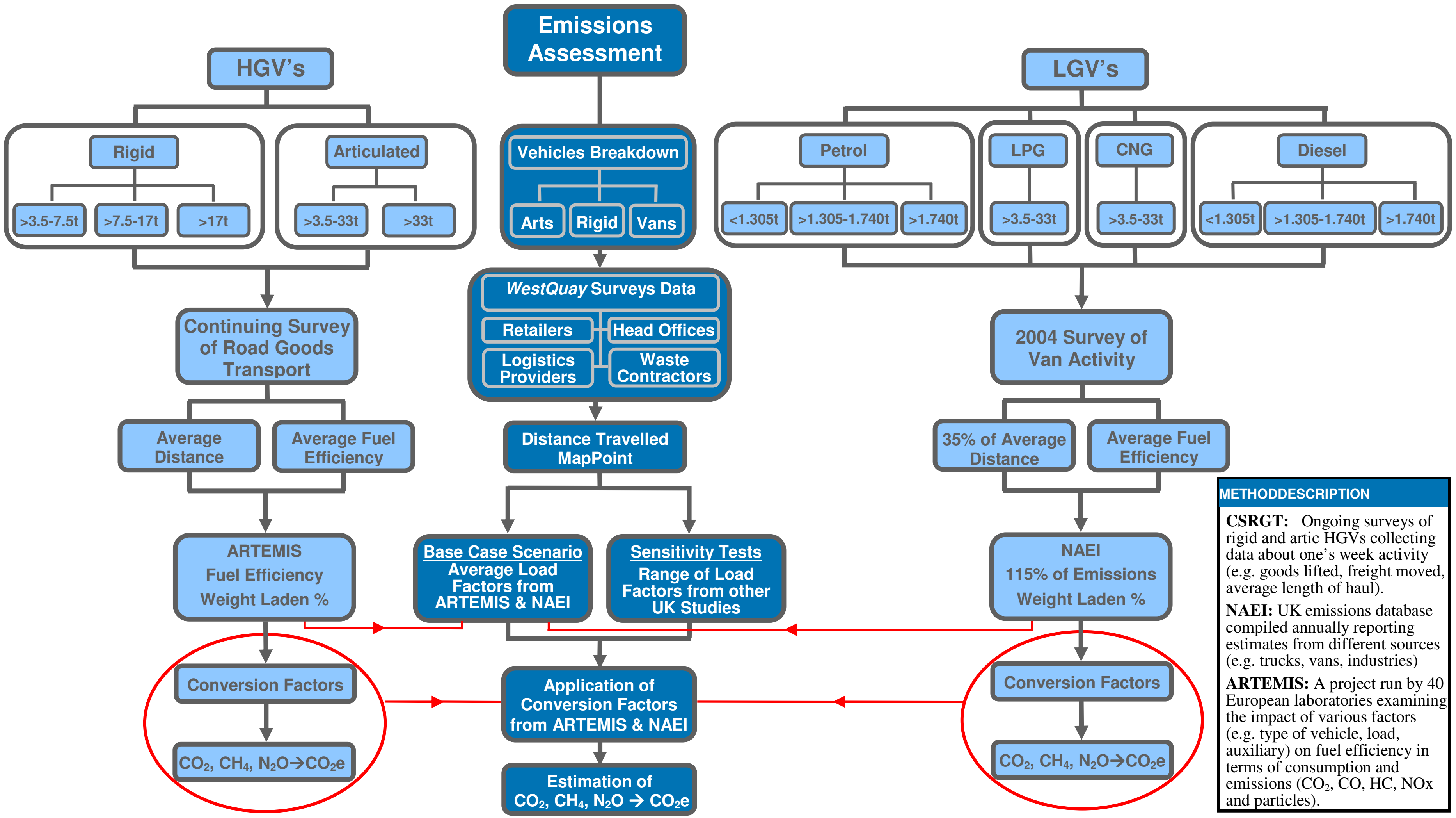


Figure 18: Process flow diagram and raw data used for the assessment of emissions in the base case and the proposed scenarios.

Using the breakdown of different vehicle types used to service *WestQuay* businesses, as they were reported during the surveys with the managers of the retail/catering units, the load factors that were applied in this study were those equal to the average national estimates (red circled values in Tables 14 and 16) derived from the UK *GSRGT* (Survey of Heavy Goods Vehicles in the UK) and the *2004 Survey of Van Activity* inventories (base case scenario). Further, scenario analysis was made to cover the range of statistical values on vehicle fill rates observed in the Birmingham/Norwich/Basingstoke study from Allen *et al* (2003) and the *Freight Best Practice* project (DfT, 2003) as described in Section 2.2.2.7. Direct, indirect and total emissions were estimated using the outputs (distances travelled) from *Microsoft MapPoint* for all the origin-destination data gathered through the surveys with retailers, logistics providers, waste contractors and head offices. A detailed description about the production of DEFRA's conversion factors is provided in Section 5.4.1 (HGVs) and Section 5.4.2 (LGVs). The emissions assessment methodology developed in this study is summarised in Figure 18.

5.4.1 Emissions Assessment for Heavy Goods Vehicles (HGVs)

Statistics about road freight in Great Britain, in terms of average distance travelled and average fuel efficiency, were derived from the '2009 *CSRGT Survey*' (DfT, 2010c). *CSRGT* activity data of rigid and artic HGVs with different sizes (Section 2.2.2.6) are combined with test data from the EU *ARTEMIS* project (http://www.trl.co.uk/artemis/) to produce the GHG conversion factors. *ARTEMIS* is a project run by 40 European laboratories examining the impact of various factors (e.g. type of vehicle, load, auxiliary) on fuel efficiency in terms of consumption and emissions (CO_2, CO, HC, NOx and particles). DEFRA (2010) provides a breakdown of the conversion factors for the different sizes of rigid and articulated HGVs with different load factors. Rigid HGVS are classified under 3 main gross vehicle weight categories (<7.5t, 7.5t-17t, >17t), while articulated HGVs under 2 categories (3.5t-33t, >33t). UK average factors for all rigid and articulated HGVs are also provided in case the weight class or the type of the HGV is not known (Table 14). Based on the *ARTEMIS* data, a breakdown of CO_2e emissions (described in Section 2.5.1) is given in terms of the 'weight laden' which expresses the extent to which the vehicle is loaded to its maximum capacity (weight laden: 0%-completely empty, 50%-half loaded, 100%: fully loaded).

Table 14: 2010 GHG emissions conversion factors per vehicle-km (source: DEFRA, 2010).

Body Type	Gross Vehicle Weight (tonnes)	% Weight Laden*	Greenhouse Gas (GHG) Emissions (gCO2e)					
			Direct*				Indirect*	Grand
			CO_2	CH_4	N_2O	Total	Total	Total
Rigid	**>3.5-7.5t**	0%	527.6	0.30	5.9	533.8	102.4	636.2
		50%	573.5	0.30	5.9	579.7	111.2	690.9
		100%	619.4	0.30	5.9	625.6	120.0	745.6
	UK average load	*41%*	*565.3*	*0.30*	*5.9*	*571.4*	*109.6*	*681.1*
	>7.5-17t	0%	671.3	0.40	7.8	679.4	130.4	809.8
		50%	767.1	0.40	7.8	775.3	148.8	924.1
		100%	863.0	0.40	7.8	871.2	167.1	1,038.4
	UK average load	*41%*	*749.9*	*0.40*	*7.8*	*758.1*	*145.4*	*903.5*
	>17t	0%	798.1	0.52	10.2	808.9	1`55.2	964.1
		50%	973.3	0.52	10.2	984.1	188.8	1,172.9
		100%	1,148	0.52	10.2	1,159.3	222.4	1,381.7
	UK average load	*53%*	*983.8*	*0.52*	*10.2*	*994.5*	*190.8*	*1,185.3*
	Rigid -UK Average	***52%***	***829.0***	***0.44***	***8.6***	***838.1***	***160.7***	***998.9***
Articulated	**>3.5-33t**	0%	692.1	0.95	8.8	701.9	134.7	836.6
		50%	865.2	0.95	8.8	874.9	167.9	1,042.8
		100%	1,038	0.95	8.8	1,048.0	201.1	1,249.0
	UK average load	*45%*	*847.9*	*0.95*	*8.8*	*857.6*	*164.5*	*1,022.2*
	>33t	0%	697.9	1.09	10.2	709.2	136.1	845.3
		50%	930.6	1.09	10.2	941.9	180.7	1,122.6
		100%	1,163	1.09	10.2	1,174.5	225.3	1,399.8
	UK average load	*61%*	*981.8*	*1.09*	*10.2*	*993.0*	*190.5*	*1,183.6*
	Arts - UK average	***60%***	***969.0***	***1.08***	***10.1***	***980.2***	***188.0***	***1,168.2***
All HGVs UK average		**58%**	**895.2**	**0.77**	**9.3**	**905.3**	**173.7**	**1,079.0**

*Red Circled Figures: UK average vehicle load (%) figure used in the calculation of freight emissions in Chapter 8-Results Consolidation Centre.
* Weight Laden: The extent to which a vehicle is loaded to its maximum capacity.
* Direct Emissions: GHG emissions produced at the point of use of a fuel/energy carrier (DEFRA, 2010).
* Indirect Emissions: GHG emissions produced prior to the use of a fuel/energy carrier e.g. as a result of extracting and transforming the primary energy source (DEFRA, 2010).

The effect of load was found to be largely independent of the HGVs Euro emission classification and type of drive cycle. In addition, the effect of vehicle loading on CO_2 emissions was found to be linear; therefore conversion factors can be linearly interpolated if a more precise figure on vehicle load is known (DEFRA, 2010). In the above table, conversion factors are in distance units, allowing the calculation of CO_2e by multiplying the distance travelled by the HGV (in km) with the appropriate conversion factor for the type of HGV and, if known, the extent of loading (Section 2.2.2.6). DEFRA also provides a breakdown of HGVs according to the fuel type used (petrol or diesel) however due to lack of such information it was not deemed necessary to include this kind of detail in the study.

Table 14 reflects the usage patterns for different types of HGVs which, once the relative degree of loading is taken into account, reveal a consistently worse fuel efficiency for large rigid HGVs than large articulated HGVs. This is due to large rigid

HGVs spending more time travelling at lower, more congested urban speeds and operating at lower fuel efficiency than artic HGVs spending more time travelling under higher speeds and free-flowing traffic conditions on motorways where fuel efficiency is closer to optimum (DEFRA, 2010). It also shows that the above conversion factors already consider parameters (e.g. driving speed) otherwise used as direct input values in a number of other GHGs assessment methods.

5.4.2 Emissions Assessment for Light Goods Vehicles (LGVs)

Emission factors for light good vehicles (LGVs) in the UK were derived from a combination of statistics from the '*2004 Survey of Van Activity*' (DfT, 2004b, Section 2.2.2.6) and a number of estimates of average fuel consumption. Considering that only 35% of the distance travelled in 2004 by company-owned vans, involved the collection and/or delivery of goods or related empty running, McKinnon (2007b) suggested that a respective percentage (35%) should also be assumed for the CO_2 output from the van sector. The assessment of GHGs is not differentiated by the trip purpose though (freight or passenger related) and is based on use of the *NAEI* which contains emissions data for the period 1990-2004. NAEI considers an uplift of CO_2, CH_4 and N_2O emission factors by 15% to represent the 'real-world' emissions, while the relevant conversion factors are provided by DEFRA (2010). In Table 15 a breakdown of the conversion factors for vehicle-km calculations is made on the basis of the fuel type (petrol, diesel, LPG and CNG) and the weight class of vans (Class I: <1,305 tonnes, Class II: >1,305-1,740 tonnes and Class III: >1,740 tonnes).

Table 15: Emissions factors per vehicle-km and tonne-km for LGV road freight (based on UK average vehicle loads in 2008) for 2010 GHG conversion factors (source: DEFRA, 2010)

Fuel Type	Gross Vehicle Weight (tonnes)	Greenhouse Gas (GHG) Emissions (gCO_2e)											
		Vehicle per km						Tonnes per km					
		Direct*				Indirect*	Grand	Direct*				Indirect*	Grand
		CO_2	CH_4	N_2O	Total	Total	Total	CO_2	CH_4	N_2O	Total	Total	Total
Petrol	**<1.305t**	194.1	0.2	0.8	195.1	37.4	232.6	1.173	1.5	5.1	1,180.0	226.4	1,406.4
	>1.305-1.740t	211.1	0.2	0.8	212.2	40.7	252.9	820.6	0.9	3.3	824.8	158.2	983.1
	>1.740t	255.8	0.3	1.8	257.8	49.4	307.3	496.0	0.5	3.6	500.1	95.9	596.0
	UK average	***240.5***	***0.3***	***1.5***	***242.2***	***46.5***	***288.7***	***563.7***	***0.6***	***3.6***	***567.9***	***108.9***	***676.8***
Diesel	**<1.305t**	157.0	0.1	1.1	158.2	30.3	188.5	949.5	0.4	6.5	956.4	183.5	1,139.8
	>1.305-1.740t	224.8	0.1	1.5	226.4	43.4	269.8	873.9	0.2	5.9	880.0	168.9	1,048.9
	>1.740t	269.1	0.1	1.8	271.0	52	323.0	522.0	0.1	3.6	525.6	100.8	626.5
	UK average	***250.8***	***0.1***	***1.7***	***252.6***	***48.5***	***301.0***	***588.0***	***0.2***	***4.0***	***592.2***	***113.6***	***705.8***
LPG	**<3.5t**	263.3	0.5	1.9	265.8	33.3	299.1	617.4	1.2	4.5	623.2	119.6	742.7
CNG	**<3.5t**	238.3	1.3	1.9	241.5	35.4	276.9	558.6	2.9	4.5	566.1	108.6	674.7
All LGVs UK average		**250.2**	**0.1**	**1.7**	**251.9**	**48.3**	**300.3**	**586.5**	**0.2**	**3.9**	**590.7**	**113.3**	**704.0**

* Direct Emissions: GHG emissions produced at the point of use of a fuel/energy carrier (DEFRA, 2010).
* Indirect Emissions: GHG emissions produced prior to the use of a fuel/energy carrier e.g. as a result of extracting and transforming the primary energy source (DEFRA, 2010).

The statistics in Table 15 are based on the use of the average load factors for the different vehicle categories (Table 16) which consider the extent to which the vehicle is loaded to its maximum capacity (weight laden). The average load factors for LGVs are summarised in the following table:

Table 16: Utilisation of vehicle capacity by company owned LGVs: annual average 2003-2005 proportion of total vehicle kilometers travelled (source: DEFRA, 2010).

Average Van Loading	Gross Vehicle Weight (tonnes)	Utilisation of Vehicle Volume Capacity %					Total
		Loading Range*	0-25	26-50	51-75	76-100	
		Midpoint*	12.5	37.5	62.5	87.5	
% of Vehicles in the Loading Range	**<1.8t**		45%	25%	18%	12%	100%
	>1.8-3.5t		36%	28%	21%	15%	100%
	All Average		*38%*	*27%*	*21%*	*14%*	*100%*
Estimated Weighted Average % Loading	**<1.8t**						***36.8%***
	>1.8-3.5t						***41.3%***
All LGVs Average % Loading							**40.3%**

*Red Circled Figure: UK Average vehicle load (%) figure used in the calculation of freight emissions in Chapter 8- Results Consolidation Centre.
* Loading Range: A range of weight laden values showing the extent to which a vehicle may be loaded.
* Midpoint: The value equidistant from two extreme values, middle value.

5.5 Scenario Analysis and Sensitivity Tests

One of the main objectives of this study was to investigate the potential mileage and emissions savings through the establishment of a consolidation centre in the outskirts of Southampton. In order to estimate the potential transport and environmental impacts of the consolidation scheme the following analysis steps were undertaken:

- *Step 1*: The survey results were used to assess the weekly and seasonal number of MCGs deliveries made to *WestQuay* businesses by each broad vehicle mode (articulated lorry, rigid lorry, van and other/unknown).
- *Step 2*: The total distance travelled (km) during a week and across a year was calculated for each vehicle mode delivering MCGs to *WestQuay* businesses.
- *Step 3*: The weekly and seasonal numbers of the various types of packaging units delivered to *WestQuay* businesses were calculated prior to being converted into volumetric (m^3) equivalents carried by each type of delivery vehicle.
- *Step 4*: The volumetric equivalents (m^3) were converted into weight equivalents (tonnes) assuming that the average recorded *WestQuay* loads by volume were equal to the UK average loads by weight and that their values were changing proportionally.

- *Step 5*: The average tonnage per delivery trip was calculated for weekly and seasonal MCGs deliveries made by the different types of vehicles.
- *Step 6*: Using the emissions factors as provided in 2010 DEFRA's guidelines the greenhouses gases produced by the four broad groups of vehicles were estimated considering the average tonnage per trip and the distance travelled for a) the full delivery trip and b) the last-mile (6km).
- *Step 7*: The calculations were repeated for the last mile for different combinations of vehicle modes and vehicle uptakes.

To this end, the following scenarios were carried out to investigate the potential benefits and risks of the consolidation scheme under various operating conditions.

5.5.1 Baseline Scenario

Analysis was based on the construction of a base-case scenario which assumed the continuation of the trends in vehicle usage (vehicle mix), route patterns (origin, destination and preferred routes) and frequency of freight movements, as they were recorded at the time of the interviews (April-May 2008). It aimed at reflecting a reasonable approximation of the overall transport (distance travelled in kilometres) and environmental footprint (CO_2e in kilograms) in accordance with the established practices. The base case scenario also served as a benchmark against which other scenarios were compared through a series of sensitivity tests (Table 17). Due to uncertainty in load estimates and the exact gross weight of the vehicles used, the study adopted the average '*2009 CSRGT Survey*' loading factors for rigid (52%) and articulated lorries (60%), described in Table 14, and the average '*2004 Survey of Van Activity*' loading factors for vans (40.3%), described in Table 16.

5.5.2 Scenarios and Sensitivity Tests

A number of sensitivity tests were performed in which several parameters were varied to elucidate the potential transport and environmental effects. Considering the establishment of the consolidation centre in the outskirts of Southampton (Section 8.3), these tests assumed that delivery and collection vehicles were passing through this centre with the aim to tranship consignments into vehicles delivering or collecting highly consolidated loads to/from *WestQuay* retailers. The variables examined were the participation and retail mix, the vehicle delivery mix and the vehicle fill rates:

Table 17: List of scenarios examined with regard to *WestQuay*'s consolidation scheme.

Scenarios		Scenarios Description	Vehicle Delivery Mix			Vehicle Fill Rate (m^3)		
			Arts	Rigid	Vans	Arts	Rigid	Vans
Scenario A	**A1**	Exclusive use of articulated lorries filled at 50% of their volume capacity.	100%			50%		
	A2	Exclusive use of articulated lorries filled at 60% of their volume capacity.	100%			60%		
	A3	Exclusive use of articulated lorries filled at 100% of their volume capacity.	100%			100%		
Scenario B	**B1**	Combined use of articulated (40%) and rigid lorries (60%), both filled at 50% of their volume capacity.	40%	60%		50%	50%	
	B2	Combined use of articulated (40%) and rigid lorries (60%), filled respectively at 60% and 52% of their volume capacity.	40%	60%		60%	52%	
	B3	Combined use of articulated (40%) and rigid lorries (60%), both filled at 100% of their volume capacity.	40%	60%		100%	100%	
Scenario C	**C1**	Combined use of articulated lorries (30%), rigid lorries (60%) and vans (10%) all filled at 50% of their volume capacity.	30%	60%	10%	50%	50%	50%
	C2	Combined use of articulated lorries (30%), rigid lorries (60%) and vans (10%) filled respectively at 60%, 52% and 40.3% of their volume capacity.	30%	60%	10%	60%	52%	40.3%
	C3	Combined use of articulated lorries (30%), rigid lorries (60%) and vans (10%), all filled at 100% of their volume capacity.	30%	60%	10%	100%	100%	100%
Scenario D	**D1**	Exclusive use of rigid lorries filled at 50% of their volume capacity.		100%			50%	
	D2	Exclusive use of rigid lorries filled at 52% of their volume capacity.		100%			52%	
	D3	Exclusive use of rigid lorries filled at 100% of their volume capacity.		100%			100%	
Scenario E	**E1**	Combined use of rigid lorries (90%) and vans (10%), both filled at 50% of their volume capacity.		90%	10%		50%	50%
	E2	Combined use of rigid lorries (90%) and vans (10%), filled respectively at 52% and 40.3% of their volume capacity.		90%	10%		52%	40.3%
	E3	Combined use of rigid lorries (90%) and vans (10%), both filled at 100% of their volume capacity.		90%	10%		100%	100%
Scenario F	**F1**	Combined use of rigid lorries (40%) and vans (60%), both filled at 50% of their volume capacity.		40%	60%		50%	50%
	F2	Combined use of rigid lorries (40%) and vans (60%), filled respectively at 52% and 40.3% of their volume capacity.		40%	60%		52%	40.3%
	F3	Combined use of rigid lorries (40%) and vans (60%), both filled at 100% of their volume capacity.		40%	60%		100%	100%
Scenario G	**G1**	Exclusive use of vans filled at 40.3% of their volume capacity.			100%			40.3%

- *Participation and Retail Mix*: Two cases were examined:
  - *Mandatory Participation*: the retail mix in this case will represent the actual profile of the businesses operating in *WestQuay* (n=92) as of the time of the interviews with retailers.

- *Voluntary Participation*: Considering that only a small percentage of these businesses will in fact participate to the consolidation centre scheme, this scenario will consider the participation of only 13 *WestQuay* businesses with branches already participating in *Broadmead*'s shopping centre's consolidation centre in Bristol (Section 8.3.2).

- *Vehicle Delivery Mix*: Various mixes of articulated and rigid lorries and vans running between *WestQuay* and the consolidation centre in Nursling (last-mile) will be examined. In total seven main take-up combinations (A to G) will be examined (Table 17).
- *Vehicle Fill Rates*: The above scenarios are further analysed to consider different weight laden factors for each vehicle category. Considering the availability of GHGs conversion factors for specific weight laden values (50%, UK average and 100%), a set of 19 scenarios will be produced and examined (described in Table 17). These scenarios are compared against the baseline scenario which reflects the actual *WestQuay* freight activity as described in Chapters 5 and 6. This requires the conversion of the actual weekly and seasonal MCGs volume into precise weight estimates which are linearly interpolated in order to produce the precise GHGs conversion factors.

Estimation of Vehicle Fill Load (tonnes): One of the difficulties faced in this study was that DEFRA's emissions assessment methodology considered the vehicle fill by load (tonnes), while the data gathered from the interviews with *WestQuay* managers were provided by volume (m^3). Due to absence of any such suggestions in previous studies, it was deemed necessary to find a way to link these two measures. It was therefore assumed that the estimated average load (m^3) per trip carried by each vehicle calling to *WestQuay*, including loads destined to potential follow-up stops, corresponded to the UK average load figures provided by DEFRA (2010) in Tables 14 and 16 (33t arts: 60%, 17t rigid: 52%, 3.5t vans: 40.3%, and vehicles of unknown mode: 58%). The relationship between the volumetric and weight vehicle capacity was assumed to be analogous and change proportionally (Table 18). For example, when an articulated lorry is filled by 60% of its weight capacity (tones), it carries 15.11 m^3 of goods destined to *WestQuay* and unknown volume of goods (χ) destined to follow-up stops (Figure 19).

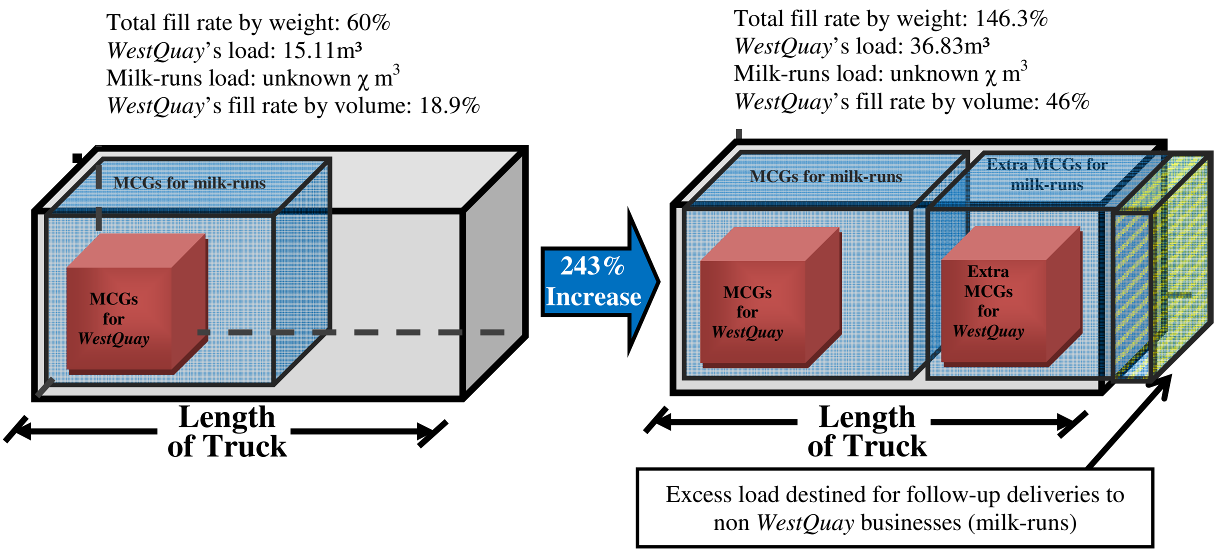


Figure 19: Diagram exhibiting the assumed relationship between the vehicle load by weight (t) and the vehicle fill by volume (m³).

A 236% seasonal increase in the volume of goods destined to *WestQuay* (236%*15.11 m^3 = 36.83 m^3) and to potential follow-up destinations (236%*χ) would correspond to 146.3% (=243%*60%) increase in the fill rate by weight. In this case, the weight threshold is exceeded probably because of the weight of the goods destined to follow-up destinations. As the volume of goods destined to *WestQuay* still fits in the vehicle (36.83 m^3<80 m^3, 80 m^3: max volumetric capacity of an articulated lorry), it is assumed that when the overall fill rate by weight exceeds the upper threshold (100%), the vehicle will be used to its maximum weight capacity (100%) by removing the excess load (+46.3%) destined to follow-up destinations. If the overall fill rate by weight is lower than the upper threshold (100%), then its exact value is assumed in the baseline scenario.

Table 18: Assumed analogy between vehicle fill rate by load (tonnes) and vehicle fill rate by volume (m^3) values.

Vehicle Type	UK Average Load Factors (DEFRA, 2010) (tonnes)	Average *WestQuay* Contribution to Vehicle Fill (m³) [Section 5.5.2]				
		Annual Average	Standard week		Busy Week	
Vans	40.3%	1.08	0.76	28.4%	2.30	85.8%
Rigid Lorries	52%	4.13	2.85	35.9%	7.88	88.1%
Articulated Lorries	60%	15.11	6.98	53.2%	36.84	280.5%
D/K → Average HGVs	58%	2.68	1.59	34.4%	7.93	171.6%

Considering the various assumptions made during the data collection and the analysis processes it should be noted that the figures generated in this study are broad estimates of the transport and environmental impacts of the consolidation scheme. The actual impacts of the scheme can only be recorded, monitored and evaluated after the implementation of the consolidation centre. However an understanding on the expected number of delivery trips and the associated emissions can be gained through the examination of existing consolidation schemes, their operational characteristics, strengths and weaknesses (Chapter 8).

5.6 Summary and Discussion

This chapter presented the conceptual framework and the analysis techniques used in order to collect the data associated with all forward and reverse logistics operations taking place in *WestQuay* shopping centre, develop a routing model to map all the inbound and outbound movements, estimate GHGs emissions and evaluate the last-mile transport and environmental impacts under a subset of scenarios with regard to the operation of a suburban consolidation centre servicing *WestQuay* businesses. To this end, this chapter described the development of a four-stage survey-based data collection plan in order to obtain all spatial, sectoral and temporal information needed to design an origin-destination logistics assessment model using *Microsoft MapPoint*. Emissions were then determined using DEFRA's emissions assessment guidelines based on statistical data from the latest GSRGT surveys of HGVs and the surveys of Van activity. A number of UCC operational scenarios were then developed in order to examine a series of vehicle take-up and weight laden combinations under a mandatory and voluntary participation regime.

In the development of the data collection plan, the development of the routing model, the application of the GHGs assessment method and the construction of scenarios regarding the operation of *WestQuay*'s consolidation centre, special attention was given to issues discussed in Figure 20.

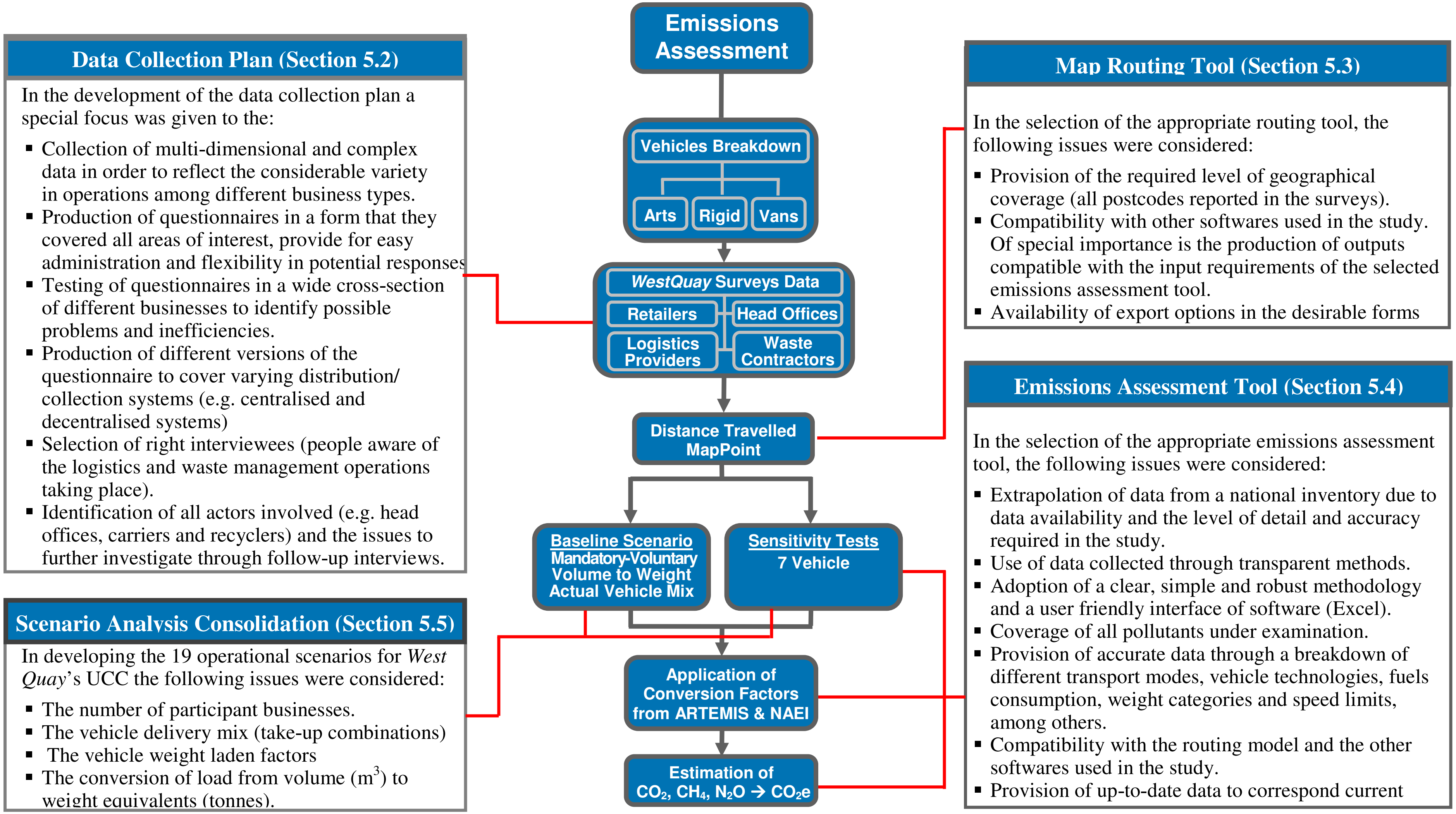


Figure 20: Important issues in the development of *WestQuay* data collection plan, route modelling and emissions assessment.

Chapter 6: Core Goods Deliveries

6.1 Introduction

One of the primary aims of this study is the examination of the delivery vehicle movements servicing the retail centre to aid understanding of the current opportunities to better utilise the existing delivery mechanisms in order to increase back-load rates and reduce urban congestion and pollution. To this end, this chapter provides a description of the forward logistics and back-loading practices as recorded at the time of the interviews with *WestQuay* retailers. Focusing on main core goods (MCGs) deliveries for up to 7 major suppliers for each business, this section reviews the forms of the distribution and collection systems adopted and examines the freight activity (e.g. number, frequency and volume of deliveries and back-loads) as of the time of the interviews with *WestQuay* retailers. These data will be used as a measure for comparing the transport and the environmental impacts of a number of alternative service regimes (e.g. vehicle and retail mix) associated with the use of the urban consolidation centre (Chapter 8).

6.2 Context of Analysis

Analysis was confined in the examination of MCGs deliveries and back-loading practices, while further business classifications were made on the basis of the main commercial activity under SIC 2007 (Section 2.6.3.1) and the retail floor size (Section 2.6.3.2).

6.2.1 Type of Deliveries Examined

In accordance with the SIC classification system (Section 2.6.3.1), commercial vehicle visits made to *WestQuay* businesses were associated with the delivery of main core goods (MCGs), secondary core goods (SCGs) and service products (SPs). The study identified that the surveyed businesses (n=92) received MCGs from 204 major suppliers visiting the shopping centre on a regular basis (at least once weekly). Almost half of these businesses (n=44) were receiving SCGs at the same time (52 suppliers). This was more predominant in the case of stores selling clothing receiving mixed consignments of clothes, jewellery and footwear. In 13 of these cases (14 suppliers), consignments also included SPs such as promotional materials, stationery and cleaning stuff. Only in 7 cases MCGs were delivered along with SPs.

With regard to SCGs deliveries, 14 businesses were receiving dedicated visits from 121 suppliers. This formed almost a third of all businesses receiving SCGs deliveries (n_{tot}=47). Among the 14 businesses, there were 6 stores selling clothes (10 suppliers), 3 restaurants (5 suppliers), 2 bookstores (75 suppliers), 1 store selling electronic games (13 suppliers), 1 store selling optical goods (3 suppliers) and 1 jewellery store (15 suppliers). In most cases, SCGs deliveries were made in a less frequent basis than MCGs and varied from a few times a month to a few times a year. Service products, on the other hand, were usually delivered upon request and with a frequency ranging from a few times a week to a few times a year. Only 28.2% (n=26) of the 92 participating businesses were receiving separate service deliveries. These were mainly stores selling clothing (n=11) and restaurants (n=6). Due to the limited number of businesses receiving dedicated and fixed SCGs and SPs deliveries, the study was confined into the examination of MCGs deliveries.

6.2.2 Business Classification Used in Analysis

MCGs deliveries were analysed on the basis of the SIC 2007 (Sections 2.6.3.1 and 4.3.1.1; Table 11) and the floor size class they belonged to (Sections 2.6.3.2 and 4.3.1.2; Table 12).

6.2.2.1 Analysis based on the Type of Commercial Activity

Analysis was made considering the 10 business types operating in *WestQuay* described in Section 4.3.1.1 (Table 11). Department stores were excluded from analysis as these were not included in the survey sample (Table 19).

Table 19: Categorisation of surveyed *WestQuay* businesses in accordance with SIC 2007.

Business Type	Activity (n=number of businesses)			
	MCGs		SCGs	
	n	%*	n	%*
Clothing	33	35.9	5	5.4
Catering Units	20	21.7	1	1.1
Bookstores	4	4.3	0	0.0
Footwear	8	8.7	29	31.5
Opticians	3	3.3	6	6.52
Electronics	7	7.6	0	0.0
Jewellery	8	8.7	19	20.6
Cosmetics	4	4.3	3	3.3
Games	3	3.3	3	3.3
Other	2	2.2	0	0.0
Total	**92**	**100**		

*% figures are estimated as percentages on the total number of *WestQuay* stores (n=92)

6.2.2.2 Analysis based on the Floor Area of Stores

Further analysis was made considering the three floor-size classes (small: $A<200m^2$, medium: $200m^2<A<500m^2$ and large: $A>500m^2$) described in Section 4.3.1.2 and Table 12. The following table (Table 20) shows the breakdown of *WestQuay* businesses in terms of their floor space. It should be noted that some of this floor area may not be used for customer sales as it may include staff rooms, offices and other private areas. In some cases the floor area may also be used for stock management, especially in the case of businesses not having dedicated storage rooms.

Table 20: Categorisation of surveyed *WestQuay* businesses according to their floor area.

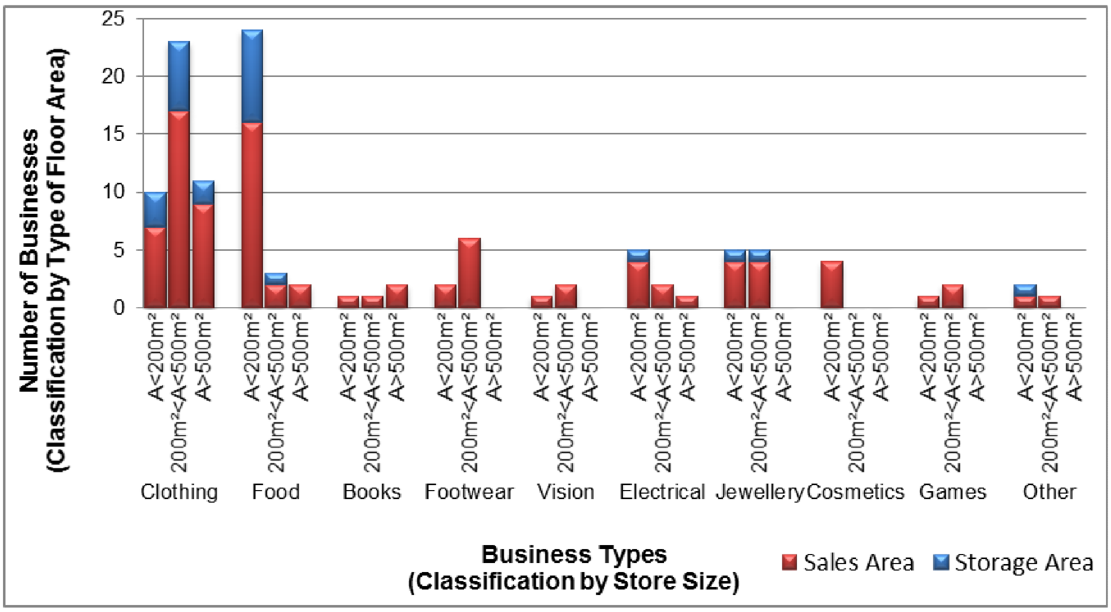
Floor Area (A) / Business Type	Stores Number	Number of Businesses (n)					
		A<200		200<A<500		A>500	
	(n_{tot})	n	%	n	%	n	%
Clothing	33	7	21	17	52	9	26
Catering Units	20	16	80	2	10	2	10
Bookstores	4	1	25	1	25	2	50
Footwear	8	2	25	6	75	0	0
Opticians	3	1	33	2	67	0	0
Electronics	7	4	57	2	29	1	14
Jewellery	8	4	44	4	56	0	0
Cosmetics	4	4	100	0	0	0	0
Games	3	1	33	2	67	0	0
Other	2	1	50	1	50	0	0
Total	**92**	**41**	**42.7**	**39**	**40.6**	**14**	**16.7**

*% figures are estimated as percentages on the total number of *WestQuay* stores belonging to each business category.

The study revealed that among the biggest stores in the shopping centre (n=14, $A>500m^2$) were bookstores, restaurants and cafes, as well as stores selling clothing and electronics. These were mainly businesses trading a wide variety of product ranges (e.g. *New Look* and *SportsWorld*), numerous product brands (e.g. *Curry's*), and restaurants with private customer sitting areas as for proximity reasons it was impossible to make use of the public sitting area located at the Food Terrace.

The results also indicated that 75% of the stores selling footwear, 33% of the stores selling optical goods and games, 25% of the bookstores and 50% of the businesses selling clothing, jewellery and other had sales floor spaces ranging from $200m^2$ to $500m^2$. Among the businesses with the smallest floor areas ($A<200m^2$) were ranked all the stores selling cosmetics (n=4), 4 stores selling jewellery (50%), 16 restaurants (80%), as well as 4 stores selling electrical and electronic equipment (57%). In general the small size of stores was associated with the small size of the merchandise traded (e.g. perfumes, jewellery, mobile phones) or the use of the public customers sitting area located on the Food Terrace, in the case of the restaurants.

In examining the businesses with designated storage areas, it was found that in total 24 stores (15.2%) used designated store rooms (Figure 21). All storage areas were smaller than 200m^2 (average floor area: 42 m^2 and standard deviation: 34.82 m^2). In the majority of the cases (75%, n=18), the dedicated storage rooms were located at the back of the stores, in five cases they were located in areas remote from the stores and normally based at the basement of the shopping centre, while in one case the same business owned two storage rooms, one at the back of its sales area and one at the basement of the shopping centre. This was one of the biggest stores selling clothing (*Next*) which was also trading a large variety of SCGs including bulky furniture demanding larger storage capacity. Half of the businesses with designated storage rooms (n=12) were stores selling clothing with estimated average sales floor area equal to 570 m^2 (standard deviation: 741.1 m^2). The vast majority (75%) of the remaining businesses were restaurants, cafes and confectioneries (n=8). The seasonal nature of clothes in the first case and the special storage requirements for food products (e.g. need for refrigeration) were the main reasons why these types of businesses had a greater demand for storage capacity.



*The classification of the store rooms in this graph is made upon the floor size of the businesses they belong and not their own size which was always smaller than 200m^2.

Figure 21: *WestQuay* business classification based on the sales floor space (A: sales area in m^2)

6.3 Types of Distribution Systems

Respondents were asked to describe the type of the distribution system (centralised or de-centralised) used to process MCGs (as described in Section 2.2.2.1).

6.3.1 Types of Distribution System per Business Type

It was found that the vast majority of stores selling cosmetics (100%, n=4 of all stores selling cosmetics), clothing (78.8%, n=26) and footwear (75%, n=6) had adopted a single sourcing system (centralised) to receive core goods (Figure 22). In addition a significant percentage of the stores selling optical goods (66.7%, n=2), electronics (57.1%, n=4), jewellery (50%, n=4) and other (50%, n=1) were served from a single distribution centre. This was not the case though for bookstores, restaurants and stores selling games and toys, as almost two thirds of those businesses were accepting deliveries from a wider base of suppliers in order to offer a greater variety of product ranges and brands.

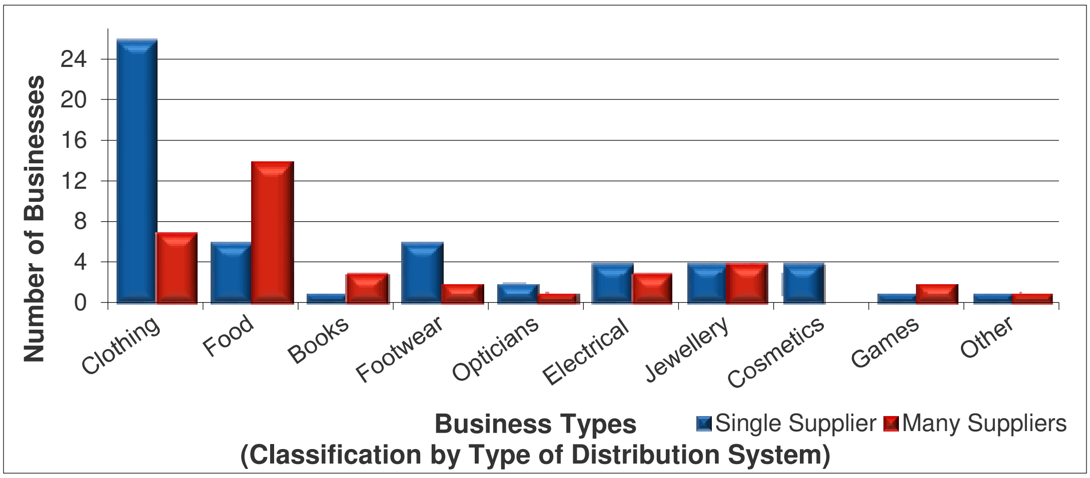


Figure 22: *WestQuay* business classification based on the type of the distribution system.

In total 40% (n=37) of the businesses operating in *WestQuay* were receiving core goods deliveries from 2 or more MCGs/SCGs distribution centres. In more detail, 12% of them were receiving MCGs from only 2 suppliers, while another 8.7% from 3 to 7 suppliers.

6.3.2 Types of Distribution System per Store Size

In examining the relationship between sales floor space and the type of distribution system, it was found that 23 out of the 41 businesses (56%) with sales areas smaller than 200m^2 were receiving core goods deliveries from a central distribution centre (Table 21). Most of these businesses were part of big brand chains focusing their activities on single product ranges and/or target groups. These included mainly stores selling clothing and cosmetics, big-chain confectioneries and small food stands. In those cases, businesses had embraced a centralised distribution system as part of wider corporate distribution strategies. The small size of their business was linked to the small size of products (e.g. mobile phones, jewellery, and cosmetics). Although this was also the case for another 18 businesses with floor areas smaller than 200m^2, the study found out that these were supplied from more than one distribution centre (de-centralised distribution system) due to the variety in the nature of core goods traded. Among them there were remarkably 12 catering units (Table 21).

Table 21: Type of distribution system serving businesses in *WestQuay* by business category and total floor area (n= *number of businesses,* A: *floor area in m*^{2})

Stores Number (n) / Business Category	Total Stores No	Single-Sourcing System				Multi-Sourcing System			
		A<200	200<A A<500	A>500	Total	A<200	200<A A<500	A>500	Total
Clothing	33	7	12	7	26	0	5	2	7
Catering Units	20	4	1	1	6	12	1	1	14
Bookstores	4	0	1	0	1	1	0	2	3
Footwear	8	2	4	0	6	0	2	0	2
Opticians	3	1	1	0	2	0	1	0	1
Electronics	7	2	2	0	4	2	0	1	3
Jewellery	8	2	2	0	4	2	2	0	4
Cosmetics	4	4	0	0	4	0	0	0	0
Games	3	0	1	0	1	1	1	0	2
Other	2	1	0	0	1	0	1	0	1
Total	**92**	**23**	**24**	**8**	**55**	**18**	**13**	**6**	**37**

A centralised distribution system was also embraced by another 24 businesses with floor areas ranging from 200m^2 to 500m^2. Half of them were stores selling clothing, usually belonging to large retail chains which produced their own brand lines for a wide range of consumer target groups (e.g. both women, men and kids). In those cases products were coming from a single warehouse or distribution centre. The wide range of product lines usually offered by most of these businesses implied that many of these distribution centres were also operating as consolidation centres bringing together products from a number of different suppliers. However in most of the cases the interviewees expressed lack of knowledge about the processes taking place prior to products reaching the distribution centre.

Although one would expect that the largest stores in the shopping centre (A>500m^2) would receive MCGs deliveries from more than one sources, the study revealed that 8 out of the 14 retail and catering units were being serviced from a single distribution centre. The vast majority of them (87.5%, n=7) were big chain businesses mainly selling clothing (e.g. *Benetton*, *New Look*, *SportsDirect*, *Next* and *H&M*). Although these businesses offered a great variety of product types and ranges, the globalisation of their activities and the sourcing of products from several European and Asian countries required the establishment of a national central distribution centre to enable the organisation and coordination of core goods supply to stores across the country. Instead, only in two cases including *Zara* products were delivered from more than one international distribution centres as a result of having more than one supplier or factories supplying directly stores with products. Apart from the seven stores selling clothing, one more restaurant was receiving consolidated food and drinks deliveries from a central distribution centre. Instead in the case of the largest café in the shopping centre (*Pret a Manger*) products were delivered from a range of suppliers. The variety in product ranges and brands originating from numerous suppliers was also the main reason why a large bookstore (*Waterstones*), a store selling cards and gifts and a store selling electronics (*Curry's Digital*) occupied some of the largest retail units in *WestQuay*. However during the course of the data collection task, *Waterstones* was testing the operation of a centralised distribution system in order to assess the potential logistics savings across its network (described in Section 8.2).

6.4 Number of Main Core Goods (MCGs) Deliveries

Respondents were asked to provide an estimate of the number of MCGs deliveries and back-loads taking place in their business.

The range of deliveries per retail/catering unit varied across the different businesses operating in *WestQuay* (Table 22). The most number of MCGs deliveries were made to business groups with a significant presence in the shopping centre. During a typical week (a week not falling during the peak business periods of the year) 28% of total MCGs deliveries (n=126) were made to catering units, 118 deliveries (26.3%) to stores selling clothing, 66 deliveries (14.7%) to bookstores and 57 deliveries (12.7%) to stores selling electronics. The least number of MCGs deliveries were made to businesses selling cosmetics, games and other (n<10 deliveries for each category).

An examination of the average number of delivery visits made per retail/catering unit revealed that the most weekly MCGs deliveries were made to bookstores (n=16.5), stores selling electronics (n=8.1), catering units (n=6.3) and stores selling optical goods (n=6). The least number of deliveries were received by stores selling cosmetics (n=1), jewellery (n=2.2) and other (n=1).

Table 22: MCGs deliveries made to businesses in *WestQuay* during a standard week.

Business Category	Total Stores No	MCGs Deliveries (A: floor area in m^2)							
		Total	%	Fixed	No fixed	Average per Store	A<200	200< <500	A>500
Clothing	33	118	26.3	118	0	3.6	20	59	39
Catering Units	20	126	28.0	109	17	6.3	99	5	22
Bookstores	4	66	14.7	28	38	16.5	7	3	56
Footwear	8	31	6.9	23	8	3.9	5	26	0
Opticians	3	18	4.0	18	0	6.0	3	15	0
Electronics	7	57	12.7	25	32	8.1	21	10	26
Jewellery	8	17	3.9	11	6	2.2	8	9	0
Cosmetics	4	4	0.9	4	0	1.0	4	0	0
Games	3	9	2.0	9	0	3.0	2	7	0
Other	2	2	0.6	1	1	1.0	1	2	0
Total	92	449	100	349	103	4.9	170	136	143

The above table also shows that overall the businesses with the smallest floor areas and a strong presence in the shopping centre (small restaurants and stores selling clothing and electronics) were receiving more MCGs deliveries (n=170) than the larger businesses (n=143). In estimating the average number of deliveries received by each business (Figure 23), it was found that each of the smallest businesses was receiving on average 4.15 deliveries, each of the medium-sized businesses was receiving 3.66 deliveries and each of the largest businesses in the shopping centre was receiving on average 10.21 deliveries a standard week.

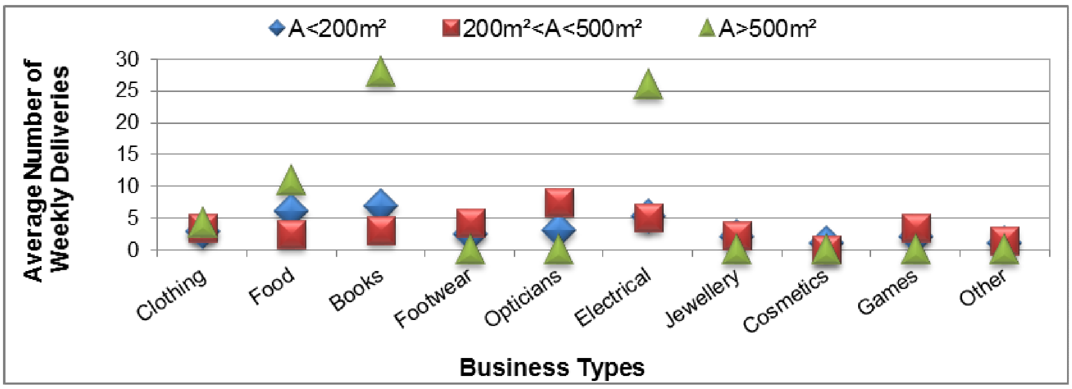


Figure 23: Average number of weekly MCGs deliveries made to each *WestQuay* business during a standard week (classification by store size).

An examination of the individual businesses receiving the most deliveries revealed that a very high percentage (68.9%, n=100, n_{tot}=143) were made to only 4 out of the 14 businesses with floor sizes larger than 500m^2. These businesses were two large stores selling books, cards and gifts (*Waterstones* and *Clinton Cards*), the largest café in *WestQuay* (*Pret a Manger*) and a large store selling electronics (*Curry's Digital*). Notably all four businesses were receiving deliveries from more than one supplier (de-centralised distribution system), the frequency of which varied from a few times a week (*Clinton Cards*) to a few times a day (*Waterstones*). This finding was further confirmed by the use of the Pearson's[4] product-moment co-efficient 'r' as a measure of the linear dependence between the number of stores with floor sizes larger than 500m^2 and the number of deliveries received [Appendix C1-1]. In this case, 'r' was found equal to 0.65 (moderate dependence between the number of stores and the deliveries received) in contrast to the businesses with floor areas smaller than 200m^2 and between 200m^2 and 500m^2 (r=0.96 and r=0.98 respectively, in both cases very strong correlation).

Further analysis showed that the largest stores were not actually receiving the most number of deliveries when examining the relationship between store size and vehicle freight activity. It was estimated that on average 0.04 deliveries a week and per m^2 were made to the smallest businesses, 0.012 deliveries/m^2 to the medium-sized businesses and 0.007 deliveries/m^2 to the largest businesses in *WestQuay*. When comparing against other UK studies (Cherrett *et al*, 2009) it appeared that *WestQuay* businesses were receiving on average less deliveries per m^2 (*WestQuay*: n=0.0127, Winchester: n=0.0205, Ealing: n=0.056, Wallington: n=0.07) due to differences in the overall profile of the businesses examined, the type of services investigated (e.g. other studies may include SCGs and SPs deliveries and waste collections) and the existence of stricter access restrictions in urban shopping areas. The compulsory use of vans when entering high street districts resulted in smaller and more frequent deliveries, contrary to the use of larger vehicles usually entering freely designated service bays of

4 'Pearson's Correlation' is a technique for investigating the relationship between two quantitative, continuous variables. The values of Pearson's co-efficient can range from -1 to +1. The correlation becomes stronger as 'r' tends to -1 (if one variable grows the other falls) or +1 (if one variable grows so does the other), and weaker as 'r' tends to 0 (no linear correlation). For interpretation purposes, the following typical classification of correlation is applied in the study: ($0<r<0.2$ negligible, $0.2<r<0.4$ weak, $0.4<r<0.7$ moderate, $0.7<r<0.9$ strong, $0.9<r<1$ very strong). A more detailed description of this technique and the results of the tests run in the study can be found in Appendix C1.

shopping centres and resulting in fewer and more consolidated deliveries. Analysis confirmed that the smaller-sized businesses were responsible for significant freight activity as they were receiving less consolidated deliveries made by smaller vehicles. For example *WestQuay* opticians (average floor area: 13.9m^2) were receiving 0.022 deliveries/m^2 and Winchester jewellers (86m^2) were receiving 0.0467 deliveries/m^2.

6.4.1 Frequency of MCGs Deliveries and Collections

The data collected showed that in total 449 MCGs deliveries and 86 MCGs collections were made weekly to/from the 92 businesses in *WestQuay*. A very large proportion of the deliveries (77%) were made on fixed days contrary to 103 deliveries (23%) taking place anytime during a week however a lower percentage (57%, n=49, n_{tot}=86) of the collections was made on a fixed basis. The frequency with which different MCGs were delivered and collected was determined from details of the individual agreements made with suppliers, head offices and carriers.

6.4.1.1 MCGs Deliveries by Day of the Week

Respondents were asked to state on which days of the week MCGs deliveries were made to their business. A very detailed breakdown of MCGs deliveries by day of the week including a classification by type of economic activity (SIC classes) and floor size class, is made in Appendix Table D1-1 and Figure D1-1 found at the end of this report. Figure 24 shows that the majority of the total MCGs deliveries, were taking place during the weekdays with a slight increase towards the coming of the weekend in order to ensure sufficient stock to cover weekend consumption.

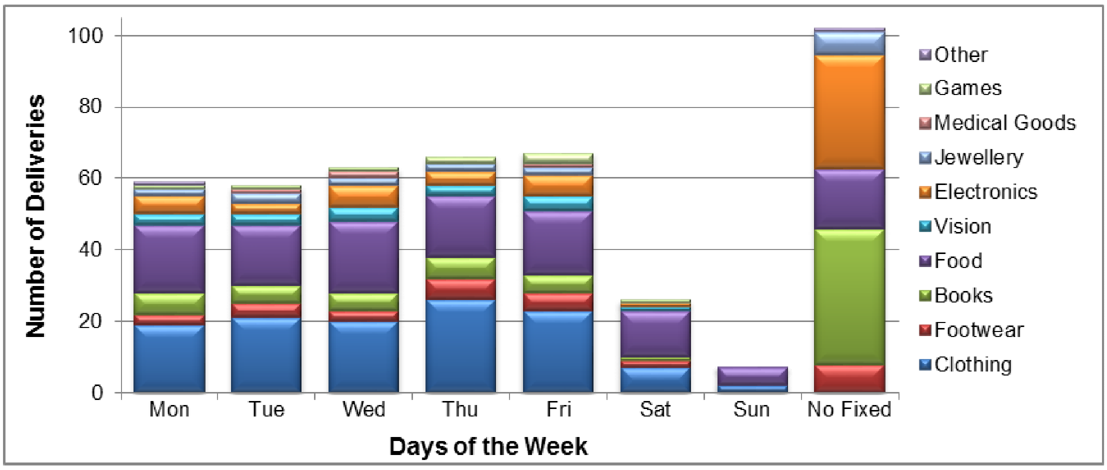


Figure 24: Number of MCGs deliveries made to *WestQuay* businesses by day of a typical (no busy) week (classification by type of economic activity).

In examining the breakdown of MCGs deliveries per business type across a typical (no busy) week it was found that stores selling clothing and games presented a peak on Thursdays and Fridays, while stores selling optical goods and cosmetics presented a peak on Wednesdays and Fridays. Restaurants and cafes instead received the most deliveries on Mondays and Wednesdays, while some top-up deliveries were processed during the weekends. These were mainly including food products which due to their fresh nature required a frequent replenishment (e.g. milk and bread). A very large number of MCGs deliveries (22.7% of total weekly MCGs deliveries, n=103, n_{tot}=449) were processed on a 'no fixed' basis. These included stores selling footwear receiving a quarter of their total weekly deliveries (25.8%, n=8, n_{tot}=31) any day during the week. In the case of the stores selling electronics, the proportion of 'no fixed' deliveries was even higher (56.1%, n=32, n_{tot}=57). Bookstores were receiving 57.6% of their deliveries (n=38, n_{tot}=66) any day during the week, while most of the fixed deliveries were made on Mondays and Thursdays (n=5 to 6). It should be noted that the 103 MCGs deliveries made on a 'no fixed' basis included 4 deliveries made to 3 jewellers on fixed weekdays that were not disclosed by the interviewed store managers for security reasons.

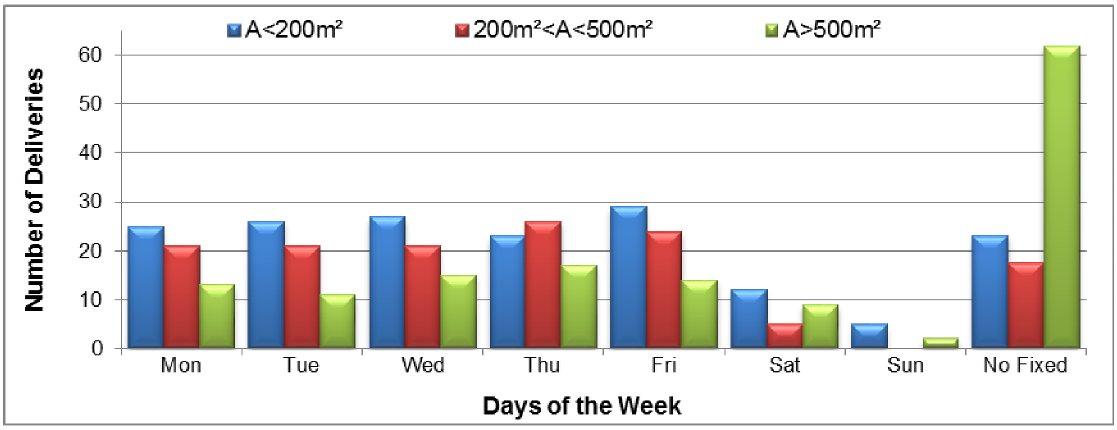


Figure 25: Number of MCGs deliveries made to *WestQuay* businesses by day of the week. (classification by store size)

In examining the variation between the numbers of deliveries received by the 3-size business categories on different days of the week excluding weekends due to the low freight activity recorded (Figure 25), it was found that the smaller businesses presented a peak on Friday (n=29, n_{tot}=170) and a bottom on Thursday (n=23). The medium-sized businesses presented a peak on Thursday (n=26, n_{tot}=136) and a bottom at the start of a week (n=21), while the 14 biggest businesses in the shopping centre presented a peak on Thursday (n=17, n_{tot}=143) and a bottom on Tuesday (n=11). Considering that the largest businesses in the shopping centre were receiving less but more consolidated deliveries than the smaller businesses, the above figures suggested that on Thursdays the delivery vehicles servicing the 14 larger businesses had bigger back-load capacity as they were expected to unload most of the MCGs carried in *WestQuay* businesses without carrying follow-up deliveries to other regional businesses. Despite unavailability of exact data about the operation of milk-runs and the high percentage of the 'no fixed' weekly deliveries (60.5%, n=62, n_{tot}=103) the examination of the existing back-load practices confirmed that the most number of daily back-loading trips during a standard week (n_{tot}=285, n_{aver}=40.1, $n_{st.dev}$=23) were taking place on Thursdays (n=57) and Fridays (n=59).

6.4.1.2 Seasonal Variation in MCGs Deliveries

Respondents were asked to state the busiest months in terms of increases in the number of MCGs deliveries. The seasonal variations in the number of deliveries were gauged by identifying periods when deliveries typically increased by more than 50% over the non-peak norm. The identification of the times of extreme supply demand was particularly useful in estimating the back-load capacity of delivery vehicles and the peak stock holdings requirements in the under examination urban consolidation centre. Again, a very detailed monthly breakdown of the seasonal variation of the number of businesses claiming times of extreme supply demand, and the seasonal variation of the MCGs deliveries including a classification by type of economic activity (SIC coding) and retail floor size, is made in Appendices Tables D1-2 and D1-3 and Figures D1-2 and D1-3 respectively.

More specifically, more than half of the businesses stated that the busiest months were the run up to Christmas (Nov: n=56, Dec: n=73). This was more apparent in the case of stores selling clothing with 57.6% (n=19, n_{tot}=33 businesses) quoting November (n=544 deliveries) and 81.8% (n=27 businesses) December as busy months (n=611 deliveries). Similarly, almost all jewellers quoted busy November (n=109 deliveries) and December (n=113 deliveries), respectively. Almost all businesses selling games (100%, n=3), bookstores (Nov: 100%, n=4, Dec: 75%, n=3, n_{tot}=4) and restaurants (Nov: 55%, n=11, Dec: 75%, n=15, n_{tot}=20) claimed the same months as the busiest in terms of supply demand (games: about n=52 deliveries, bookstores about n=300 deliveries, catering units about n=550-570 deliveries). Thus, a slight increase in the number of deliveries received by bookstores and stores selling games was noted before and after Christmas, as well as the run up to summer sales period (June and July). The latter was also apparent in the case of stores selling seasonal goods such as clothing and footwear (Figure 26).

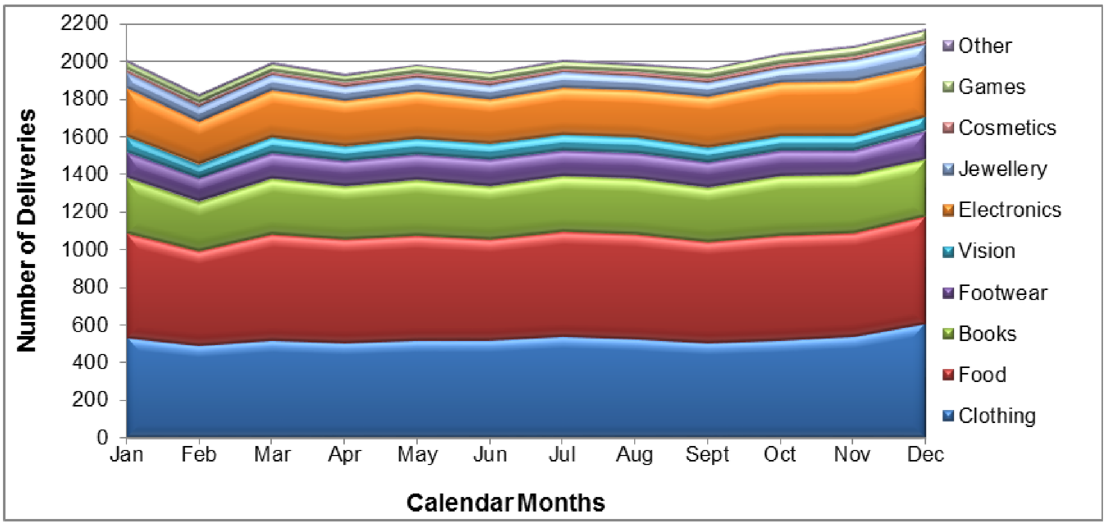


Figure 26: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses. (classification by type of economic activity)

In terms of the maximum number of MCGs deliveries received by the sample businesses during a busy week, it was estimated that 55 deliveries were made on top of the 449 deliveries processed during a standard week. Considering the seasonal variation in the number of deliveries, it was estimated that on average 1,997 deliveries (n=460 average weekly equivalent) were taking place every month (Figure 26). A general increase was recorded from October to January (n=2,009-2,172), mainly in the stores with a significant presence in the shopping centre (restaurants and stores selling clothing and electronics). The lowest levels of MCGs deliveries were noted in February (n=1,826), just after the end of the winter 'discount' sales period. Analysis of variance (one-way ANOVA[5] test) across calendar months showed that the mean values of the MCG deliveries made to the ten different business categories operating

[5] 'One-way ANOVA test' is a statistical technique used to examine if the means of a population are the same (null hypothesis) or if they differ between populations (research hypothesis) by looking at the variances. The examined samples of the population are assumed to be close to normally distributed and have similar variances. If the sample sizes are equal, these two assumptions are not critical. If the test shows significant inequality of the means (small P) post-hoc tests are needed to further investigate the cause of the differences of the class means. A more detailed description of this technique and the results of the tests run in the study can be found in Appendix C3.

in *WestQuay* differed significantly in the 95% confidence level (F{9, 110}=2,651, P<0.001) [detailed calculations are presented in Appendix C3.1]. Therefore, a Tukey's[6] post-hoc range test was run to identify which business categories received significantly more MCGs than the remaining businesses. It was estimated that the Least Significant Difference (LSD) was equal to 217.2 deliveries in the 0.05 confidence level and 252.4 deliveries in the 0.01 confidence level showing that catering units, stores selling clothing and electronics (at 0.05 significance level) plus stores selling electronics (at 0.01 significance level) were receiving significantly more MCGs deliveries than the majority of the remaining businesses.

With regard to the 3-size store categories (Figure 27) the largest stores (A>500m²) presented a rise in the numbers of MCG deliveries at the beginning of the academic year (September) due to increased sales of products (e.g. books and laptops) to regional school and university students. It was found that 3 out of the 4 businesses receiving the majority of the deliveries (*Waterstones*, *Clinton Cards* and *Curry's Digital*) were trading such products.

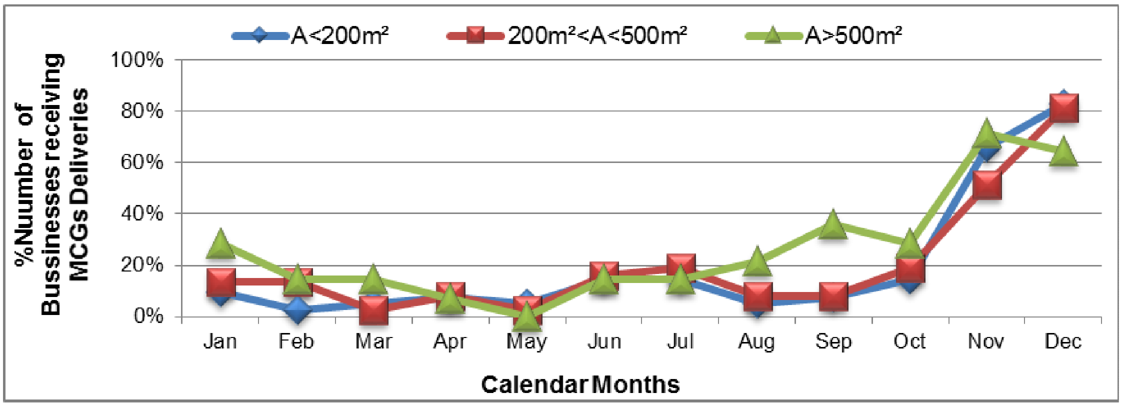


Figure 27: Percentage of *WestQuay* businesses stating busy months in terms of deliveries received (classification by store size).

In examining the variation between the numbers of deliveries received by the 3-size business categories on different calendar months (Figure 28), it was found that the 41 businesses with A<200m² were receiving on average 750 deliveries a month (n=18.3

[6] 'Tukey's post-hoc range test' is a single-step multiple comparison procedure which uses the Studentized range statistic to make all pairwise comparisons between similar size samples of a population. It is applied when the one-way ANOVA test identifies a significant difference among the examined group means (small P) with the aim to investigate the cause of rejection of the null hypothesis. A more detailed description of this technique and the results of the tests run in the study can be found in Appendix C3.

deliveries each), the 37 businesses with 200m²<A<500m² were receiving 611 deliveries a month (n=16.5 deliveries each) and the 14 biggest businesses in the shopping centre (A>500m²) were receiving 363 deliveries a month (25.6 deliveries each). Analysis of variance (ANOVA) across calendar months showed that the mean values of the MCG deliveries made to the three different floor area business groups did not differ significantly in the 95% significance level [Appendix C3.2].

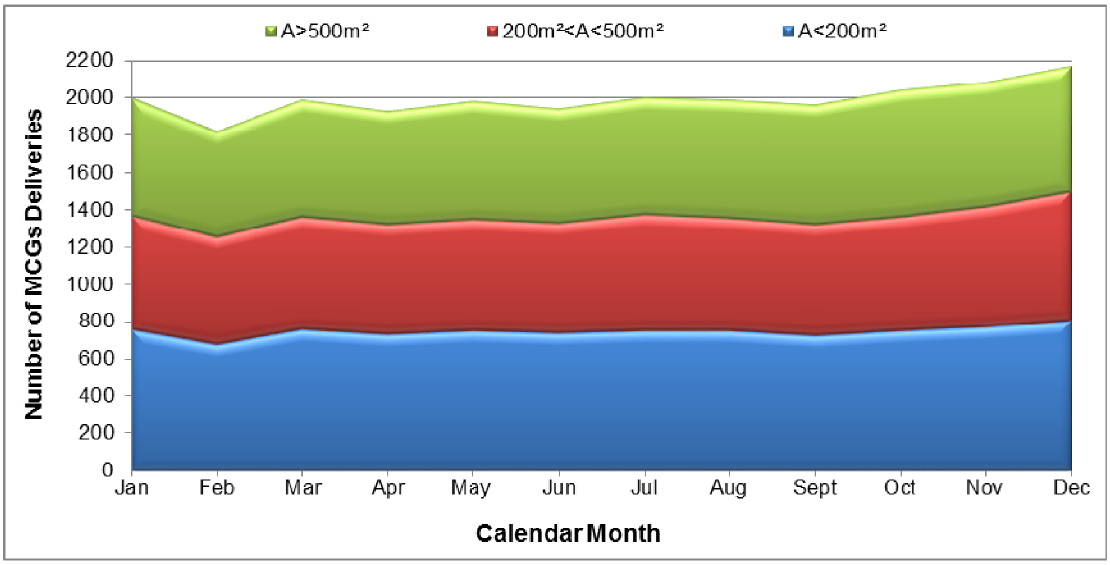


Figure 28: Seasonal variation in the number of MCGs deliveries delivered to *WestQuay* businesses. (classification by store size)

6.4.2 Origin of MCGs Deliveries and Distance Travelled

During the interviews with *WestQuay* retailers, the respondents were asked to provide the contact and location details (distribution origin point) for each supplier and carrier. This had led to a variety of responses depending on the status and experience of each interviewee. In several cases it was found that details of distribution centre origins were not known and had to be subsequently followed up with head offices. The survey identified 10 main logistics providers delivering to stores, originating from over 200 different distribution centres across the UK. Seventy five percent of those distribution centres were considered to provide core goods at least once a week, while the rest provided SCGs, such as jewellery and footwear, or SPs, such as packaging, cleaning materials and stationery, usually under request and on a less frequent basis. Figure 29 presents the origin-locations of MCGs deliveries, classified into 3 main groups, based on the frequency at which deliveries were made to *WestQuay* businesses at the time of the interviews with retailers.

In order to estimate the total distance travelled by the fleet of vehicles delivering MCGs to *WestQuay* businesses, the study considered the significant variation of MCGs suppliers, the spatial distribution of their depots, and the seasonal variation on MCGs demand in terms of consignment size and frequency of services. Very detailed calculations were made for up to 7 suppliers for each business considering multiple pick-ups and drop-offs in intermediate locations (milk-run deliveries) when such information was available.

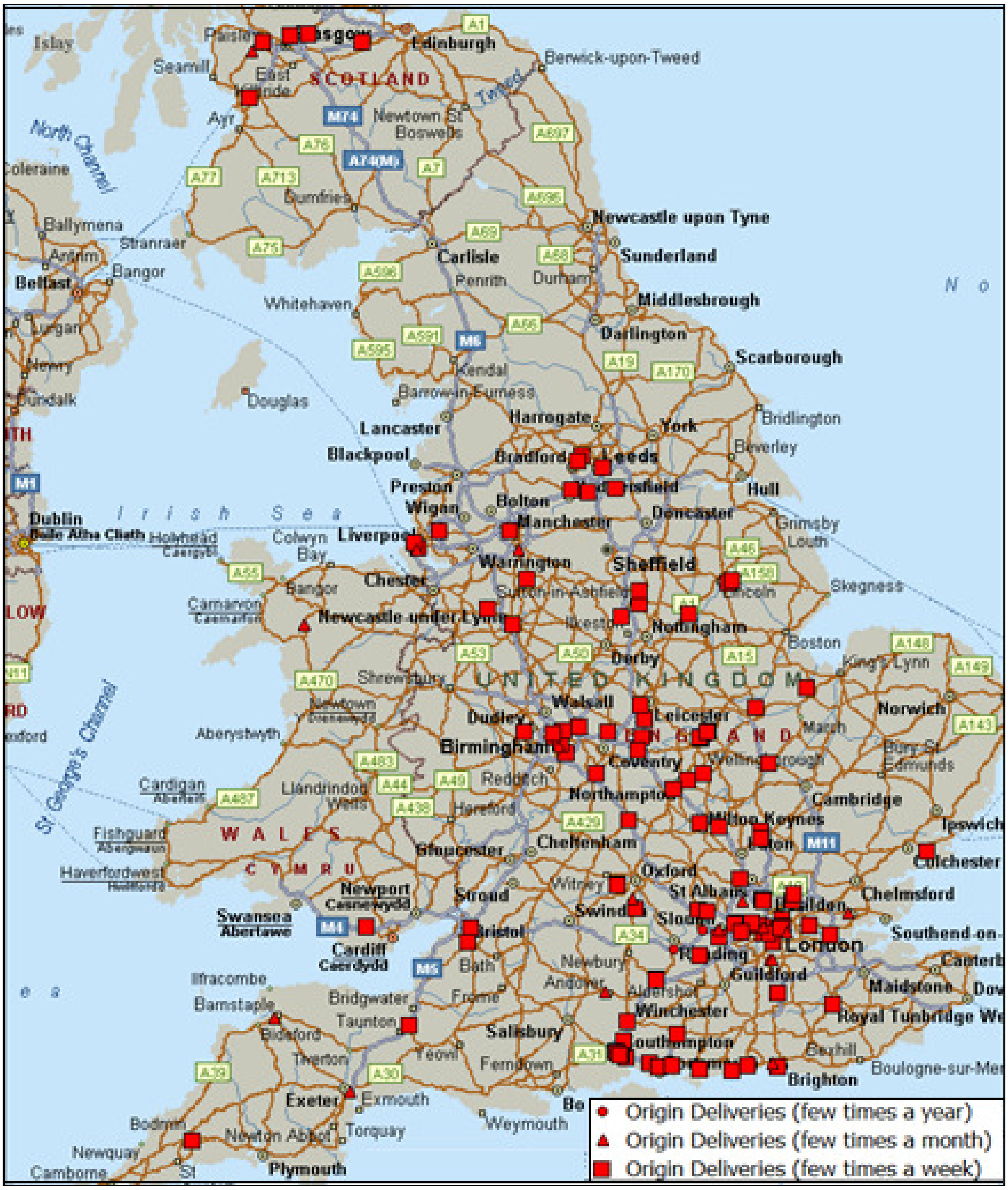


Figure 29: Map showing the origins of the MCGs deliveries received by *WestQuay* businesses.

6.4.2.1 Weekly Distance Travelled

Distance estimations showed that in total 98,068 kilometres (km) were travelled during a typical week and 111,975 km during a busy week. In examining the breakdown of the kilometres travelled per type of economic activity (SIC classification), it was found that the stores selling clothing, the catering units and the bookstores in *WestQuay* accounted for the majority of the overall kilometres travelled during a typical week (28.2%, S=27,606 km; 20.6%, S=20,219 km; 16.35%, S=16,035 km, respectively). Stores selling optical equipment and electronics accounted for about 8.5% each (S=8,646 km and S=8,221 km, respectively), while the remaining businesses accounted for less than 1% each of the total distance travelled during a typical week. However the estimation of the average distance travelled for every business unit (Table 23) suggested that each of the stores selling clothing accounted for less (S=837 km) than the average distance travelled by any *WestQuay* business (S=1,066 km). Instead the contribution of bookstores and stores selling optical equipment was much higher with the former accounting for 4,009 km and the latter for 2,882 km per store each week. The data suggested that this was happening as most of the stores falling into these two categories were serviced by a wide base of suppliers. The distance travelled in order to deliver MCGs to each catering unit, and store selling footwear or electronics was equal to the average distance travelled in order to serve any *WestQuay* store, while the remaining businesses accounted for less than a third of the average kilometres travelled.

Table 23: Total weekly distance travelled (km) to deliver MCGs to businesses in *WestQuay*.

Business Category / Stores Number (n)	Total Stores No	Distance Travelled (km) (A: floor area in m^2)						
		Standard Week						Busy Week
		A<200	200< <500	A>500	Total	%	Per Store	Total
Clothing	33	3,005	12,320	12,281	**27,606**	28.2	837	**32,992**
Catering Units	20	17,901	38	2,280	**20,219**	20.6	1,011	**20,746**
Bookstores	4	1,985	819	13,231	**16,035**	16.4	4,009	**16,628**
Footwear	8	1,265	10,425	0	**11,689**	11.9	1,461	**13,254**
Opticians	3	366	8,280	0	**8,646**	8.8	2,882	**8,646**
Electronics	7	4,711	2,826	684	**8,221**	8.4	1,174	**12,209**
Jewellery	8	1,394	2,458	0	**3,852**	3.9	481	**5,328**
Cosmetics	4	621	0	0	**621**	0.6	155	**696**
Games	3	98	450	0	**548**	0.6	183	**847**
Other	2	217	412	0	**629**	0.6	315	**629**
Total	**92**	**31,563**	**38,028**	**28,476**	**98,068**	**100**	**1,066**	**111,975**

The above table also shows that although the businesses with the smallest floor areas were receiving as a whole more MCGs deliveries (n=170; Table 22) than the other businesses, they accounted for less kilometres travelled (S=31,563 km) than the medium-sized businesses (n=136 deliveries and S=38,028 km a week). This suggested that the smaller businesses in the shopping complex were serviced by a wider base of local/regional suppliers contrary to medium-sized businesses receiving more consolidated deliveries from national distribution centres. This was confirmed through the estimation of the average distance travelled for each of the businesses in the shopping centre and the estimation of the linear dependence between the number of stores of each floor size area group and the number of kilometres travelled a week (a detailed calculation of Pearson's correlation is provided in Appendix Section C1.2). It was found that 770 km were travelled every week in order to deliver MCGs to each of the 41 smallest businesses (r=0.94 very strong correlation). Instead it was estimated that 975 km were travelled a week in order to deliver MCGs to the 39 medium-sized businesses in *WestQuay*, (r=0.79 strong correlation) while 2,034 km were travelled weekly in order to deliver MCGs to each of the 14 largest businesses in the shopping centre (r=0.77 strong correlation).

Although the largest businesses were also receiving less and more consolidated MCGs deliveries (n=143) than the smaller businesses, the average distance travelled per business was almost triple. This was happening mainly for two reasons: first because many highly consolidated deliveries were coming from international distribution centres (e.g. *Benetton* from Italy, *Zara* from Spain), and second because the 4 large businesses (*Waterstones*, *Clinton Cards*, *Curry's Digital*, *Pret a Manger*) that accounted for the majority of weekly deliveries (69.9%, n=100, n_{tot}=143) were either serviced by a wide base of suppliers located across the country or were receiving many small deliveries (e.g. top-up deliveries) from the main distribution centre. To examine the linear dependence between the weekly number of MCGs deliveries and the weekly distance travelled, Pearson's correlation for these two variables was estimated (detailed calculations in Appendix Section C1.3). It was found that the smallest and the largest businesses in the shopping centre presented a very strong correlation between the kilometres travelled and the number of deliveries received (r=1 and r=0.91 correspondingly), while the medium-sized businesses presented a slightly less strong correlation (r=0.89).

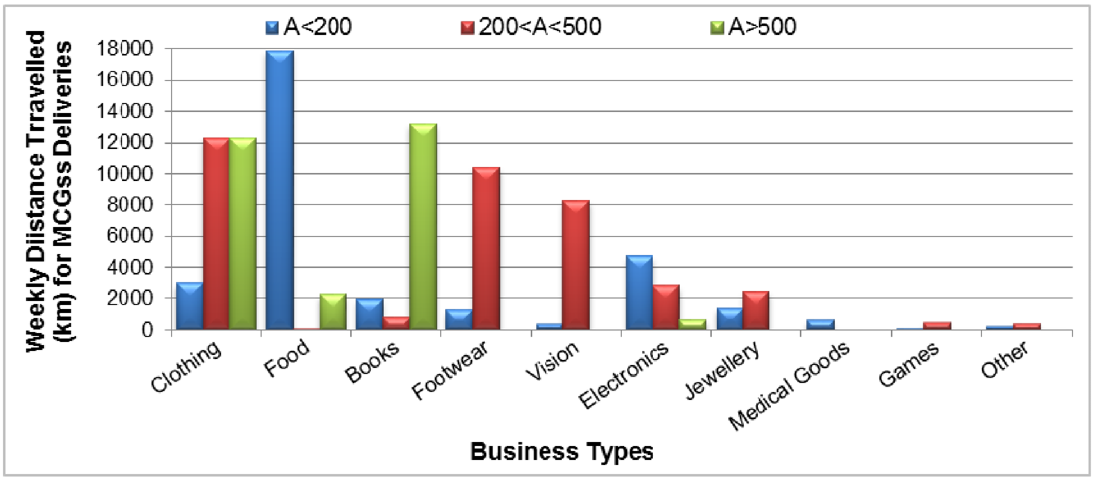


Figure 30: Weekly distance travelled (km) to deliver MCGs to *WestQuay* business. (classification by store size)

Analysis per m^2 showed that the largest stores were not actually responsible for the longest distances travelled (Figure 30). It was estimated that on average 7.5 km a week and per m^2 were made in the case of the smallest businesses, 3.3 km/m^2 in the case of the medium-sized businesses and 1.45 km/m^2 in the case of the largest businesses in *WestQuay*. This implied that faster replenishment of stock was taking place in the case of the smaller stores. However this assumption could not be confirmed due to lack of data on market sales. On the other hand, this trend suggested that larger stores were receiving more consolidated deliveries contrary to the smallest stores which were receiving part loads from a wider base of suppliers. This highlighted the need for smaller businesses to use store rooms in anticipation of or to react to increased demand for products.

6.4.2.2 Seasonal Variation in the Distance Travelled

Considering the times of extreme supply demand and the subsequent seasonal variations in the number of MCGs deliveries made to *WestQuay* businesses, the overall distances (km) travelled were estimated. A detailed monthly breakdown of the seasonal variation in the distance travelled (km) classified by type of economic activity (SIC) and retail floor size is made in Appendix Table D1-4 and Figure D1-4.

In accordance with the peak periods in terms of MCGs deliveries made to *WestQuay* businesses in order to meet increased supply demand, the study identified a general increase in the number of kilometres travelled in the run-up to Christmas (Figure 31).

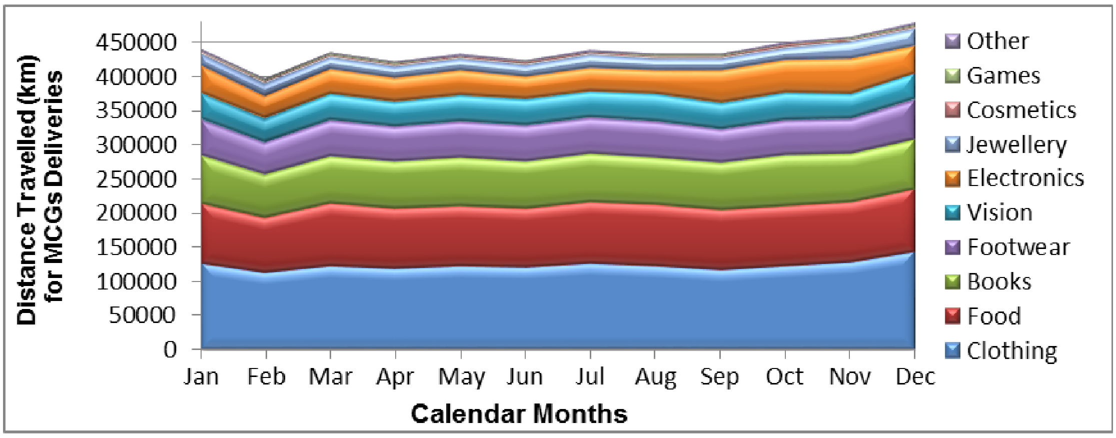


Figure 31: Seasonal variation in the distance travelled (km) to deliver MCGs to *WestQuay* businesses (classification by type of economic activity).

The biggest increase was noted in the stores selling clothing in November and December (Nov: n=132,179 km; Dec: n=144,211 km, Monthly average: n=126,331 km) and electronics from September to November (Sep and Oct: n=50,269 km; Nov: 54,460 km, Monthly average: n=41,146 km). Thus a slight general increase was noted during the summer sales period (June and July).

With regard to the 3-size store categories, all of them presented an increase in the total number of kilometres travelled towards the coming of Christmas and summer sales period (Figure 32). In examining the seasonal variation between the total distance travelled by the 3-size business categories, it was found that the 41 businesses with A<200m² accounted on average for 139,455 km a month (n=3,401 km each), the 37 businesses with 200m²<A<500m² accounted for 169,823 km a month (n=4,580 km each) and the 14 biggest businesses in the shopping centre (A>500 m²) accounted for 129,025 km a month (9,216 km each).

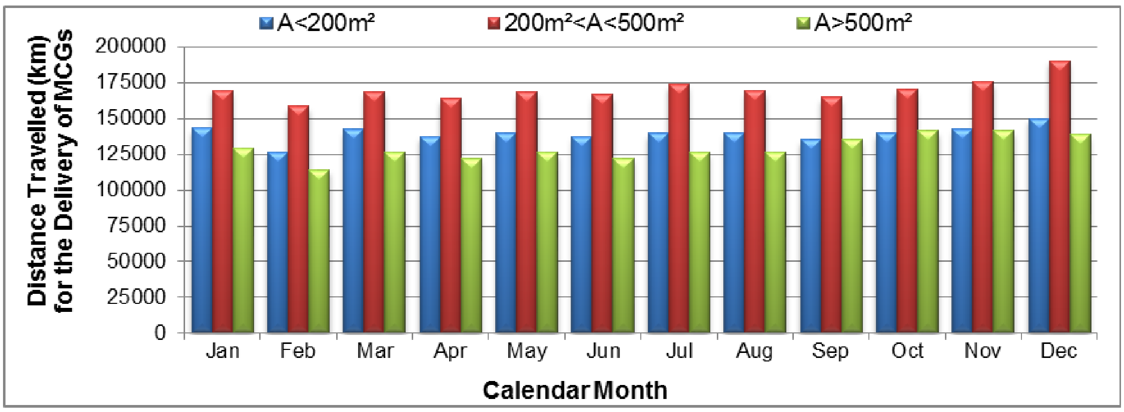


Figure 32: Seasonal variation in the total distance travelled (in km) for the delivery of MCGs to *WestQuay* businesses (classification by store size).

6.4.3 Carriers Delivering MCGs

The respondents were asked about the details of the carriers delivering MCGs to their premises.

6.4.3.1 Weekly Number of Carriers delivering MCGs

It was found that more than half (73%, n=329) of the total MCGs deliveries made during a standard week (n_{tot}=449) were processed by 7 main dedicated logistics providers (*DHL*, *Citylink, Direct UK*, *Lynx-UPS*, *DTS*, *TNT* and *Parceline*), 14% (n=62) were made through the use of in-house fleet, and 13% (n=57) through the use of suppliers-owned fleet. Notably the businesses receiving most direct MCGs deliveries from suppliers were some of the stores selling clothing (26.3%, n=31), and optical equipment (27.8%, n=5). Half of the deliveries made to the businesses selling cosmetics (50%, n=2), a third of the deliveries made to stores selling footwear (32.3%, n=10) and a quarter of the deliveries made to stores selling clothing (24.6%, n=29) were processed using in-house fleet. It was noted that these were mainly businesses marketing their own-branded product lines and receiving MCGs as part of centrally-coordinated multi-run delivery operations. The majority of the deliveries processed by dedicated logistics providers were made to stores selling electronics (100%, n=57), bookstores (87.9%, n=58), catering units (81%, n=102), stores selling jewellery (82.4%, n=14) and stores selling games (88.9%, n=8). A considerable number of MCGs deliveries processed by 3PL providers were also made to stores selling clothing (49.2%, n=58 deliveries). A breakdown of the MCGs deliveries processed by different carriers to the different businesses operating in *WestQuay* is shown in Table 24.

Table 24: Total weekly MCGs deliveries made to businesses in *WestQuay* by various carriers.

Business Category	MCGs Weekly Deliveries made by various Carriers (A: floor area in m^2)																			
	A<200					200<A<500					A>500					Total				
	3PL	IH	SF	Other	Total	3PL	IH	SF	Other	Total	3PL	IH	SF	Other	Total	3PL	IH	SF	Other	Total
Clothing	10	10	0	0	**20**	29	13	17	0	**59**	19	6	14	0	**39**	58	29	31	0	**118**
Catering Units	82	2	15	0	**98**	2	3	0	0	**5**	18	4	0	0	**22**	102	9	15	0	**125**
Bookstores	7	0	0	0	**7**	0	0	3	0	**3**	51	5	0	0	**56**	58	5	3	0	**66**
Footwear	5	0	0	0	**5**	16	10	0	0	**26**	0	0	0	0	**0**	21	10	0	0	**31**
Opticians	0	3	0	0	**3**	10	0	5	0	**15**	0	0	0	0	**0**	10	3	5	0	**18**
Electronics	21	0	0	0	**21**	10	0	0	0	**10**	26	0	0	0	**26**	57	0	0	0	**57**
Jewellery	8	0	0	0	**8**	6	3	0	0	**9**	0	0	0	0	**0**	14	3	0	0	**17**
Cosmetics	1	2	0	1	**4**	0	0	0	0	**0**	0	0	0	0	**0**	1	2	0	1	**4**
Games	2	0	0	0	**2**	6	1	0	0	**7**	0	0	0	0	**0**	8	1	0	0	**9**
Other	0	0	1	0	**1**	0	0	2	0	**2**	0	0	0	0	**0**	0	0	3	0	**2**
Total	**136**	**17**	**16**	**1**	**17**	**79**	**30**	**27**	**0**	**136**	**114**	**15**	**14**	**0**	**143**	**329**	**62**	**57**	**1**	**449**

*3PL: Third Party Logistics Provider, IH: In-house Fleet, SF: Supplier's Fleet, A: Retail Floor Area

In examining the 3-size store categories, it was found that the vast majority (80%) of the MCGs deliveries made to the smallest (n=136, n_{tot}=170) and the largest (n=114, n_{tot}=143) businesses in *WestQuay* were processed by 3PL providers contrary to a lower percentage (58%, n=79, n_{tot}=136) noted in the case of the medium-sized businesses. In the latter case, a higher usage in-house and suppliers fleet was noted.

In examining the range of the 3PL providers servicing each of the three business groups, it was found that the smallest businesses were served by many different logistics providers contrary to the medium-sized businesses which were served by the least number of 3PL providers. This finding along with relevant evidence gathered from *WestQuay* interviewees suggested that the biggest businesses outsourced delivery operations to specific logistics providers when the smallest businesses selected 3PL contractors on a case-by-case dependent on the service requirements and cost parameters. Medium-sized businesses, on the other hand, presented the lowest variability in the 3PL providers employed due to the increased use of in-house fleet and the selection of specific logistics providers at a corporate level. Analysis of variance (one-way ANOVA test) regarding the number of the different 3PL providers employed by the businesses in the shopping centre yielded no significant statistical differences between the three group means ($F(2,9)=0.4228$, $P=0.661>0.05$). The following graph (Figure 33) shows the number of MCGs deliveries made by various carriers during a standard week.

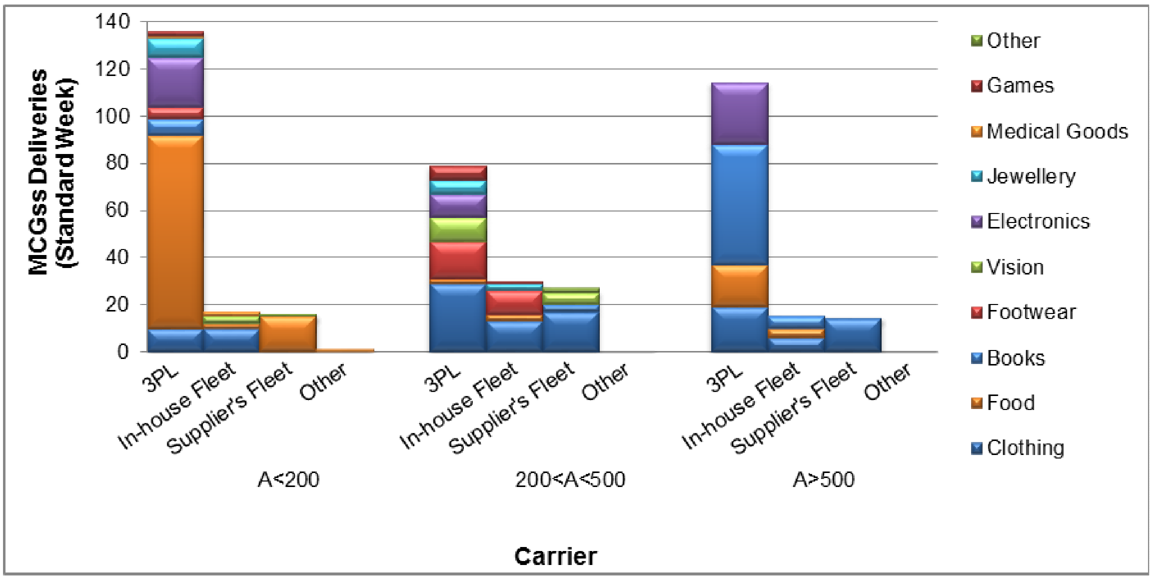


Figure 33: Variation of weekly MCGs deliveries made to *WestQuay* businesses by various carriers (classification by type of economic activity and store size).

6.4.3.2 Seasonal Variation in the Number of Carriers delivering MCGs

From the data collected during the interviews with the managers of *WestQuay* businesses it was estimated that the total number of MCGs deliveries made to the 92 businesses increased from 449 during a standard week to 504 during a busy week. Most of the respondents claimed that the same carriers delivering MCGs deliveries during a standard week were processing the 55 extra weekly deliveries during peak sales seasons. Only a couple of businesses selling jewellery and cosmetics reported the use of Post Office and/or courier companies services on rare occasions in order to accommodate the extra demand in MCGs deliveries. An estimation of the seasonal variation in the number of MCGs deliveries processed by the different carriers was carried out showing that the general trend (increased deliveries towards the run up to Christmas and the summer sales period, described in Section 6.4.1.2) was followed by all of them (Figure 34). A more detailed breakdown of the seasonal variation in the number of MCGs deliveries classified by type of economic activity (SIC coding) and type of carrier is made in Appendix Table D1-5 and Figure D1-5.

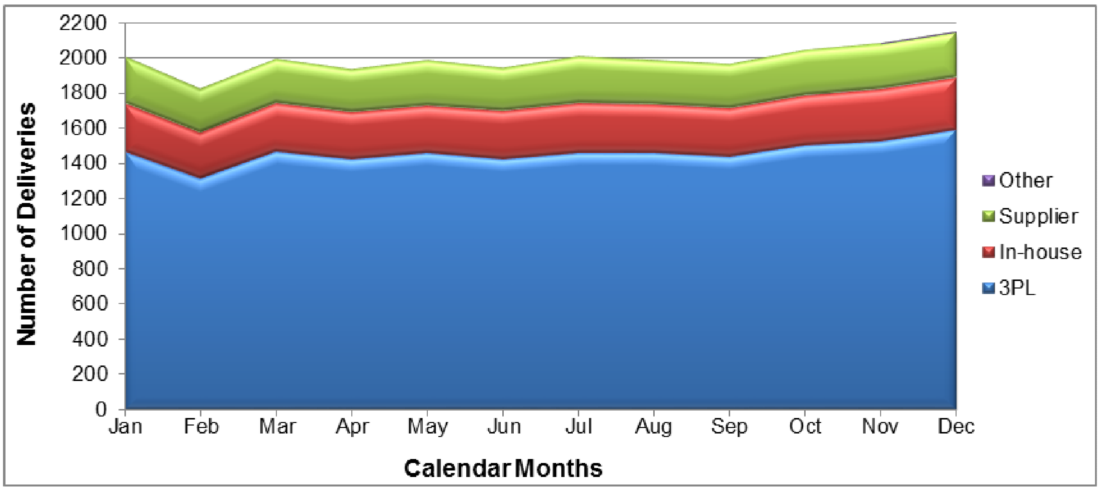


Figure 34: Seasonal variation in the MCGs deliveries made to *WestQuay* businesses. (classification by type of carrier)

With regard to the 3-size store categories and considering the variability of the MCGs deliveries processed by the different carriers, the study noted that in all cases a peak was noted in December and a bottom in February with the exception of a peak noted in the case of MCGs deliveries processed by 3PL providers to the largest businesses (A>500m²) in October and a bottom in the number of MCGs deliveries processed using in-house fleet in March. A more detailed breakdown of MCGs deliveries by store size and carrier type is presented in Appendix Figure D1-6 and Table D1-6.

6.4.4 Fleet Delivering MCGs

The respondents were also asked to specify the vehicle type (articulated lorry, rigid lorry, van and other) delivering MCGs products to their premises.

6.4.4.1 Weekly Number of Different Vehicle Modes Delivering MCGs

The surveys with the managers of *WestQuay* businesses showed that during a standard week 35.3% (n=159) of the MCGs deliveries were made by rigid lorries up to 33 tonnes, another 34.8% (n=156) by vans and only 4.9% (n=22) by articulated lorries up to 44 tonnes. Although usage of other transport modes such as car, sea, air, post, foot was very minor in this sample respondents were unaware of the exact vehicle type (articulated or rigid lorry and van) used in the 25% (n=112) of the overall weekly MCGs deliveries made to their premises.

Analysis suggested that the majority of the MCGs deliveries processed by articulated lorries (n=22) were made to the stores selling clothing (45.5%, n=10) and catering units (50%, n=11) (Table 25). In most cases, fixed contracts existed between these businesses and specific 3PL providers. Rigid lorries and vans, on the other hand, were widely used by businesses selling clothing, restaurants, bookstores and electronics. Considering the average number of weekly MCGs deliveries made by the different vehicle modes to each retail/catering unit, it was found that the highest number of MCGs deliveries processed by articulated lorries and vans were made to individual catering units (n=0.33 and n=2.06, correspondingly) against those processed by rigid lorries made to individual stores selling clothing (n=1.76).

Table 25: Weekly MCGs deliveries made by various vehicles to *WestQuay* businesses.

Business Category	Total Stores No	n: Weekly number of MCGs deliveries (A: floor area in m^2)								
		Arts	Rigid	Van	D/K	A<200	200<<500	A>500	Total	Average
Clothing	33	10	58	25	25	20	59	39	**118**	3.6
Catering Units	20	11	27	68	20	99	5	22	**58**	6.3
Bookstores	4	0	28	0	38	7	3	56	**34**	16.5
Footwear	8	0	19	4	8	5	26	0	**33**	3.9
Opticians	3	0	0	5	13	3	15	0	**27**	6.0
Electronics	7	1	14	39	3	21	10	26	**36**	8.1
Jewellery	8	0	5	9	3	8	9	0	**28**	2.1
Cosmetics	4	0	1	2	1	4	0	0	**8**	1.0
Games	3	0	7	1	1	2	7	0	**6**	3.0
Other	2	0	0	3	0	1	2	0	**2**	1.5
Total	**92**	**22**	**159**	**156**	**112**	**170**	**136**	**143**	**449**	**4.9**

In examining the 3-size store categories, it was found that the most MCGs deliveries made to the smallest businesses in *WestQuay* (A<200m²) were made by vans (54.8%, n=86, n_{tot}=156), the most MCGs deliveries made to the medium-sized businesses (200m²<A<500m²) were processed using rigid lorries (41%, n=65, n_{tot}=158) and the most MCGs deliveries made to the largest businesses (A>500m²) were made by articulated lorries (50%, n=11, n_{tot}=22). This confirmed the earlier finding that larger businesses were receiving larger and more consolidated deliveries. The highest percentage of uncertainty regarding the exact type of vehicle delivering MCGs to *WestQuay* businesses was noted in the case of the largest businesses (Figure 35).

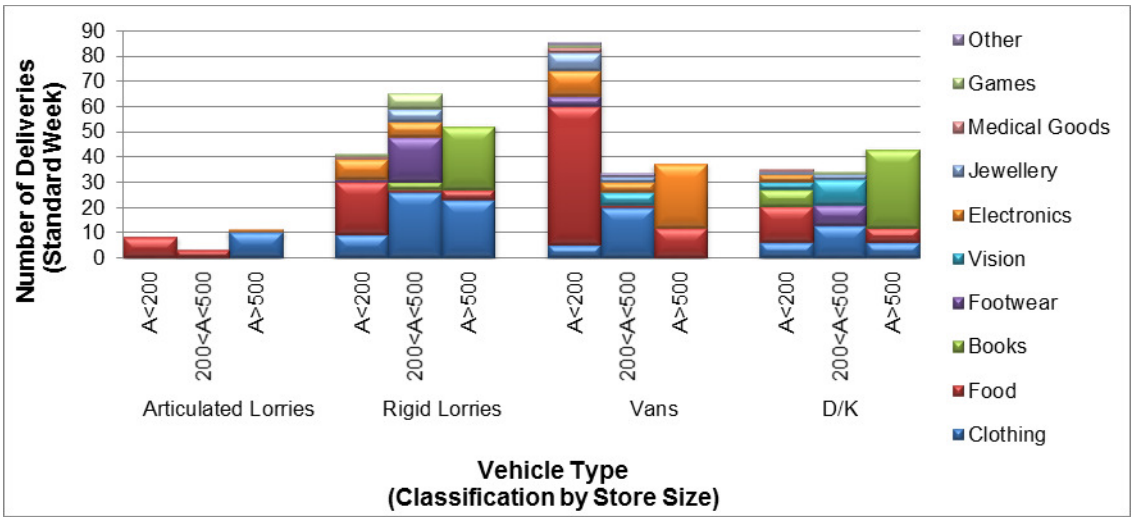


Figure 35: Variation of weekly MCGs deliveries made to *WestQuay* businesses using various vehicle modes (classification by type of economic activity and store size).

6.4.4.2 Seasonal Variation in the Vehicle Modes Delivering MCGs

Analysis of the weekly number of MCGs deliveries made to the 92 *WestQuay* businesses recorded a slight increase in the use of the biggest vehicles (articulated and rigid lorries) during busy periods (Figure 36). More specifically out of the extra 55 MCGs deliveries taking place during a peak sales week, 8 (14.5%) were processed by articulated lorries, 21 (38.2%) by rigid lorries, 10 (18.2%) by vans and 16 (29.1%) by unknown vehicle types. This has meant that the overall take-up of articulated and rigid lorries increased from 4.9% (n=22 weekly deliveries) to 6% (n=30) and from 35.3% (n=159) to 35.6% (n=179) correspondingly. In response the overall take-up of vans decreased from 34.8% (n=156) to 33% (n=166), while the take-up of the vehicles of unknown mode remained equal to 25% (standard week: n=112; busy week: n=128). These figures suggested that apart from an increase in the total number of MCGs deliveries during busy periods, an increase in the size of consignments was also happening. Figure 36 presents the breakdown of the monthly MCGs deliveries per vehicle mode, while a more detailed breakdown of the seasonal variation in the number of MCGs deliveries classified by type of economic activity (SIC coding) and vehicle mode is made in Appendix Table D1-7 and Figure D1-7.

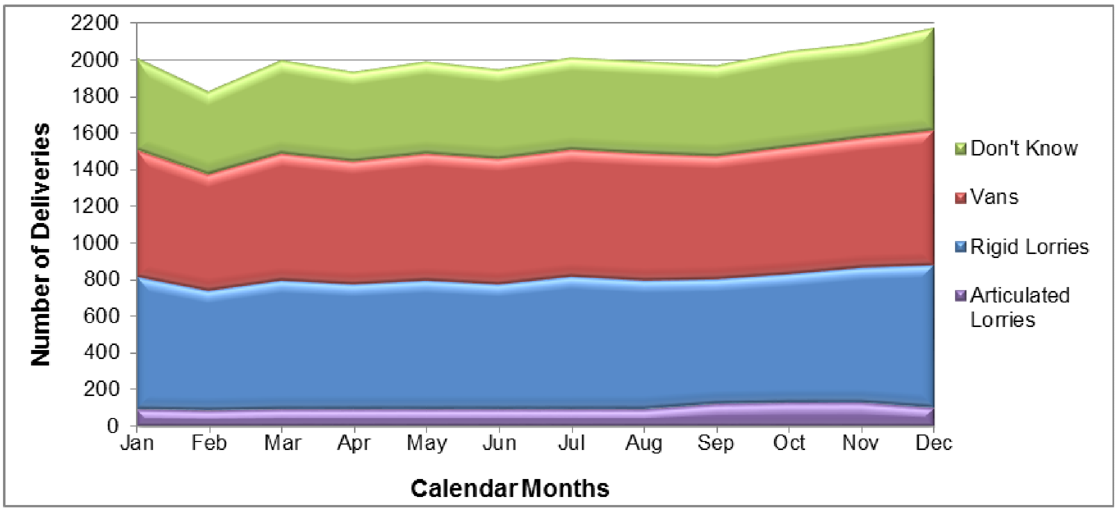


Figure 36: Seasonal variation in the MCGs deliveries made to *WestQuay* businesses (classification by vehicle mode).

With regard to the 3-size store categories and considering the seasonal variation of the MCGs deliveries processed by different vehicle modes, the study noted the increased use of articulated lorries servicing the largest businesses ($A>500m^2$) from October to November (n=77-80 monthly delivery visits) against December to September (n=44-49, n_{aver}=55.4). Very little variations in the use of the other vehicle modes servicing the largest businesses were noted from October to December, however the level of uncertainty about the exact vehicle type servicing *WestQuay* businesses increased significantly during the same period (n=673-678, n_{aver}=635). With regard to the MCGs deliveries made to the medium-sized businesses ($200m^2<A<500m^2$) it was noted in all cases that a bottom occurred in February and a peak in November and December with vans being increasingly used towards the coming of Christmas sales (n=173-179, n_{aver}=151). The same trends were noted in the smallest businesses ($A<200m^2$) with articulated and rigid lorries being more used around the Christmas sales period (rigid: n=40, n_{aver}=35; articulated: n=210, n_{aver}=185). A detailed breakdown of the seasonal variation in the number of MCGs deliveries classified by vehicle mode and retail floor size is made in Appendix Table D1-8 and Figure D1-8.

6.4.5 Weekly Distance Travelled by Different Fleet

To estimate the GHG emissions produced under the existing conditions (base-case scenario, Section 8.3) it was essential to examine the distance travelled (S) by each business type and vehicle mode.

6.4.5.1 Weekly Distance Travelled by Different Vehicle Modes Delivering MCGs

It was estimated that during a standard week a total of 98,067 km were travelled in order to deliver MCGs to *WestQuay* businesses. Although rigid lorries accounted for 35.3% (n=159) of the MCGs, their contribution to the overall distance travelled was higher (40.6%, S=39,815 km). Vans contribution to the overall weekly distance travelled, on the other hand, was equal to 29.1% although they accounted for 34.8% (n=156) of the overall delivery visits made to *WestQuay* during a standard week. This suggested that rigid lorries were used more for long-haul deliveries when vans were used more on a local/regional level (Table 26).

Table 26: Weekly distance travelled (km) by various vehicles delivering MCGs to *WestQuay* businesses.

Business Category	Total Stores No	S: Weekly distance travelled in km (A: floor area in m^2)							
		Arts	Rigid	Van	D/K	A<200	200<A<500	A>500	Total
Clothing	33	2,758	14,253	4,016	6,579	3,005	12,320	12,281	27,606
Catering Units	20	1,266	2,546	1,467	1,736	17,901	38	2,280	20,219
Bookstores	4	0	7,693	0	8,342	1,985	819	13,231	16,035
Footwear	8	0	10,717	972	0	1,265	10,425	0	11,689
Opticians	3	0	0	1,408	7,238	366	8,280	0	8,646
Electronics	7	435	2,459	4,914	414	4,711	2,826	684	8,221
Jewellery	8	0	1,626	1,653	573	1,394	2,458	0	3,852
Cosmetics	4	0	74	315	232	621	0	0	621
Games	3	0	447	0	101	98	450	0	548
Other	2	0	0	629	0	217	412	0	629
Total	**92**	**4458**	**39815**	**28,580**	**25,215**	**31,563**	**38,028**	**28,476**	**98,068**

Analysis of the data on the frequency and origin of MCGs deliveries suggested that the majority of the weekly distance travelled by articulated lorries (S_{tot}=4,458 km) was mainly due to servicing stores selling clothing (61.9%, S=2,758 km) although these businesses accounted for a much smaller percentage in the overall number of MCGs deliveries (45.5%, n=10). This showed that clothing businesses were receiving more consolidated deliveries originating from longer origins than catering units. Although the latter accounted for 50% (n=11) of the total weekly MCGs deliveries they presented a lower (28.4%, S=1,266 km) contribution to the overall distance travelled. Rigid lorries were responsible for 26% (S=14,253 km) and 27% (S=10,717 km) of the distance travelled in order to deliver MCGs to stores selling clothing and footwear, correspondingly, while vans were primarily responsible for the distance travelled to deliver MCGs to catering units (51%, S=14,672 km). Considering the average weekly distance travelled by individual vehicles of each vehicle category, it was found that rigid lorries travelled the longest distances (S=251.3 km), followed by articulated lorries (S=202,6 km) and vans (S=183.3 km). This confirmed the use of the larger vehicle modes for long-haul trips and the use of vans for shorter-haul deliveries (Figure 37).

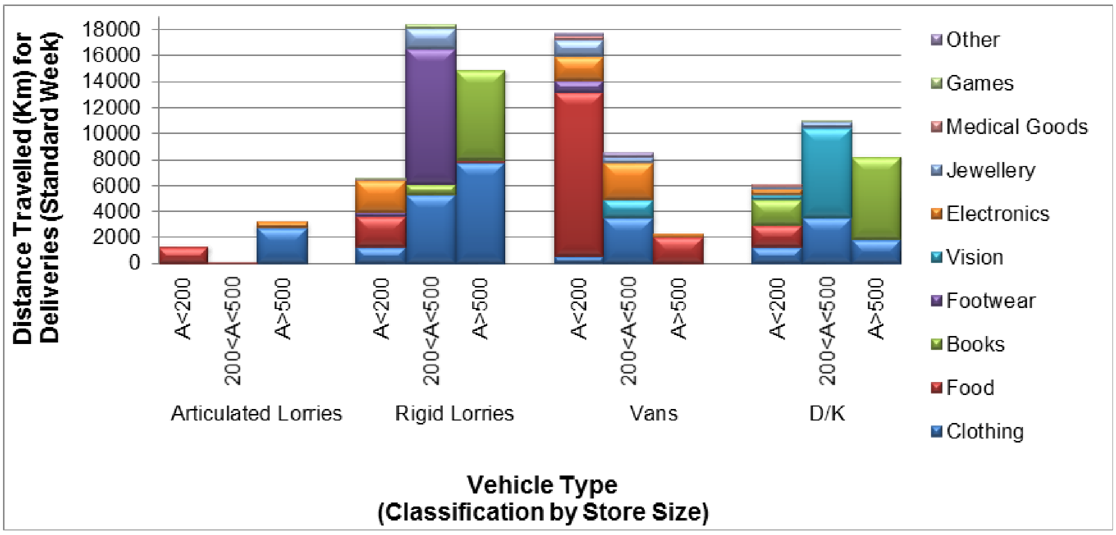


Figure 37: Variation of weekly distance travelled by type of vehicle mode delivering MCGs to *WestQuay* businesses (classification by store size).

In examining the weekly distance travelled by the different vehicle modes in order to deliver MCGs to the 3-size store categories, it was found that vans accounted for the most kilometres travelled to deliver MCGs to the smallest businesses (A<200m²) and especially catering units (56.1%, S=12,628 km, S_{tot}=31,563 km). Rigid lorries accounted for the most kilometres travelled a week to deliver MCGs to medium-sized businesses (200m²<A<500m²) mainly stores selling footwear (27.4%, S=10,425 km) and clothing (13.8%, S=5,258 km, S_{tot}=38,028 km). Considerable was also the distance travelled by unknown vehicle modes (28.8%, S=10,970 km). Rigid lorries accounted for the most kilometres travelled to deliver MCGs to the largest businesses (A>500m²) and especially stores selling clothing (27%, S=7,737 km) and bookstores (24%, S=6,874 km, S_{tot}=28,476 km). Again, considerable was the usage of unknown vehicle types (22%, S=6,357 km) and articulated lorries (10%, S=2,758 km).

6.4.5.2 Seasonal Variation in the Distance Travelled by Different Vehicle Modes

Considering the times of extreme supply demand and the subsequent seasonal variations in the number of MCGs deliveries made to *WestQuay* businesses, the overall distances (km) travelled by the different vehicle modes calling in *WestQuay* were estimated. Figure 38 presents the seasonal variation in the distance travelled by each vehicle mode, while a more detailed monthly breakdown of the seasonal variation in the distance travelled (km) by type of economic activity (SIC coding) and retail floor size is made in Appendix Table D1-9 and Figure D1-9.

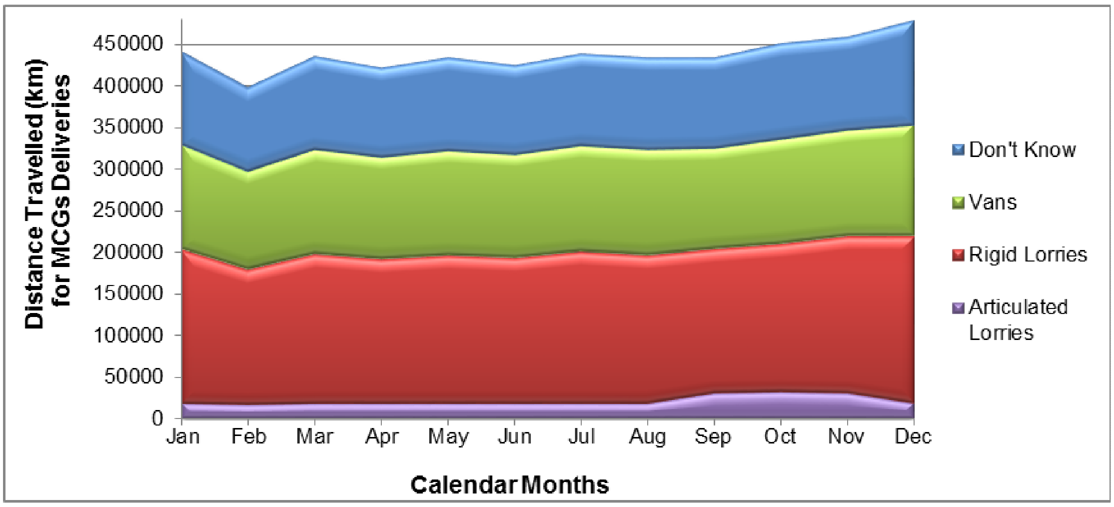


Figure 38: Seasonal variation in the distance travelled (km) to deliver MCGs to *WestQuay* businesses (classification by vehicle mode).

As a result of the seasonal increase in the number of the MCGs deliveries made to *WestQuay* businesses, the study identified a subsequent rise in the number of kilometres travelled in the run-up to Christmas (Figures 31 and 38). The biggest increase was noted in the distance travelled by articulated lorries between September and November (October: 147% increase of km travelled over monthly average, S=33,212 km) due to the increased distance travelled in order to deliver MCGs to the largest (A>500m^2) *WestQuay* businesses (161%, S=27,607 km; Table 27). Rigid lorries on the other hand presented a slighter increase which peaked in December (112%, S=199,216 km) mainly as a result of the increasing number of MCGs deliveries made to the smallest (118%, S=35,180 km) and the medium-sized businesses (113%, S=93,512 km) in the shopping centre (Table 27). Similarly, the distance travelled by vans peaked in December (107%, S=134,684 km) mainly as a result of the increasing number of MCGs deliveries made to the medium-sized

($200m^2<A<500m^2$) businesses (114%, S=43,963 km). Finally, the distance travelled by vehicles of uncertain mode peaked in December (112%, S=125,134 km) mainly due to the increase in MCGs deliveries made to the largest *WestQuay* businesses (121%, S=44,421 km). Analysis of variance (one-way ANOVA) across calendar months showed that the mean values of the distance travelled by articulated and rigid lorries, vans and unknown vehicle modes delivering MCGs to *WestQuay* businesses differed significantly at the 95% confidence level ($F\{3, 44\}=1,208$, $P<0.001$). To identify which vehicle mode travelled an average monthly distance that differed significantly from the distance travelled by the other vehicle modes a Tukey's post-hoc range test was run. It was estimated that the Least Significant Difference (LSD) in the average monthly distance travelled from the 4 different vehicle modes (Table 27) was equal to 13.9 km in the 95% confidence level and 17.2 km in the 99% confidence level. Therefore in all cases the different vehicle modes travelled distances that were significantly different to each other.

Table 27: Distance travelled by various vehicles delivering MCGs to *WestQuay* businesses. (classification by vehicle mode and store size).

Vehicle Mode	S: Monthly distance travelled in km (A: floor area in m^2)										
	A<200			200<A<500			A>500			Total	
	S_{max}	S_{aver}	$S_{St.Dev.}$	S_{max}	S_{aver}	$S_{St.Dev.}$	S_{max}	S_{aver}	$S_{St.Dev.}$	S_{aver}	$S_{St.Dev.}$
Arts	5,556	5,432	209	73	71	3	27,607	17,166	533	22,669	5,962
Rigid	35,180	29,885	2,079	93,512	82,943	2,383	70,524	65,495	3,140	178,323	9,210
Vans	80,636	77,352	3,022	43,963	38,590	654	10,085	9,895	380	125,837	3,937
Unknown	28,440	26,786	1,227	52,573	48,218	1,832	44,121	36,470	1,366	111,474	5,505
Total		**139,455**	**6,073**		**169,823**	**4,108**		**129,025**	**5,330**	**438,303**	**19,722**

6.5 Type of Core Goods Packaging

In order to quantify the volume of the products delivered respondents were asked to identify the types of the secondary or tertiary packaging (as defined in Section 2.3.3.4) used for the shipping of the MCGs delivered in their premises (Table 28).

Through the interviews with the managers of the 92 businesses in *WestQuay* it was found that the secondary and/or tertiary packaging types used varied across different business types due to the range of products carried. Stores selling clothing, footwear, books and games for example used mainly cardboard and plastic boxes. Catering units on the other hand used a combination of packaging types dependent on the nature of the food served. For instance, trays were used to enable cooking of fresh products, while beverages were grouped in packs and sacks, cardboard and plastic boxes were used for frozen/chilled products (e.g. ice-cream).

Table 28: Types of core goods packaging used by businesses in *WestQuay*.

Packaging Type*	Name	Material	Reusability	Category	Business	Size (mxmxm)
	Totes (or containers or boxes)	Plastic	Yes	Primary Secondary	All	**Varying** 0.4x0.6x0.25
	Boxes (or containers)	Cardboard	No (exemptions may apply)	Primary Secondary	All	**Varying** (0.07~0.91)^3 (Cube) (0.15~1.22)x(0.07~0.4)^2 (Long) (0.3~1.93)x(0.1~1.88)^2 (Tall)
	Shoe Boxes	Cardboard	Yes (exemptions may apply)	Primary	Stores selling Footwear	Varying **0.295x0.18x0.095** (Average)
	Sacks	Paper Polythene	No	Primary Secondary	Catering Units	Varying **0.25x0.3x0.12** (Average)
	Hanging Rails	Metal	Yes	Secondary Tertiary	Stores selling Clothing	**0.57x1.27x1.9** Adjustable height
	Trays for food	Plastic Metal Wooden	Yes	Primary Secondary	Catering Units	Varying **0.66x0.46x0.03 (Full)** 0.53x0.38x0.03 (3/4) 0.46x0.33x0.03 (1/2) 0.23x0.33x0.03 (1/4)
	Packs of Drinks	Polythene Cardboard	No	Secondary	Catering Units	**Varying** 0.2x0.3x0.35 (6 bottle) 0.3x0.9x0.12 (24 cans)
	Drums	Metal Plastic	Yes	Primary	Catering Units	**Varying**
	Roll Cage	Metal	Yes	Tertiary	All	Varying 0.68x0.8x1.72 0.61x0.72x1.51 **0.7x0.82x1.55** 0.58x0.85x1.36
	Pallet	Wooden Metal Plastic	Yes	Tertiary	All	Varying 0.8x1.2x0.02 (EUR/1) 1.2x1.0x0.02 (EUR2) **1.0x1.2x0.02 (EUR3)** 0.4x0.3x0.02 (EUR6)

*Illustrations may not relate to the actual packaging used

6.5.1 Number of MCGs Packaging Units

Respondents were asked to quantify the numbers of the different packaging items delivered to their business during a typical delivery visit. Possible seasonal variations in the size of consignment were also recorded to provide a rough estimation of the total number of packaging items delivered to *WestQuay* across a year.

6.5.1.1 Weekly Number of MCGs Packaging Items

The analysis of the data collected during the interviews with the managers of *WestQuay* businesses showed that in total 6,986 items were delivered to their businesses during a standard week. A very large proportion (85%, n=5,941) consisted of cardboard boxes (67.9%, n=4,743) and plastic boxes (17.1%, n=1,198). Most cardboard and plastic boxes were delivered to stores selling clothing (n=2,355), restaurants (n=1,645) and stores selling footwear (n=899). In the case of the stores selling footwear (n=899) a packaging unit consisted of 4 to 6 grouped shoe boxes, while some stores selling clothing indicated that clothes were delivered in hanging rails or clips (2.6%, n=181). In addition many catering units were receiving food products in trays (3.8%, n=268) and sacks (2.1%, n=147), while drinks were delivered in packs of 6, 12 or 24 bottles or cans (3.1%, n=219). When the number and size of packaging items varied significantly, respondents quantified consignments in terms of pallets (1.3%, n=91) and roll cages (2%, n=140). This was most common across the businesses selling electronics, clothing and catering units (Table 29).

Table 29: Total weekly number of MCGs packaging units delivered to *WestQuay* businesses using different vehicle modes.

Business Category	n: Weekly number of MCGs items delivered (A: floor area in m^2)													
	Cardboard Boxes	Plastic Boxes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	A<200	200<A<500	A>500	Total	Average per Store	Average per Delivery
Clothing	1,486	869	40	181	75	120	0	0	217	873	1,681	**2,771**	84.0	23.5
Catering Units	1,491	154	38	0	48	0	219	268	2,112	21	84	**2,217**	110.8	38.2
Bookstores	550	50	2	0	0	0	0	0	19	102	481	**602**	150.5	17.7
Footwear	869	30	0	0	0	0	0	0	136	763	0	**899**	45.0	27.2
Opticians	53	15	0	0	0	0	0	0	3	65	0	**68**	22.7	2.5
Electronics	76	73	10	0	9	27	0	0	100	33	62	**145**	27.9	4.0
Jewellery	88	6	0	0	0	0	0	0	35	59	0	**94**	11.8	3.4
Cosmetics	54	2	2	0	0	0	0	0	57	0	0	**57**	14.3	7.1
Games	80	0	0	0	8	0	0	0	14	74	0	**88**	29.3	14.7
Other	47	0	0	0	0	0	0	0	25	22	0	**47**	23.5	23.5
Total	**4,793**	**1,198**	**91**	**181**	**140**	**147**	**219**	**268**	**2,717**	**2,012**	**2,308**	**6,986**	**75.9**	**15.6**

As happened with the weekly number of MCGs deliveries (Section 6.4, Table 22), the most numbers of packaging items were delivered to the businesses with a significant presence in the shopping centre. More specifically, most MCG items were delivered to stores selling clothing (39.4%, n=2,771), catering units (31.7%, n=2,217) and stores selling footwear (12.9%, n=899). A smaller number of packaging units were delivered to bookstores (8.6%, n=602) and stores selling electronics (2.1%, n=145), while each of the remaining business categories was receiving less than 100 items per week (Figure 39). Considering the average number of packaging items received by each retail/catering unit, it was found that bookstores received the highest number of products during a standard week (n=150.5). The next in order were the stores selling footwear, catering units and stores selling clothing, each receiving 112.4, 110.8 and 84 items per week. Although the stores selling electronics were among the businesses receiving the most number of delivery visits, the numbers of MCGs received in terms of packaging items were very low (n=27.9). This was due to the quantification of the MCGs in terms of pallets and roll cages whose size differed significantly from that of cardboard boxes, sacks and the other packaging units used for MCGs transport.

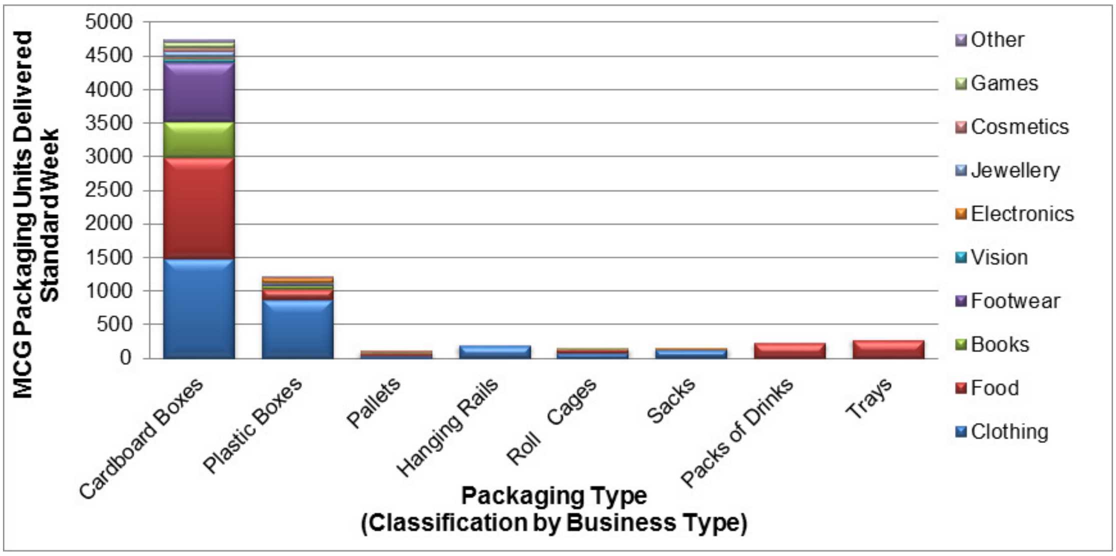


Figure 39: Weekly number of MCGs packaging units delivered to *WestQuay* businesses (classification by type of secondary <grouping> or tertiary <transport>packaging).

In examining the vehicle mode used to deliver the different MCG packaging units to *WestQuay* businesses (Table 30), it was found that rigid lorries transferred half of the overall MCG items (50%, n=3,494) during a standard week. Cardboard boxes (77.1%, n=2,694), plastic totes (13.8%, n=481) and hanging rails (4.7%, n=163) were the predominant types of packaging units transferred by rigid lorries. Vans were used for the transfer of a quarter (24.1%, n=1,682) of the total number of packaging units with cardboard boxes (60.3%, n=1,013), plastic totes (13.6%, n=229), trays (15.3%, n=258), packs of drinks (7.1%, n=120) and sacks (3.7%, n=62) forming the array of the packaging types used. Considerable was also the number of packaging units moved by unknown vehicle types (23.4%, n=1,632) with cardboard boxes (61.6%, n=1,004) and plastic totes (29.9%, n=489) forming the majority of the packaging units composition. Finally, only 179 items (2.6% of total packaging units) were moved by articulated lorries however one should consider the high percentage of large packaging units such as roll cages (40.1%, n=75) and pallets (40%, n=72).

Table 30: Total weekly number of MCGs packaging units delivered to *WestQuay* businesses using different vehicle modes (classification by store size).

Packaging Type	Weekly number of packaging items received (A: floor area in m^2)																			
	A<200					200<A<500					A>500					Total				
	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Cardboard Boxes	30	654	859	350	**1,893**	0	1,025	154	173	**1,352**	2	1,015	0	481	**1,498**	32	2,694	1,013	1,004	**4,743**
Plastic Totes	0	84	176	5	**264**	0	322	53	94	**469**	0	75	0	390	**465**	0	481	229	489	**1,198**
Pallet	13	4	0	0	**16**	9	4	0	0	**13**	50	0	0	12	**62**	72	8	0	12	**91**
Hanging Rails	0	64	0	0	**64**	0	31	0	0	**31**	0	68	0	18	**86**	0	163	0	18	**181**
Roll Cages	0	24	0	0	**24**	0	9	0	8	**17**	75	24	0	0	**99**	75	57	0	8	**140**
Sacks	0	0	27	0	**27**	0	35	35	50	**120**	0	0	0	0	**0**	0	35	62	50	**147**
Packs of Drinks	0	57	110	42	**209**	0	0	10	0	**10**	0	0	0	0	**0**	0	57	120	42	**219**
Trays	0	0	210	10	**220**	0	0	0	0	**0**	0	0	48	0	**48**	0	0	258	10	**268**
Total	**43**	**886**	**1,381**	**406**	**2,717**	**9**	**1,426**	**252**	**325**	**2,012**	**127**	**1,182**	**48**	**901**	**2,258**	**179**	**3,494**	**1,682**	**1,632**	**6,986**

In terms of the number of the different types of secondary and/or tertiary packaging items received by the 3-size business categories during a standard week (Figure 40), it was found that the smallest businesses (A<200m²) received in total 38.9% (n=2,717) packaging units, mainly cardboard boxes (n=1,893) and plastic totes (n=264). Notably, the smallest stores also received the vast majority of the overall trays (82.1%, n=220) and packs of drinks (95.4%, n=209) delivered in the shopping centre however it should be considered that largest catering units received trays and packs of drinks as part of the content of pallets and roll cages. Medium-sized businesses (200m²<A<500m²) received in total 2,012 MCGs units (28.8% of total MCGs items received during a standard week) with cardboard boxes (n=1,352) and plastic totes (n=469) being the main packaging forms used to transport MCGs. These businesses, all clothing stores, received the vast majority of sacks (n=120) carrying garments and clothing accessories. Finally, it was estimated that 2,308 packaging units (32.3%) were delivered to the biggest businesses in the shopping centre (A>500m²) with most being cardboard boxes (67.1%, n=1,548) and plastic totes (20.2%, n=465). The presence of packaging items in the form of pallets (2.7%, n=62) and roll cages (4%, n=99) was quite increased in this case with 68.1% (n=62) and 71% (n=99) of total pallets and roll cages, correspondingly, being delivered to the largest businesses.

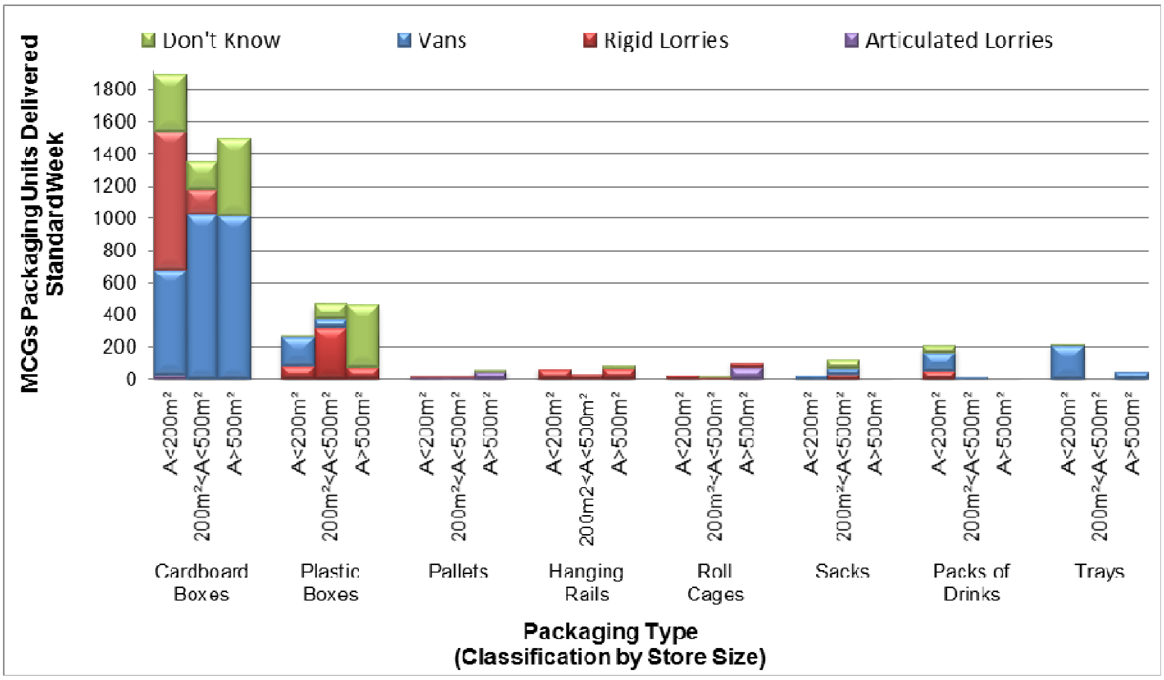


Figure 40: Total weekly number of MCGs packaging units delivered by different vehicle modes to *WestQuay* businesses (classification by store size and vehicle mode).

The estimation of Pearson's correlation between the number of the stores classified in terms of their floor size area and the number of MCGs packaging units received during a standard week showed that in all cases there was a strong linear dependence between these two variables (A<200m²: r=0.93; 200m²<A<500m²: r=0.87; A>500m²: r=0.98; Appendix C1.4). However, the examination of the Pearson's correlation between the weekly number of MCGs deliveries and the number of MCGs packaging units showed that there was a weak correlation in the case of the largest businesses in *WestQuay* (r=0.64) due to the increased level of consolidated deliveries processed by articulated lorries in the case of the 3-4 biggest retail units [Appendix C1.5].

6.5.1.2 Seasonal Variation in the Number of MCGs Packaging Items

During busy periods, a rise in the number of packaging items delivered to *WestQuay* businesses was noted due to increases in the size of consignments and the frequency of delivery visits. It was estimated that a simultaneous increase in the consignment sizes and the frequency of deliveries led to a total increase of 413.5% in the overall number of MCGs packaging units delivered during a week (standard: n=6,986; busy: n=29,097). A significant increase was recorded during Christmas (all packaging types), Easter (particularly cardboard boxes, roll cages and sacks) and summer holidays (only sacks; Figure 41).

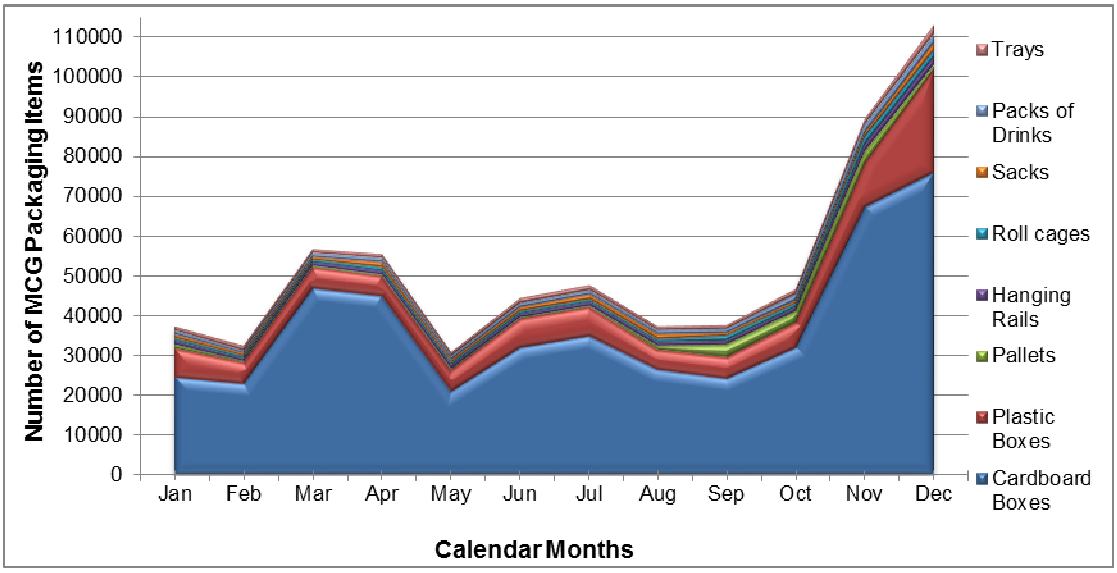


Figure 41: Monthly variation in the number of MCGs packaging items delivered to *WestQuay* businesses (classification by packaging type).

Analysis of variance (one-way ANOVA) across calendar months showed that the mean values of the 8 different types of packaging units delivered to *WestQuay* businesses (cardboard boxes, plastic totes, pallets, hanging rails, roll cages, sacks, packs of drinks and trays) differed significantly ($F\{7,88\}=45$, $P<0.001$). Tukey's post-hoc test showed that all packaging groups were significantly different to each other in both the 95% and the 99% confidence level with the exception of the pack of drinks and trays in the latter case which were found not to differ significantly with each other (LSD=10.94 at 0.05 and LSD=12.83 at 0.01 significance level; detailed statistical results at Appendix C3.3).

The examination of the seasonal variation in the number of packaging units delivered to the different business groups operating in *WestQuay* showed that all businesses received larger consignments towards the coming of the Christmas sales period (Figure 42). Catering units also presented an increase in the number of MCGs items delivered to their premises during summer holidays. Most of the restaurant managers linked this increase to the seasonal rise in the number of cruise passengers visiting

Southampton however this could not be confirmed due to lack of availability in the study of the actual shopping centre's footfall figures. Stores selling footwear presented a significant increase (around 175% over average monthly figures and 350% over a no busy period figures) during the introduction of summer collections (around Easter period), while bookstores, stores selling electronics and games recorded a higher than 150% increase over the average monthly figures at the beginning of the academic year (around September).

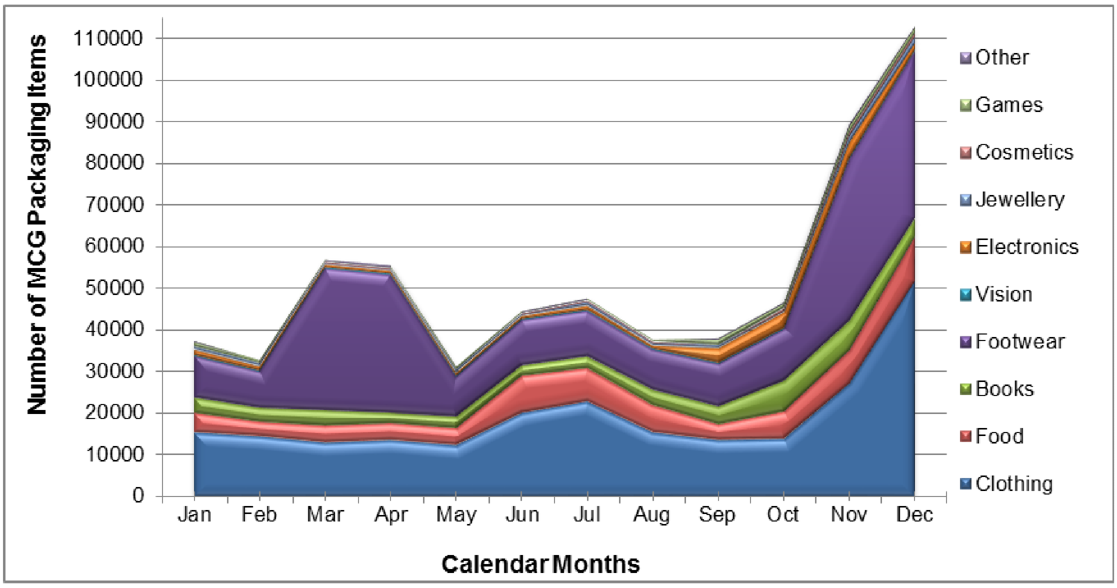


Figure 42: Monthly variation in the number of MCGs packaging items delivered to businesses in *WestQuay* (classification by business type).

Analysis of variance (ANOVA) for the 10 independent groups of businesses across calendar months, confirmed that the mean values of packaging items received by them differed significantly in the 95% confidence level ($F\{9,110\}=23.2$, $P<0.0001$). It was estimated that the LSD in the average monthly number of the packaging units received by the 10 different business groups was equal to 10,527 and 13,749 at the 0.05 and the 0.01 significance level correspondingly. Therefore the number of packaging items received by stores selling clothing and bookstores across a year differed significantly from the number of packaging units delivered to the remaining stores in both the 95% and the 99% confidence level.

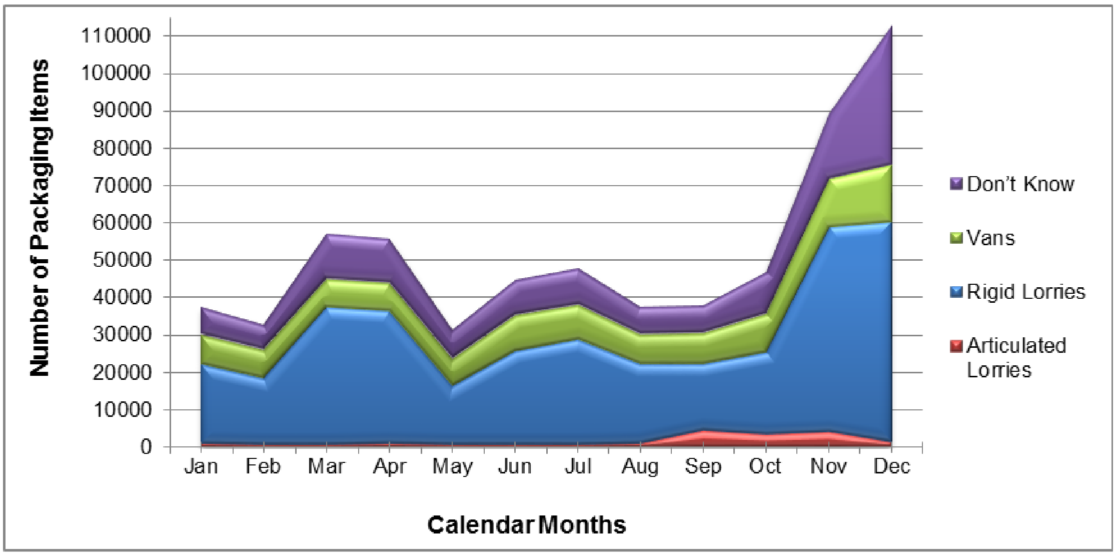


Figure 43: Monthly variation in the number of MCGs packaging items delivered to businesses in *WestQuay* by various vehicle modes (classification by business type).

Through the examination of the seasonal usage of the four vehicle modes (articulated/rigid lorries, vans, unknown mode) it was found that the number of rigid lorries carrying MCGs packaging units varied considerable across the year (Figure 43). Analysis of variance (ANOVA-test) regarding the number of the MCG packaging units transported to the various businesses in the shopping centre by the four different vehicle modes yielded significant statistical differences ($F(3,44)=9.674$, $P<0.001$). A Tukey's post-hoc test (LSD=2,249 at 0.05 significance level and LSD=2,775 at 0.01 significance level) showed that the number of the MCGs units carried by the four vehicle modes different significantly in all cases from each other.

6.5.2 Volume of MCGs packaging items and product returns

In order to gain an assessment of the total volume of the products transported from and to *WestQuay*, the fill rate of the delivery vehicles and the available back-load capacity, respondents provided an estimate of the size of the storage units (cardboard boxes, plastic totes, sacks, roll cages, hanging rails, pallets, drums, packs of drinks and trays) used for the shipment of products to and from *WestQuay* stores (Table 28). The dimensions of the storage items were then multiplied by the number of the units delivered during the same period (Section 6.5.1.1) to estimate the total volume of MCGs delivered and collected. When the exact dimensions of the packaging units were not available then a mean value was used (in bold in Table 28).

6.5.2.1 Weekly Volume of MCGs Packaging Items Delivered

It was estimated that during a standard week, in total 901.2 m³ of MCGs products were delivered to the 92 *WestQuay* businesses (Figure 4). Almost half (44.1%) of the total estimated volume consisted of cardboard boxes (n=4,743, V=397.3 m³) mainly delivered to stores selling clothing, footwear and catering units, while a fifth (18.3%) consisted of hanging rails (n=181, V=165 m³) delivered to stores selling clothing (Table 31). Roll cages were mainly delivered to stores selling clothing and catering units and accounted for 13.3% (n=140, V=119.9 m³) of the total volume of MCGs delivered to respondents. Plastic boxes were mainly delivered to stores selling clothing and electronics and accounted for 8% (n=1,198, V=72.3 m³) of the total MCGs volume. Pallets were used extensively by stores selling clothing, electronics, cosmetics and catering units to carry 13.2% (n=91, V=119.4 m³) of the total weekly MCGs volume delivered to *WestQuay* businesses. Sacks accounted for 1.4% of the total volume (n=147, V=13.1 m³) and were mainly delivered to stores selling electronics and clothing, while packs of drinks and trays accounted for 1.3% (n=219, V=11.7 m³) and 0.3% (n=268, V=2.4 m³) correspondingly, both delivered to catering units.

Table 31: Total weekly volume (m^3) of MCGs packaging units delivered to *WestQuay* businesses.

Business Category	V: Weekly volume (m^3) of MCGs items delivered (A: floor area in m^2)												
	Cardboard Boxes	Plastic Boxes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	A<200	200<A<500	A>500	Total Standard	Average per Store	Average per m^2
Clothing	158.9	47.9	48.0	165.0	66.7	3.5	0.0	112.6	69.4	308.1	490.1	14.9	0.022
Catering Units	97.2	1.8	45.0	0.0	38.5	0.0	11.7	146.8	13.6	36.2	196.6	24.6	0.087
Bookstores	44.7	4.8	2.4	0.0	0.0	0.0	0.0	3.6	12.0	36.4	51.9	13.0	0.028
Footwear	67.8	3.0	0.0	0.0	0.0	0.0	0.0	8.2	62.6	0.0	70.8	3.5	0.019
Opticians	2.8	0.1	0.0	0.0	0.0	0.0	0.0	0.4	2.5	0.0	2.9	1.0	0.004
Electronics	0.7	11.8	12.0	0.0	8.0	9.5	0.0	21.3	8.5	12.2	42.0	6.0	0.023
Jewellery	6.5	2.6	0.0	0.0	0.0	0.0	0.0	2.0	7.2	0.0	9.2	1.1	0.007
Cosmetics	7.5	0.3	12.0	0.0	0.0	0.0	0.0	19.8	0.0	0.0	19.8	5.0	0.065
Games	6.3	0.0	0.0	0.0	6.7	0.0	0.0	1.0	12.0	0.0	13.0	4.3	0.017
Other	4.9	0.0	0.0	0.0	0.0	0.0	0.0	2.7	2.2	0.0	4.9	2.4	0.013
Total	**397.3**	**72.3**	**119.4**	**165.1**	**119.9**	**13.1**	**11.7**	**318.4**	**189.9**	**392.8**	**901.2**	**9.8**	**0.025**

In terms of the businesses categories receiving the most volume of products (Table 31), the study identified that these were stores selling clothing (54.4%, V=490.1 m³, n=2,271), catering units (21.8%, V=196.6 m³, n=2,217) and stores selling footwear

(7.9%, V=70.8 m³, n=899). The lowest weekly volume levels were received by stores selling optical goods (0.3%, V=2.9 m³, n=68) and other (0.5%, V=4.9 m³, n=47). The estimation of the average volume of the products delivered to each store showed that catering units were actually the businesses receiving the largest weekly volume of MCGs (V=24.6 m³) against opticians who received 1 m³ of MCGs a week (Figure 44).

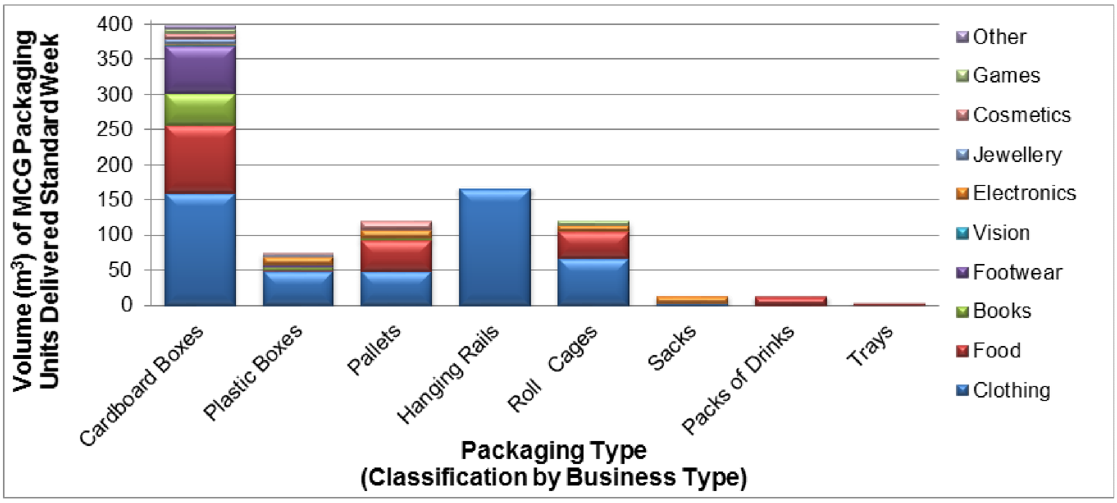


Figure 44: Weekly volume (m^3) of MCGs packaging units delivered to *WestQuay* businesses. (classification by type of secondary or tertiary packaging)

The estimation of the average volume (m^3) of products delivered per metre square (m^2) showed that catering units were again receiving the highest weekly MCGs volume levels (V=0.087 m³/m^2), followed by stores selling cosmetics (V=0.065 m³/m^2), books (V=0.028 m³/m^2) and electronics (V=0.026 m³/m^2), while the smallest weekly consignments per metre square were received by stores selling jewellery (V=0.007 m³/m^2) and optical goods (V=0.004 m^3/m^2).

In examining the MCGs volume carried by the different vehicle modes to *WestQuay* businesses (Table 32), it was found that rigid lorries transferred half of the overall MCGs volume (50.1%, V=451.6 m^3 n=3,494) during a standard week mostly in the form of cardboard boxes and hanging rails. Vans, on the other hand, were used to carry 13.1% (V=117.9 m^3) of the total MCGs volume moved during a standard week although they transported a quarter (24.1%, n=1,682) of the total number of packaging units. This suggested that vans were used to carry packaging units of smaller size (e.g. trays, packs of drinks and sacks). Instead, articulated lorries were used for the transport of larger MCGs units (2.6%, n=179) such as pallets and roll cages which accounted for a considerable percentage (17% V=153.5 m^3) of the total MCGs volume delivered to the 92 businesses during a standard week. Finally, the volume of the packaging units transported by vehicles of unknown mode was equal to 19.8% (V=178.2 m^3, n=1,632) and consisted of cardboard boxes and plastic totes.

Table 32: Total weekly volume (m^3) of MCGs packaging units delivered to *WestQuay* businesses using different vehicle modes (classification by store size).

Packaging Type	Weekly volume (m^3) of packaging items received (A: floor area in m^2)																			
	A<200					200<A<500					A>500					Total				
	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Cardboard Boxes	0.8	22.4	77.4	40.1	**140.6**	0.0	85.9	15.3	11.2	**112.4**	0.2	98.5	0.0	45.6	**144.2**	1.0	206.8	92.6	96.9	**397.3**
Plastic Totes	0.0	16.3	3.1	0.9	**20.3**	0.0	13.5	3.1	8.8	**25.4**	0.0	3.2	0.0	23.4	**26.6**	0.0	33.0	6.3	33.1	**72.3**
Pallet	15.0	14.4	0.0	0.0	**29.4**	10.8	4.8	0.0	0.0	**15.6**	60.0	0.0	0.0	14.4	**74.4**	85.8	19.2	0.0	14.4	**119.4**
Hanging Rails	0.0	88.0	0.0	0.0	**88.0**	0.0	17.9	0.0	0.0	**17.9**	0.0	34.4	0.0	24.8	**59.1**	0.0	140.3	0.0	24.8	**165.0**
Roll Cages	0.0	17.1	0.0	0.0	**17.1**	0.0	8.0	0.0	6.7	**14.7**	66.7	21.4	0.0	0.0	**88.1**	66.7	46.5	0.0	6.7	**119.9**
Sacks	0.0	0.0	9.5	0.0	**9.5**	0.0	2.8	0.3	0.5	**3.5**	0.0	0.0	0.0	0.0	**0.0**	0.0	2.8	9.9	0.5	**13.1**
Packs of Drinks	0.0	3.1	6.5	1.8	**11.3**	0.0	0.0	0.4	0.0	**0.4**	0.0	0.0	0.0	0.0	**0.0**	0.0	3.1	6.9	1.8	**11.7**
Trays	0.0	0.0	1.9	0.1	**2.0**	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.4	0.0	**0.4**	0.0	0.0	2.3	0.1	**2.4**
Total	**15.8**	**161.4**	**98.4**	**42.9**	**318.4**	**10.8**	**132.9**	**19.1**	**27.2**	**189.9**	**126.**	**157.3**	**0.4**	**108.1**	**392.8**	**153.5**	**451.6**	**117.9**	**178.2**	**901.2**

In terms of the volume of the various MCGs delivered to the 3-size business categories during a standard week, it was found that the 41 businesses with A<200m² were receiving in total 318.4 m³ (average per store V_{aver}=7.8 m^3), the medium-sized businesses received 189.9 m³ a week (V_{aver}=5.1 m^3) and the 14 largest businesses received 392.8m³ (V_{aver}=28.1 m³) a week. Although one would assume that most of the MCGs volume was delivered to the biggest businesses in the retail complex, the estimation of the volume of products delivered per metre square suggested that it was actually the smaller businesses receiving most of the MCGs volume (V=0.076 m^3/m^2), followed by the biggest (V=0.02 m^3/m^2) and finally the medium-sized businesses (V=0.016 m^3/m^2). The examination of Pearson's correlation showed that there was a strong linear dependence between the number of the smaller, medium-sized and the largest stores and the volume of the MCGs received by them during a standard week (A<200m²: r=0.92; 200m²<A<500m²: r=0.86; A>500m²: r=0.99; Appendix C1.6). However the estimation of the Pearson's correlation between the number of MCGs deliveries made and the volume of MCGs delivered showed that there was a weak linear dependence of these two variables in the case of the largest

WestQuay businesses (r=0.54; Appendix C1.7). This suggested that there was a considerable lack of homogeneity in the fill rates of the vehicles servicing the largest businesses. The estimation of the % fill rate in the following section (Table 33) confirmed this finding as stores selling clothing and electronics were estimated to have a 15% fill rate against the catering units which presented a fill rate at just 3%.

One of the interesting elements of this study was the estimation of the vehicles fill rates and the back-load capacity. To gauge the fill rates it was essential to make some assumptions for the overall fill capacity of the examined vehicle modes. Following consultations (phone contacts) with *Mercedes Benz* representatives it was considered that a 33t articulated lorry had a maximum capacity of 120 m³, however an 80 m³ figure used in the study would be more realistic. Rigid lorries were expected to have a slightly smaller capacity however a 60 m³ figure was suggested. Regarding vans it was suggested that their typical maximum load-space volume was equal to 15.8 m³ and therefore a 10 m³ figure should be considered in calculations to ensure vehicle design and size variations. Regarding the vehicles of unknown mode an average figure of 30 m³ was considered. To gauge the overall available capacity in terms of volume these figures were multiplied by the number of the vehicles visiting the retail complex during a week, while the average vehicle fill rates were estimated by dividing the volume of MCGs transported by the overall estimated vehicle capacity.

Table 33: Fill rates of MCGs delivery vehicles calling in *WestQuay* during a week.

Business Category	Weekly Fill Rates in terms of Volume (m^3) of MCGs items delivered to *WestQuay*																			
	Articulated Lorries				Rigid Lorries				Vans				Don't Know				Total			
	MCGs Deliveries	MCGSs Volume	Fill Capacity	Fill Rate %	MCGs Deliveries	MCGSs Volume	Fill Capacity	Fill Rate %	MCGs Deliveries	MCGSs Volume	Fill Capacity	Fill Rate %	MCGs Deliveries	MCGSs Volume	Fill Capacity	Fill Rate	MCGs Deliveries	MCGSs Volume	Fill Capacity	Fill Rate %
Clothing	10	114.7	800	14.3	58	266.7	348	7.7	25	14.1	25	5.6	25	94.7	750	12.6	118	490.1	528	9.3
Catering	11	26.6	880	3.0	26	60.6	156	3.9	68	69.4	68	10.2	20	40	600	6.7	126	196.6	372	5.3
Bookstores	0	0	-	-	28	22.9	168	1.4	0	0	-	-	38	29	114	2.5	66	51.9	282	1.8
Footwear	0	0	-	-	19	62.6	114	5.5	4	6	40	15.0	8	2.2	240	0.9	31	70.8	142	5.0
Opticians	0	0	-	-	0	0	-	-	5	0.1	50	0.2	13	2.8	390	0.7	18	2.9	440	0.7
Electronics	1	12.2	80	15.3	14	18.7	840	2.2	39	10.3	39	2.6	3	0.9	90	1.0	57	42	140	3.0
Jewellery	0	0	-	-	5	2.6	300	0.9	9	4.7	90	5.2	3	1.9	90	2.1	17	9.2	480	1.9
Cosmetics	0	0	-	-	1	12	60	20	2	7.7	20	38.5	1	0.1	30	0.3	4	19.8	110	18.0
Games	0	0	-	-	7	5.5	420	1.3	1	0.8	10	8.0	1	6.7	30	22.3	9	13	460	2.8
Other	0	0	-	-	0	0	-	-	2	4.9	20	24.5	0	0	-	-	2	4.9	20	24.5
Total	**22**	**153.5**	**1760**	**8.7**	**158**	**451.6**	**9480**	**4.8**	**156**	**117.9**	**1560**	**7.6**	**112**	**178.2**	**3360**	**5.3**	**449**	**901.2**	**1616**	**5.6**

Table 33 presents the total estimated fill capacity and the percentage of the utilised fill-rate of the vehicles delivering MCGs to the 92 *WestQuay* businesses during a standard week. Comparison with the vehicle capacity by volume usage data (average 51%, range: 22.6-68.6%) as provided by the *Freight Best Practice* project survey of 22 UK businesses (DfT, 2003; Section 2.2.2.7) showed that the vehicles servicing *WestQuay* were using a very low percentage of their available fill capacity. This could happen because:

- The fill capacity of the vehicles calling in *WestQuay* was overestimated.
- The overall volume of MCGs in the *WestQuay* study was underestimated, while additional loading/unloading equipment and other items carried on board were not taken into consideration.
- The delivery vehicles may carry further core goods destined to following delivery stops (milk-runs) and/or product returns collected from previous stops.
- The upper limit of vehicle capacity by load (t) was possibly reached before the total volumetric capacity (m^3) was utilised.
- The above estimated weekly usage of the vehicles fill capacity may present significant differences from the actual usage rates due to seasonal increases in the volume of MCGs carried (to be examined in the following Section).

6.5.2.2 Seasonal Variation in the Volume of MCGs Packaging Items

The study estimated that the seasonal increases in consignment sizes and the frequency of deliveries resulted in a maximum increase of 434% in the total volume of MCGs delivered to the 92 businesses during a week (standard week: V=901.2 m^3, busy week: V=3,917 m^3). The greatest rise in the total MCGs volume resulted from a considerable increase in the volume of MCGs products transported through pallets (+880%), plastic totes (+545%), cardboard boxes and roll cages (both +360%). This was confirmed through analysis of variance (one-way ANOVA) for the 8 independent groups of packaging types and their volume variation across calendar months (95% confidence level $F\{7,88\}=4.6653E+05$, $P<0.0001$). A Tukey's post-hoc test provided LSD=1,126 at the 0.05 significance level and LSD=1,321 at the 0.01 significance level. Therefore the volume of MCGs carried through pallets was significantly higher than the volume carried by any other tertiary packaging.

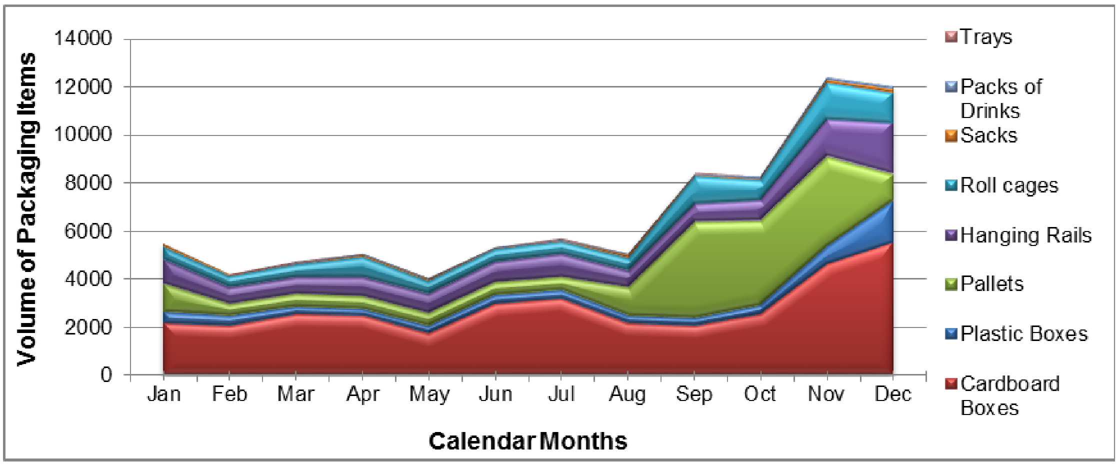


Figure 45: Monthly variation in the volume of MCGs packaging units delivered to *WestQuay* businesses (classification by type of packaging).

In terms of the monthly volume of MCGs products transported using the 8 packaging types, it was estimated that on average 6,769 m³ a month were received by the respondent businesses (Figure 45). A peak in the volume of the MCGs delivered to *WestQuay* businesses was noticed in November (V=12,409 m³), while a bottom was observed in May (V=4,082 m³). In general, a significant rise in the monthly volume of products delivered to *WestQuay* was recorded during the second half of the year. This was further confirmed through t-test analysis (95%: t{10}=2.37, p=0.0393<0.05) for the total volume of the packaging items delivered to *WestQuay* during the first 6 months of the year (January to June) against the last 6 months (July to December).

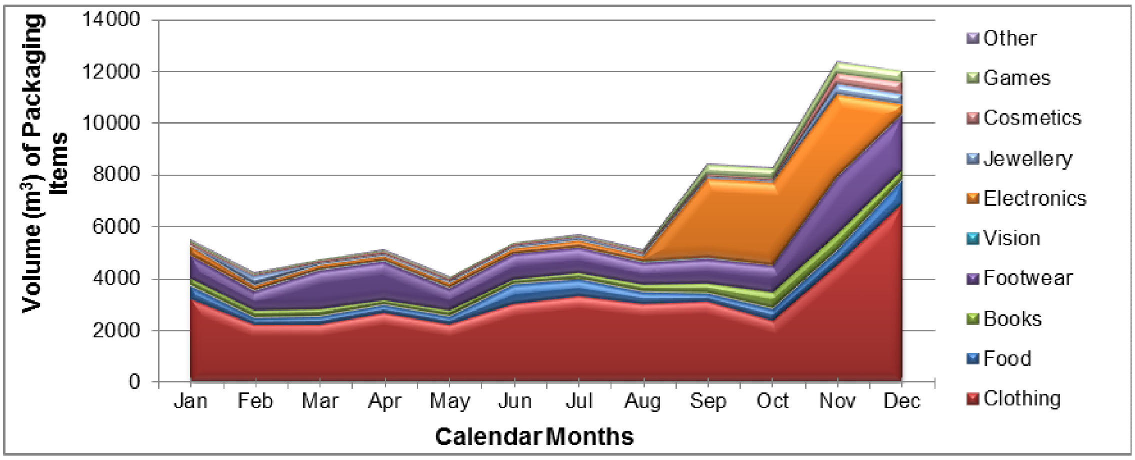


Figure 46: Monthly variation in the volume of MCGs packaging units delivered to *WestQuay* businesses (classification by type of economic activity).

With regards to the seasonal MCGs volume variation across the different business categories in *WestQuay* (Figure 46), it was observed that the stores selling clothing presented a significant rise in the volume of products received during November (139% over average monthly volume, V=4,563 m³, V_{aver}=3,271 m^3) and December (211%, V=6,904 m³). A significant incoming volume rise was also noted in stores selling electronics which presented a 320-330% increase in the volume of the MCGs received against the mean monthly figure towards the coming of the Christmas period. All businesses presented an increase in the volume of MCGs delivered to their premises during November and December.

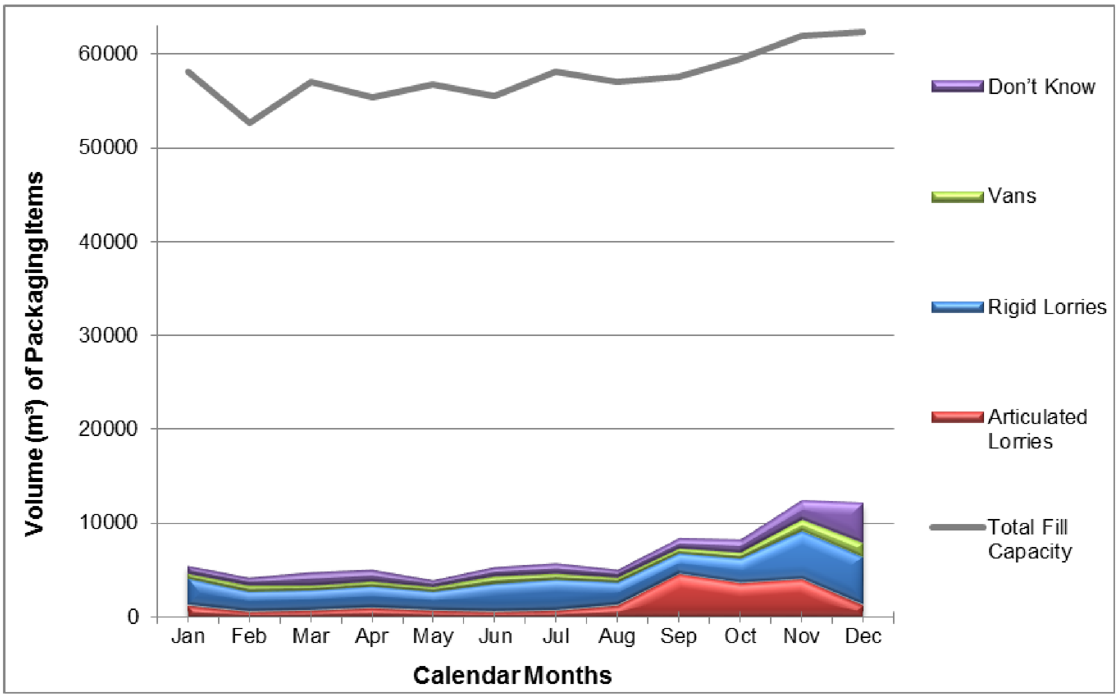


Figure 47: Monthly variation in the volume of MCGs packaging items delivered to businesses in *WestQuay* by various vehicle modes (classification by vehicle mode).

Figure 47 shows the seasonal variation of the volume of the MCGs transported by the different vehicle modes. A significant rise in the MCGs volume carried by articulated lorries was noted from October to November. Analysis of variance (one-way ANOVA) for the 4 independent groups of vehicle modes and seasonal variation of the MCGs volume carried yielded significant differences among the examined groups ($F\{4,44\}=9.674$, $P<0.0001$ at 95% significance level). Tukey's post-hoc test provided LSD=2,249 at the 0.05 significance level and LSD=2,775 at the 0.01 significance level. Through comparisons of the pair differences between the mean monthly volume (m^3) of the MCGs carried by the different vehicle modes it was found that the volume of MCGs carried by rigid lorries differed significantly from the volume of MCGs carried by vans.

The examination of the seasonal variation of the volume of MCGs delivered to the 3-size store categories showed that the 41 smaller businesses ($A<200m^2$) in the shopping centre were receiving on average 2,018 m^3 per month most of which were delivered to catering units and stores selling clothing. The 37 medium-sized stores ($200m^2<A<500m^2$) were receiving on average 1,436 m^3, with stores selling clothing and footwear receiving more than half of the total volume received by this group. Finally, the 14 largest stores in *WestQuay* were receiving on average 3,314 m^3 per month with the vast majority of this being delivered to stores selling clothing. Analysis of variance (one-way ANOVA) for the 3 independent floor-area business groups receiving the MCGs volume across the year did not yield significant differences among the examined groups ($F\{3,33\}=7.939$, $P=0.0015>0.0001$ at 95% significance level).

Furthermore, Figure 47 shows the total available fill capacity (grey line) considering that an articulated lorry can carry 80 m^3 of goods, rigid lorries 60 m^3, vans 10 m^3 and the vehicles of unknown mode can carry on average 30 m^3 each. A comparison of the overall seasonal fill capacity against the estimated used capacity (volume of MCGs carried across the year) shows that the seasonal fill rate varies between 8.5-9.5% from January to August and 13-20% from September to December. Despite the existence of uncertainties about the actual vehicle capacity and existing vehicle load in terms of volume (as described in Section 6.5.2.1) these figures are considered as relatively low when compared to the average fill rates identified in the *Freight Best Practice* project (DfT, 2003; Section 2.2.2.7). Therefore the statistical analysis conducted in this section suggested that there is a considerable level of available vehicle fill capacity which can be used to enable further consolidation of consignments to reduce freight activity and mitigate the associated emissions.

6.6 Summary

This chapter described the distribution systems developed by *WestQuay* businesses with the aim to identify opportunities on existing processes to better use the load capacity of delivery vehicles and thus minimise the overall transport and environmental footprint. The main aim of the study is to examine the reduction in the number of trips and emissions through the use of a consolidation centre. On this basis the vehicles servicing *WestQuay* were found to have a very low fill rate.

Chapter 7: Waste and Returns Management

7.1 Introduction

This chapter provides details about waste generation in *WestQuay* and describes the main waste management and collection practices developed centrally by *Hammerson*, and individually by *WestQuay* retailers. Using quantitative data provided by *Hammerson* along with data collected through the interview surveys with 96% of the retailers (n=92), the logistics implications of the waste management activities undertaken as of the time of the interviews with *WestQuay* retailers (2008) are investigated with the aim to identify potential opportunities to reduce the freight transport footprint associated with waste collections.

In more detail this chapter provides an overview of the waste management activities and resources utilised by the management company to manage certain types of waste, identifies the type of recyclables currently produced and quantifies their volumes and the frequency of waste collections, reviews the collection and disposition methods employed, identifies the associated waste contractors currently used, compares current practices employed among different business types, identifies typical practices and best practice examples in 'recyclate' and waste management and finally provides a detailed picture of the reverse logistics practices associated with the most typical hazardous wastes (e.g. WEEE, mobile phones, clinical waste and used cooking oil) produced by retail outlets or catering units.

7.2 Waste Generation in *WestQuay*

Monthly waste statistics for the period January 2006 to August 2008 were provided by *WestQuay*'s management company. The first set of data concerned monthly waste arisings produced by the entire shopping centre including waste produced by retailers in individual stores, waste produced by customers in all public areas and waste produced by *WestQuay*'s staff in common/designated areas such as services areas and offices. In addition, another set of data concerning the waste quantities being diverted from landfill were provided. Both datasets referred to the period starting on January 2006 and ending on August 2008 (Figure 48).

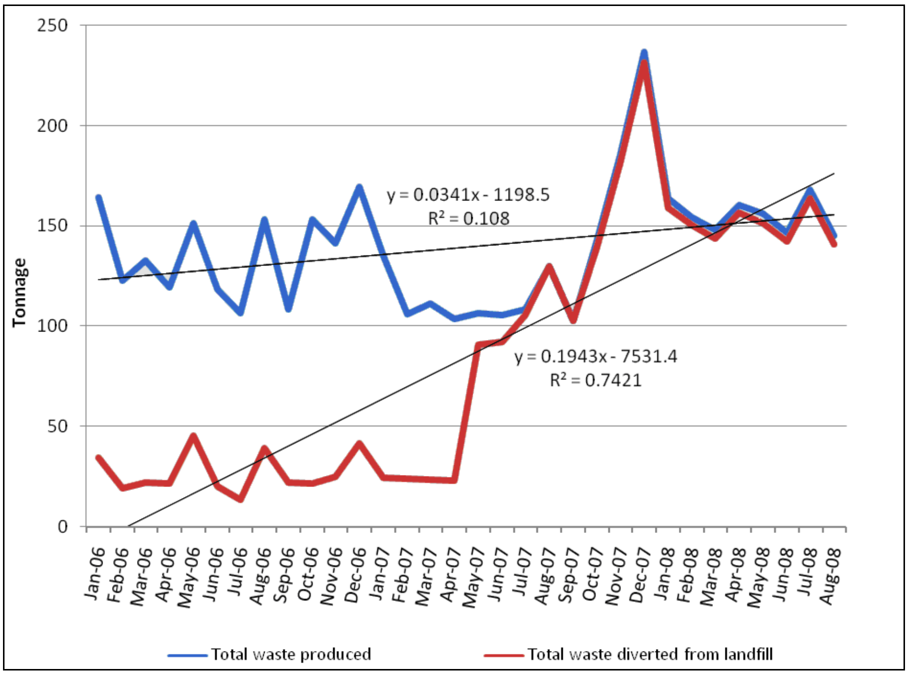


Figure 48: Monthly waste tonnage produced in *WestQuay* and monthly waste tonnage diverted from landfill.

The figures indicate a slight increase in total waste tonnage produced in *WestQuay*. Temporal variations in waste production are usually caused by changes in visitation/spending patterns (e.g. during school holidays, the annual boat show and sale periods). Waste production tends to peak in November/December for the Christmas period and then stay low until Easter when momentum starts to build again. Despite the trend of slightly increasing waste arisings, a t-test showed that there were significant differences in the mean waste tonnage being diverted from landfill between the periods January 2006 to April 2007 (mean: 26.1 tonnes) and May 2007 to August 2008 (mean=142.5 tonnes). The difference in waste tonnage diverted for the period January 2006 to April 2007 versus the period May 2007 to August 2008 was significant at the 0.05 error level $T_{(30)}=12.71$, $p<0.05$ (*t at 30 degrees of freedom is 12.71. There is less than a 5% chance that the difference in waste tonnage diverted from landfill is due to mere chance*). This large observed difference in waste tonnage diverted from landfill was mainly due to the increase in recycling and recovery rates. In 2006, only 19.7% (323 tonnes) of the total waste produced by the retail complex (1,642 tonnes) was recycled/recovered, while in 2007 this figure had increased to 28% (442 tonnes) and an additional 46% was incinerated (726 tonnes), while the total annual waste tonnage (1,575 tonnes) slightly decreased when compared to 2006 figures. During the first 8 months of 2008, recycling/recovery rates had further increased with 47% of the total waste produced being recycled/recovered and exceeding the overall 2007 figures (577 tonnes). Another 51% was incinerated (631 tonnes) indicating a total decrease in the proportion of the waste (2.4%) being landfilled (30 tonnes) (Figure 49).

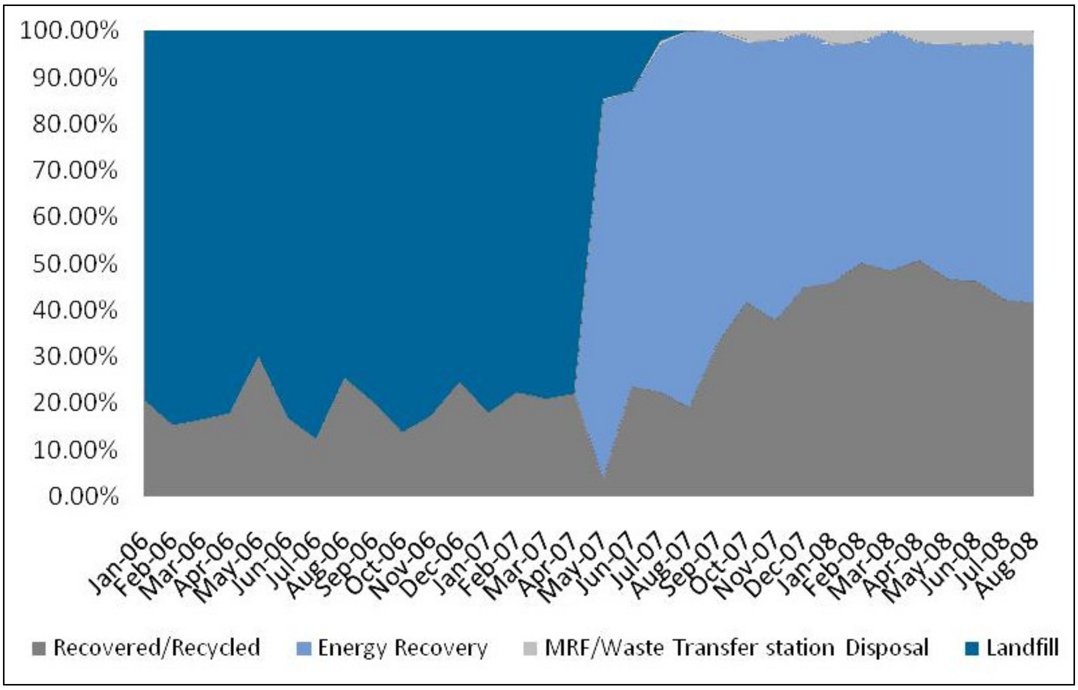


Figure 49: Waste management options (%) for *WestQuay*.

Recyclable materials produced by the retailers in the shopping centre included cardboard, polythene, glass, paper, coat hangers, pallets, cages/scrap metal, fluorescent lighting tubes and wood. In addition, some of the stores were producing used cooking oil and biodegradable kitchen and canteen waste (green waste). The two department stores and one shop selling clothing, footwear and sports equipment had developed their own in-house waste collection systems (described in more detail in Section 7.4) however the waste tonnages provided by *WestQuay*'s management company included these waste arisings.

The waste statistics showed that the only waste material being recycled prior to 2006 was cardboard. In the summer of 2007, *WestQuay* initiated separate polythene and paper collections, while *WestQuay*'s anchor tenant, *John Lewis* introduced its own glass recycling scheme. In December 2008, *WestQuay* started coat hanger recycling.

In 2006, 93.3% of all waste materials being recycled/recovered (Figure 50) consisted of cardboard (302 tonnes), whilst the remaining 6.7% (22 tonnes) consisted of pallets and cages/scrap metal collected for recycling/reuse (Figure 50). In 2007, cardboard recycling accounted for 69% (305 tonnes), while pallets collected by waste contractors for repair, reuse or recycling accounted for 11% (48 tonnes) of the overall recycling rate. Polythene recycling accounted for 8.2% (37 tonnes), while glass, paper and hanger recycling accounted for 9% (40 tonnes) of overall recycling. The remaining 2.7% was waste being transferred to a materials reprocessing facility (MRF) (12 tonnes) where any remaining value was extracted. During the first 8 months of 2008, packaging recycling fell to 63% of the overall recycling rate but yielded more recyclate tonnage (366 tonnes) compared to 2007. Polythene and hanger recycling rates had increased, reaching 16% (94 tonnes) and 8% (47 tonnes) of overall recycling/recovery rates respectively. Glass (27 tonnes), paper (20 tonnes), and pallets (17 tonnes) collectively account for 11% of the overall recycling rate.

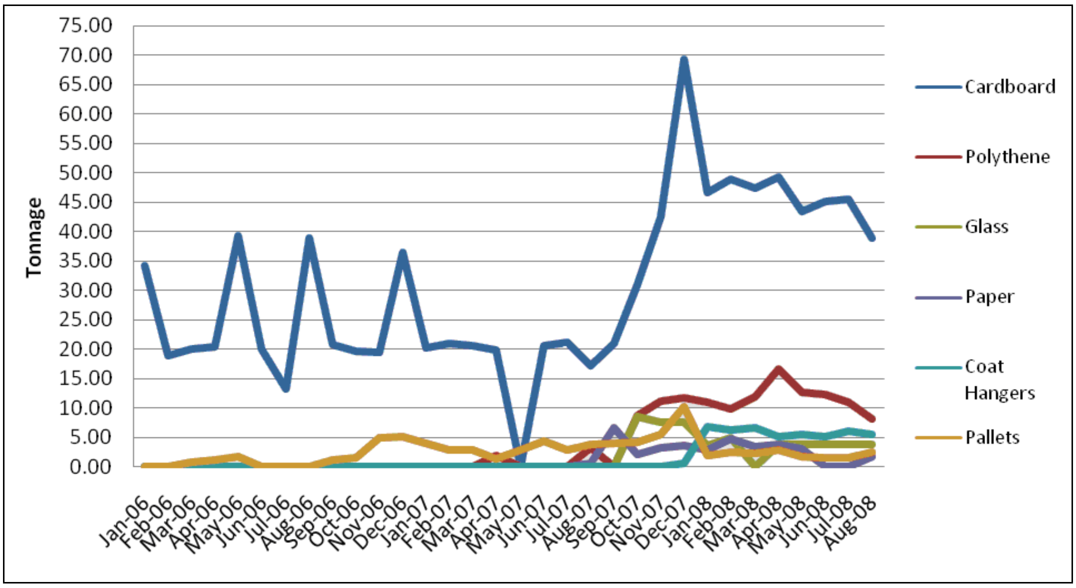


Figure 50: Monthly tonnage of recycled/recovered waste materials produced in *WestQuay* from January 2006 to August 2008.

WestQuay holds certificates for 'General Waste' disposal and has the right to collect, treat and dispose of retailers waste through the provision of the necessary Transfer Notes to tenants, under an agreed annual waste management service charge. Individual businesses are given the option to join the centrally organised waste collection system, or make their own arrangements with private contractors. At the time of the research, *WestQuay* had a contract with '*Veolia*' to collect general mixed waste and mixed paper produced by *WestQuay* staff and retailers who had joined the central waste collection system, general mixed waste produced by customers in *WestQuay* public areas, as well as hazardous waste and WEEE produced by *WestQuay* staff, and in some cases, by stores as part of their day-to-day commercial operations (e.g. fluorescent lighting tubes, fridges and cash registers). Cardboard and polythene collected and consolidated by *WestQuay* were collected by '*Futur*' and sent to Kent when 42 bales have been consolidated. Hangers are baled and collected by '*What a Waste*' and sent to Derby.

Businesses obligated under legislation to provide specialised collection and disposal of WEEE and other hazardous wastes such as used cooking oil and clinical waste had made arrangements with several specialised waste contractors for the collection and disposal of those wastes. General mixed waste, mixed paper and WEEE/hazardous waste collected by '*Veolia*' was moved and incinerated at the local incinerator in Marchwood. Individually managed hazardous wastes along with confidential waste are analysed in more detail in Section 7.8.

With regard to the two department stores that had developed in-house waste collection systems, one moved all waste types (except for general mixed and glass waste) to a distribution centre located in Southampton's Quays (a short distance from *WestQuay*) where it was further consolidated and processed. This business was considering using electric vehicles for transporting waste from *WestQuay* to the distribution centre in the Quays. *Biffa* collected the general mixed waste which was landfilled and glass. The general mixed waste generated by the other department store was managed by *WestQuay* and was collected by '*Veolia*' on their behalf. Cardboard, polythene and hangers were taken to Wincanton. Finally, the retail outlet selling clothing, footwear and sports equipment used in-house collection mechanisms to manage the waste produced (Section 7.8.2).

The recycling statistics suggested that the sustainable waste policy adopted by *WestQuay* and implemented by the retailers was having positive impacts in terms of reducing the landfill impact and increasing material recovery. Through the on-going investment programme and new recycling schemes, *WestQuay*'s management company aims to further increase recycling levels to 80%.

7.3 Waste Logistics Management Practices

The results from the interviews with the managers of the stores suggested that 91 stores joined *WestQuay*'s central waste management scheme (Figure 51), collecting their general mixed waste, cardboard and polythene and in doing so, some retailers were opting out of their own corporate waste management practices. As part of the scheme, special disposal bins located in the two internal service bays were available for the collection of end-of-life fluorescent lighting tubes. Twelve stores indicated that they replaced tubes themselves and disposed of them into *WestQuay*'s bins on a regular basis. Three more stores indicated that end-of-life tubes were normally collected by contracted electrical/maintenance companies servicing the stores on a regular basis, however, members of staff would occasionally replace tubes themselves and dispose of them in *WestQuay*'s bins. In addition, bins for the collection of excess or broken plastic hangers were made available in the designated collection points servicing the stores selling clothing. *WestQuay* also collected (on request) various other waste arisings. These included empty detergent bottles, spent aerosols, glass cleaning products, broken glass, and discarded end-of-life electrical and electronic equipment used in the operation of the stores (e.g. fridges, cash machines, computers).

The survey identified that 23% (n=21) of the stores that joined *WestQuay*'s waste management scheme were also producing confidential paper waste and/or hazardous wastes such as WEEE, medical waste, end-of-life batteries and/or used cooking oil. In addition 90% (n=83) of all participant businesses (n=92) were producing end-of-life fluorescent lighting tubes which along with the other hazardous wastes were collected by either specialised waste contractors (71%, n=59), by *WestQuay* (14.5%, n=12), or were back-loaded using the existing delivery vehicles to other locations in the supply chain such as head offices or distribution centres (4%, n=3) or were managed through other means (10.5%, n=9).

In only one case (*SportsWorld*; Section 7.8.2) were collections entirely organised by the businesses head office. *SportsWorld* belongs to a group of 375 stores in the UK which has developed its own waste management scheme and runs a fleet of 40 trailers and 131 company cars to deliver products and backfill waste. The company recycles its waste paper, cardboard and plastic (and occasionally ink toners, redundant IT equipment and light bulbs) within its national distribution centre in Shirebrook and aims to reduce its impact on the environment. In 2008, 60 tonnes of waste paper, 5,557 tonnes of cardboard and 860 tonnes of baled plastic were recycled in Shirebrook reducing the amount of rubbish put into landfill to 1,400 tonnes.

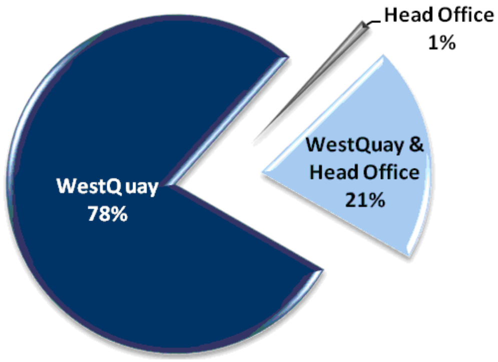


Figure 51: Organiser of waste collections in *WestQuay* businesses.

A review of waste management procedures across the retailers operating in *WestQuay* identified 4 main waste collection systems (Figure 52):

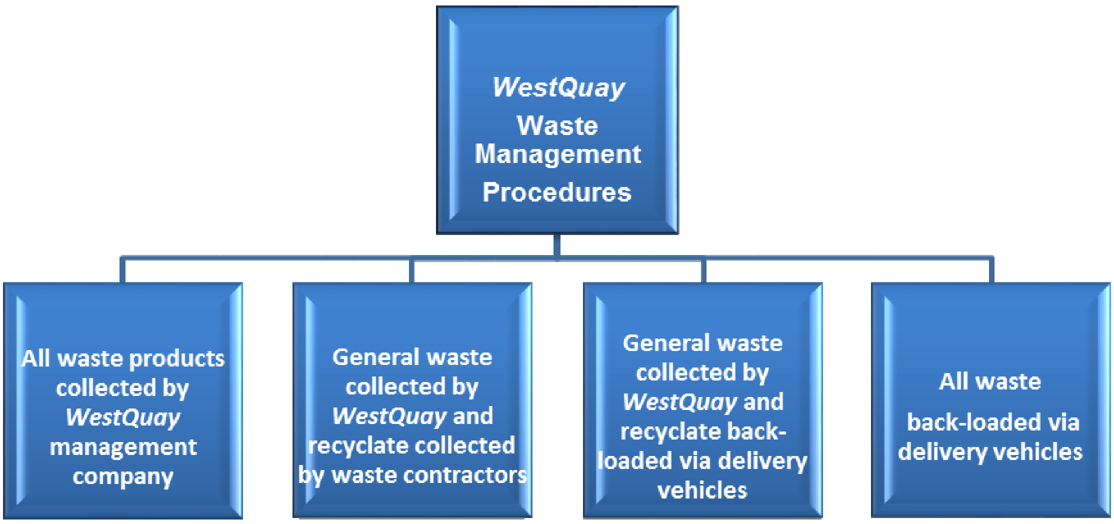


Figure 52: Waste management systems used by businesses operating in WestQuay.

Seventy two stores (78.3%) used *WestQuay*'s waste collection services to handle all their waste and recyclate (excluding end-of-life fluorescent lighting tubes) as part of the landlord-tenant agreement between *Hammerson* and businesses operating in the retail complex. Fourteen stores (15.2%) had general mixed waste including separated cardboard, paper and polythene collected by *WestQuay*, whilst confidential waste and other recyclate such as WEEE, batteries and cooking oil were collected by specialist waste contractors employed by the individual businesses. Five stores (5.4%) had general mixed waste including separated cardboard, paper and polythene collected by *WestQuay*, with other recyclate including WEEE, batteries and cooking oil back-loaded to individual head offices, distribution centres or other facilities in the retailers supply chain. One store (1.1%) used back-loading for all of its waste and recyclate using scheduled delivery vehicles.

7.4 Waste Generation (Surveyed Businesses)

Retailers were asked to specify their facilities for consolidating and storing waste prior to disposal in *WestQuay*'s designated collection points or collection by specialist waste contractors or delivery vehicles. The number of the waste packaging items (e.g. bags, boxes and roll cages) filled/disposed of on a weekly basis was estimated to determine the volume of the waste per product type generated across all businesses operating in *WestQuay*.

7.4.1 Waste Types Produced

Respondents were asked to provide a list of all waste types produced by their business during a typical week (Figure 53). The survey identified that cardboard, polythene, mixed paper and hazardous lighting tubes were produced by the majority of retailers. Restaurants also produced considerable amounts of food, used cooking oil, glass and plastic bottles, while stores selling jewellery and electronics produced batteries and end-of-life electronics.

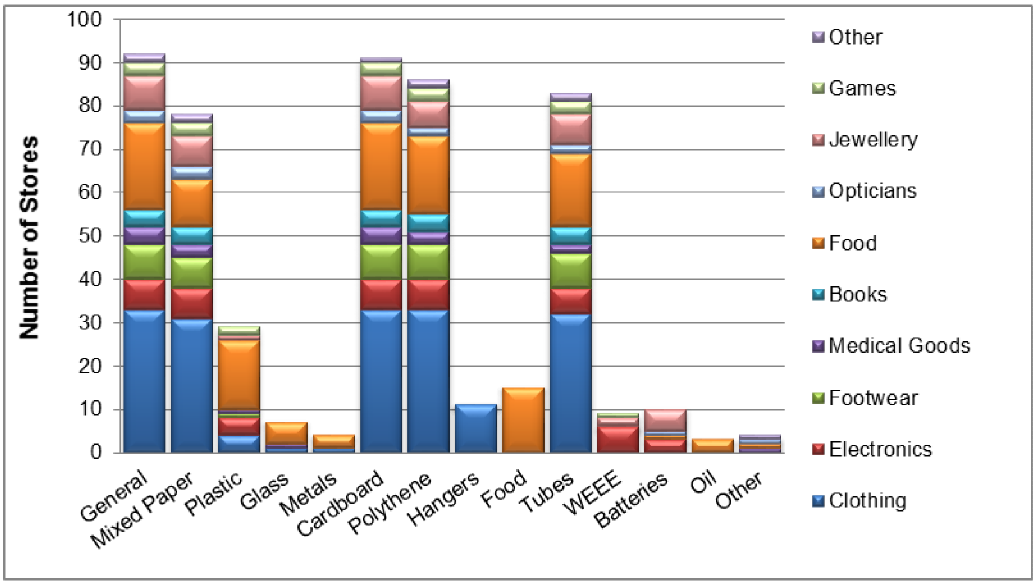


Figure 53: Waste types produced by different business types operating in *WestQuay*.

The survey identified that separate collections of cardboard, polythene, mixed paper, hangers and tubes were provided by *WestQuay* which was also planning at the time of the interviews to initiate separate collections for glass and plastic bottles (Figure 54). In addition, a number of retailers producing hazardous waste (WEEE, batteries, clinical waste, used cooking oil and fluorescent lighting tubes) and/or confidential documents to be shredded/destroyed had set agreements with specialised waste contractors who collected and disposed of wastes in accordance with current legislative requirements.

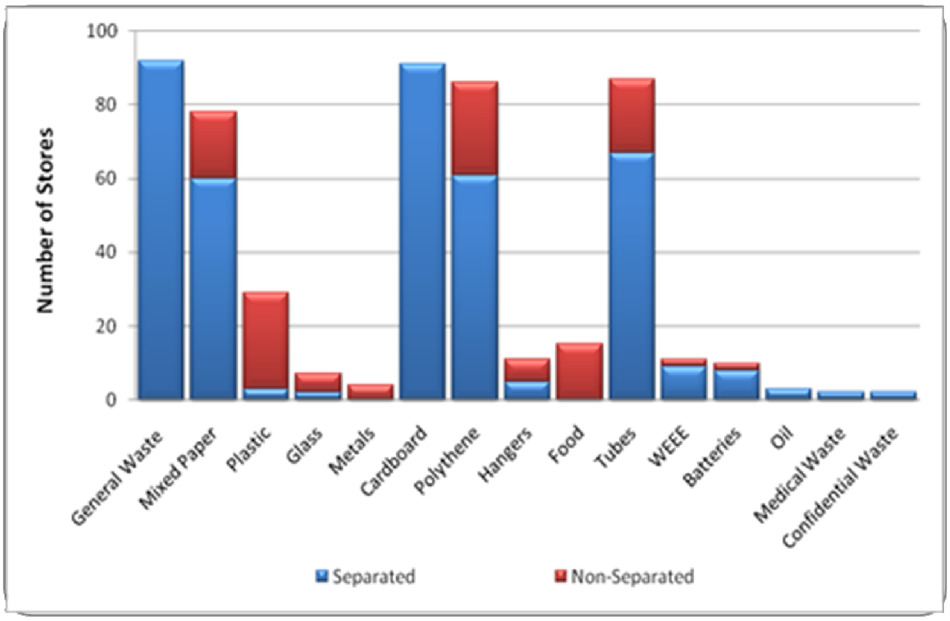


Figure 54: Percentage of separate (dedicated) and non-separated (non-dedicated) waste collections in *WestQuay*.

Figure 54 highlights the fact that although central waste collections of mixed paper, hangers and polythene were provided by *WestQuay*, 23% of the retailers producing mixed paper (18 out of 78 businesses), 29% producing polythene (25 out of 86) and 55% disposing of plastic hangers (6 out of 11) did not separate out these streams from their general mixed waste due to either a lack of time or available staff. In three cases, the interviewees were not aware of their legal obligation to dispose of fluorescent lighting tubes separately from the general mixed waste. In two cases, respondents took it upon themselves to take away items for recycling, there being no suitable service available to them. It is uncertain whether facilities provided for the general public (and therefore not appropriate for commercial waste) were used in these cases (e.g. a household waste recycling centre).

There was a lack of participation in the central mixed paper and polythene recycling schemes across the business categories. Greater numbers of businesses producing mixed paper in the food and footwear sectors (55%, n=6 and 43%, n=3 respectively) but not apparently separating it out from the general mixed waste were found compared to those selling electronics (15%), jewellery (15%) and clothing (4 out of 30 businesses, 13%) (Figure 55). Again, lack of time and adequate provision of recycling bins to effectively separate out mixed paper were cited as the most important reasons impeding retailers recycling performance in this area.

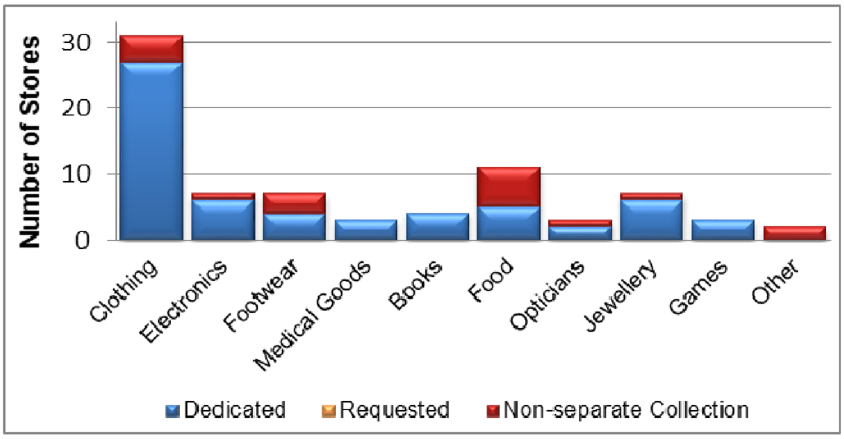


Figure 55: Dedicated collections of mixed paper produced by businesses operating in *WestQuay*.

There were also similar trends in terms of the businesses who stated that they did not separate out polythene from the general mixed waste stream (Figure 56). Food outlets would be expected to encounter considerable cross contamination of food waste with polythene, reflecting the high proportion put out in the general waste stream. Availability of staff and time were cited as the main reasons for not further separating out polythene from the general waste stream.

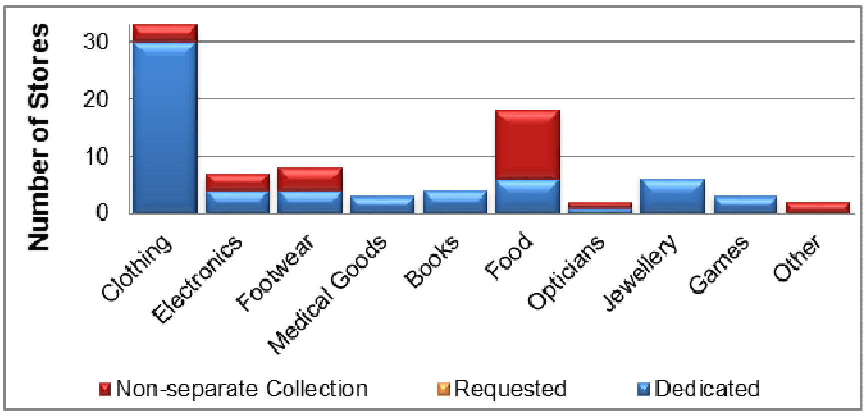


Figure 56: Separate collections of polythene produced by businesses operating in *WestQuay*.

7.4.2 Hazardous Waste Produced

The study identified that in total, 20 stores were producing hazardous wastes as part of their commercial activities and were obligated under several pieces of legislation to make special arrangements for their collection, storage and disposal.

The surveys suggested that 3 restaurants were producing used cooking oil and another 2 stores selling optical equipment and medical goods were producing clinical waste (e.g. needles, medicines, chemicals). In addition, 11 stores selling electrical equipment (computers, household appliances, mobile phones and electronic games) were producing WEEE and were obligated under the 'WEEE Directive' to develop customer take-back schemes. Six stores producing WEEE were also producing batteries and had common arrangements in place for WEEE and battery take-back. Another four stores were producing batteries collected either by *WestQuay* or back-loaded/posted to head offices (Figure 57). All 92 interviewed stores were found to use several types of EEE (e.g. computers, cash registers and fridges) to support their day-to-day commercial operations. Collections of end-of-life electronics used in this way were arranged through individual Head Offices and made either by *WestQuay*, specialised contractors or delivery vehicles transferring waste/recyclate back to either the head office or distribution centre. These collections are not examined in this report as they take place occasionally and their management varies case by case.

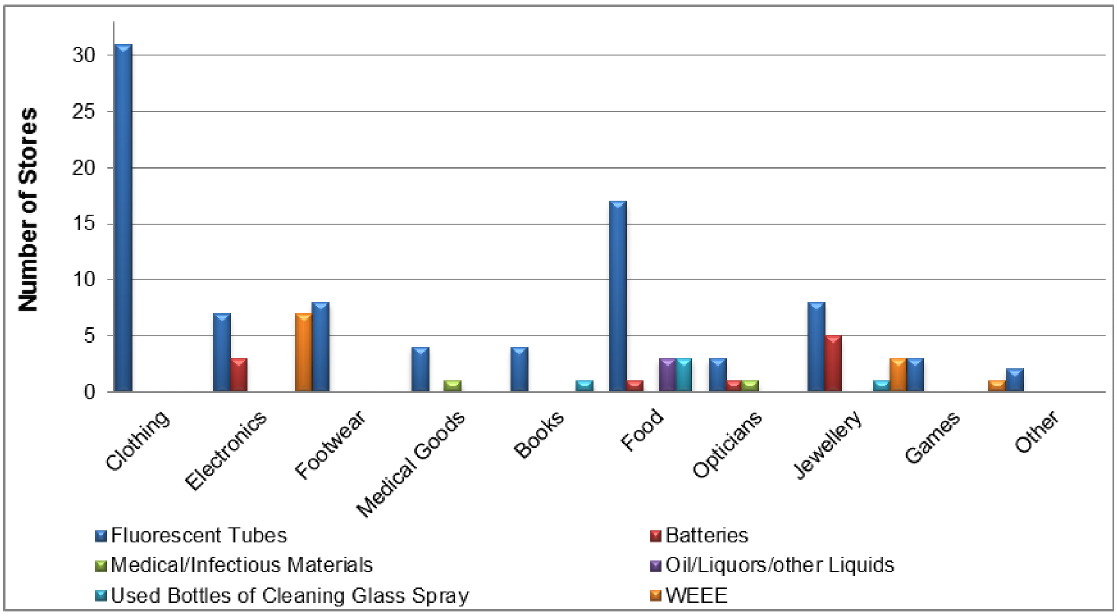


Figure 57: Hazardous waste produced by different business types operating in *WestQuay*.

Regarding the output of hazardous end-of-life fluorescent lighting tubes, 90% of the retail outlets and the catering units (n=83) used such lighting. Their treatment and disposal varied across the individual businesses with 13% of the stores/restaurants using *WestQuay*'s disposal bins (n=12), while contracted electrical/maintenance companies collected tubes during their routine visits to 59 stores. However, 3 out of the 59 stores being serviced by electrical/maintenance companies also used *WestQuay*'s bins. In one case, tubes were back-loaded and in three cases, respondents stated that tubes were collected by members of store staff who disposed of them in public waste collection areas outside *WestQuay*. In one case, tubes were allegedly disposed of in the general waste. Finally, 7 respondents stated that they did not have any knowledge of the issues regarding disposal of fluorescent tubes because it was either the responsibility of other staff members (5 cases) or because tube replacement had not taken place (2 stores having opened recently in *WestQuay*) (Figure 58).

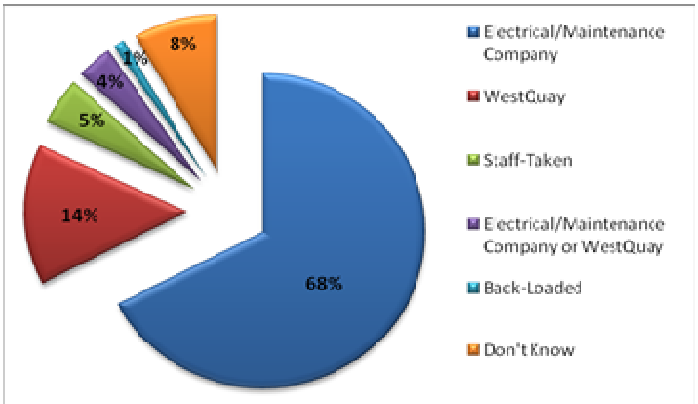


Figure 58: Hazardous waste produced by different business types operating in *WestQuay*.

The study identified that there was still some misunderstanding with regard to the legal requirements obligating individual businesses to dispose of fluorescent lighting tubes separately from the general mixed waste.

7.4.2.1 WEEE Take-Back

During the course of the surveys it was found that 11 out of the 18 stores selling electronics (computers, watches, electronic games etc) were obligated under the '*Waste Electrical and Electronic Equipment (WEEE) Requirements*'. These stores either offered customer take-back services in-store (9 stores) or provided customers with prepaid envelopes to return specific items (2 stores).

The study identified that the development of take-back systems at store level was interlinked to the associated 'gate-keeping' procedures run to scrutinise returned products before a decision was made about their passage through the reverse logistics system, back to either 'grade A' stock, repair, re-furbish, cannibalise for parts, or send for disposal. Dependent on the resources (expertise staff and equipment) available at stores to check returned products, EEE repairable items were separated from WEEE either at stores or in other locations in the supply chain. More specifically, it was found that only 2 out of the 7 stores with in-house mechanisms to collect WEEE had in-store gate-keeping functionality in place, with the necessary equipment and staff to make repairs and single out products from the reverse flow. In 71% of the cases (in 7 out of 9 businesses) mixed repairable products and WEEE were collected by outsourced collectors having the expertise and the infrastructure to gate-keep returns in other locations in the supply chain (e.g. distribution centres, consolidation centres and warehouses). Figure 59 shows the 3 main business types selling electronics as a main part of their commercial activity (7 stores selling purely electronics, 8 selling jewellery and 3 games). It was found that 5 stores selling jewellery and 2 stores selling games were not obligated under the WEEE to provide customers take-back services due to the type of the products and/or the limited quantities of WEEE produced.

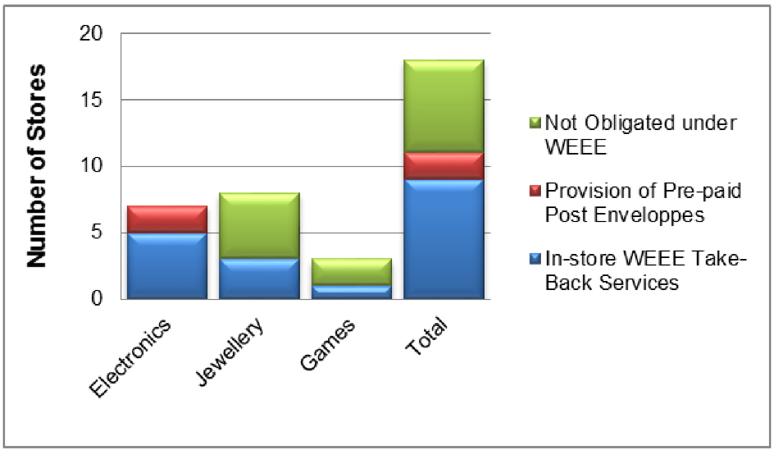


Figure 59: WEEE take-back services offered by businesses selling electronics in *WestQuay*.

7.4.3 Waste Storage Location

Respondents were asked to specify the consolidation and storage procedures followed by their business in order to manage the waste generated. Sixty retailers (65%) stated that they disposed of waste sacks as soon as they filled a bin in-store along with flattened, one-off delivery cardboard boxes, into *WestQuay*'s designated collection points located in the corridors at the back of the stores. A third of the respondents indicated that they consolidated waste temporarily in internal areas, such as stock rooms, corridors, staff rooms or kitchen areas, prior to disposal in *WestQuay*'s collection points. Only 2% of respondents stated that they had designated in-store waste collection areas (Figure 60).

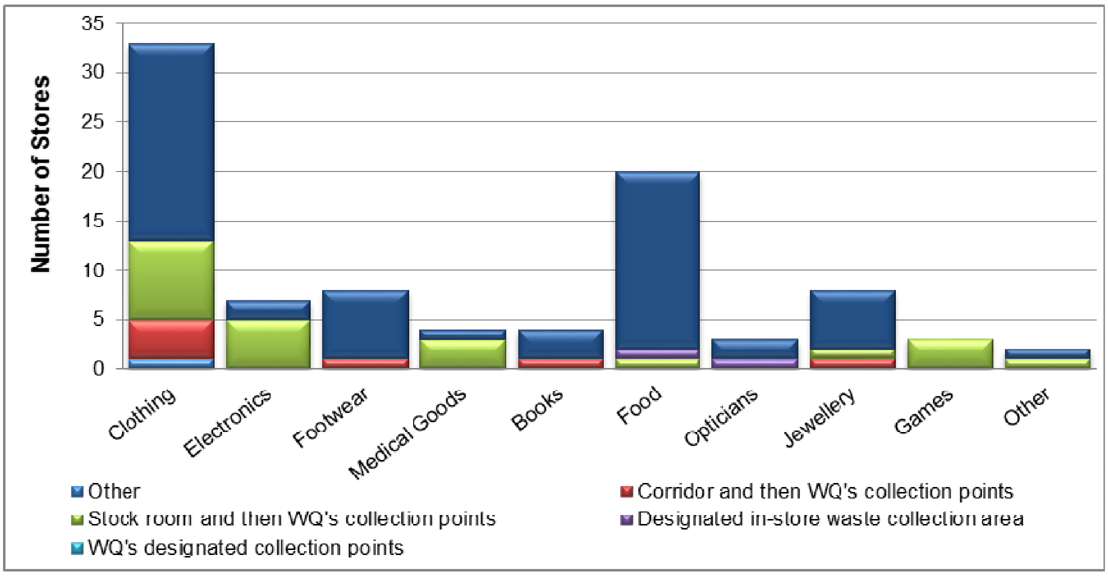


Figure 60: Storage location of waste produced by businesses operating in *WestQuay*.

Stores selling electronics, games and medical goods and some stores selling clothing kept a large proportion of the waste generated in their stock rooms (Figure 60). It was observed that the types of businesses and the availability of stock rooms were interlinked. The majority of these stores were selling fast-moving products (e.g. electronics), and therefore large quantities of stock were being handled on a daily basis requiring internal storage space away from the shop floor.

Stores with designated stock rooms predominantly ran their gate-keeping operations from these areas, where appropriate. Stores selling medical goods were in many cases obligated under 'Health and Safety' and the 'Hazardous Waste Regulations' to separate certain types of waste from the general waste stream and keep them in designated areas. Under these regulations a store selling optical equipment, but also operating as a surgery was obligated to have a designated waste storage area to keep certain clinical wastes separate prior to collection.

The most commonly used waste storage devices used by retailers at stores were found to be bins (quantities/proportions of all waste storage devices are given in Section 7.5.5). Respondents were asked to provide a breakdown of the different locations in stores where bins were situated. Businesses selling fast-moving merchandise such as electronics, games, footwear and medical goods predominantly had stock rooms and subsequently placed a larger proportion of their bins in that location. Restaurants situated more bins in the kitchens and customer areas (Figure 61).

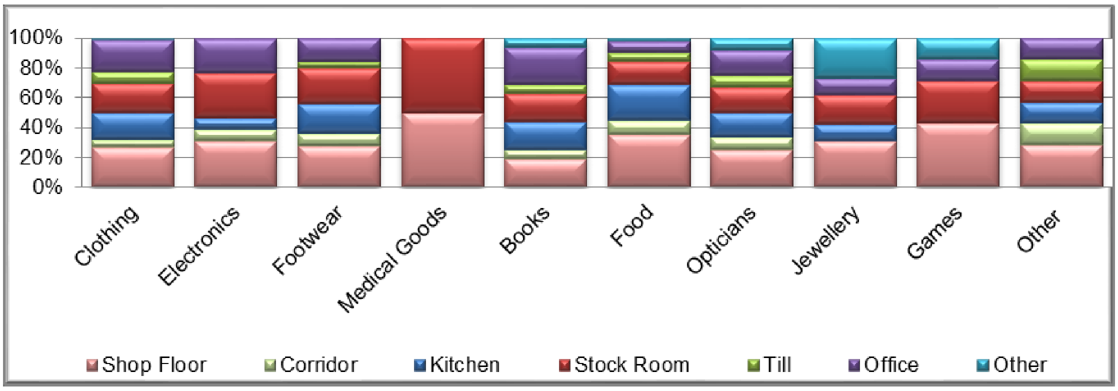


Figure 61: Location of bins at stores in *WestQuay*.

In total, 44.5% (n=228) of the total bins (n=512) were located on the shop floor, 19.7% (n=101) in stock rooms, 12.9% (n=66) in offices, 17% (n=87) in kitchens and 5.9% (n=30) elsewhere (e.g. corridors).

Finally, respondents were asked to specify the location (specific service yard) where waste was transferred by *WestQuay*'s staff collecting waste/recyclables from the 28 collection points in the corridors at the back of the stores. The majority of the respondents had a lack of knowledge about the waste operation run by *WestQuay* once it left their store and were unsure which of the three service yards were used to consolidate their waste.

7.4.4 Waste Packaging

The study identified that the vast majority of retailers strictly followed the waste packaging requirements set out in the '*Waste Packaging*' regulations. Interviewees highlighted the contribution of the frequent retailer training seminars provided by *Hammerson* to increase awareness about appropriate storage, disposal and collection of waste and recyclables produced.

7.4.4.1 In-store Waste Storage Devices

Respondents were initially asked to quantify the number of waste storage devices used internally to collect and store waste and recyclables produced by their business. Across the 92 respondents, approximately 512 bins of varying type were used in-store (Table 34). Three basic sizes of internal waste storage devices were identified (Table 35):

- Small Bins: usually used behind tills and in offices with a capacity of between 10-15 litres.
- Medium bins: usually used in kitchens, offices and on shop floors with a capacity of between 50-60 litres.
- Large bins: usually used in corridors and in stock rooms with a capacity of up to 90 litres.

Table 34: Average 'bin' units per retail units for business types operating in *WestQuay*.

Business Type	Retail Units	No of Bins	Average No of Bins/Retail Unit	Median	Standard Deviation
Clothing	33	203	6.0	5.0	5.1
Footwear	8	42	5.1	4.5	2.5
Electronics	7	34	4.9	3.0	3.8
Medical Goods	4	14	5.0	4.0	3.5
Books	4	29	7.0	6.0	3.6
Restaurants/Cafes	20	98	4.7	4.5	2.6
Opticians	3	31	10.3	10.0	9.5
Jewellery	8	36	4.5	5.0	2.3
Games	3	16	2.3	3.0	2.1
Other	2	9	4.5	5.5	4.9
Total	**92**	**512**	**5.6**	**5.0**	**4.1**

Bin utilisation was high in the case of the travel agency, the bookstores and the stores selling optical equipment and clothing. The high standard deviations in the case of stores selling optical equipment, clothing, electronics books and medical goods is due to the varying floor sizes of the respondents within the same business categories. Respondents were also asked to specify the size of the bins used in their stores. It was found that more than half of the bins used (267 out of 512 bins) were considered medium size bins (50-60l), 13.3% of the bins (68 out of 512) were considered small (10-15l) and 34.6% (177 out of 512 bins) were large (up to 90l) (Figure 62).

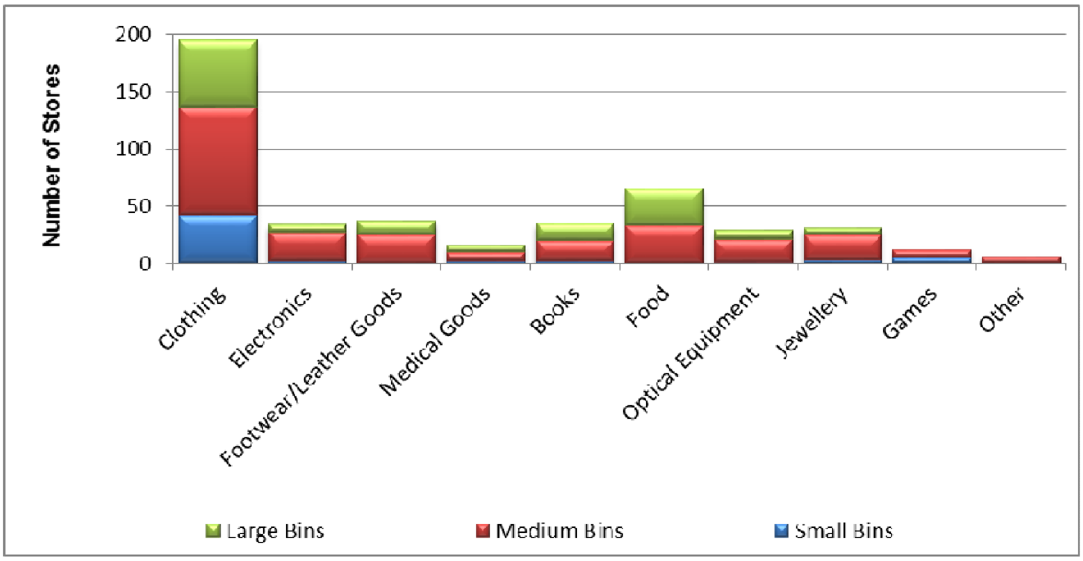


Figure 62: Quantities of large/medium/small bins used by businesses operating in *WestQuay*.

Small bins were mainly used by businesses selling clothing and games and were usually situated near the tills. Large bins were used by catering units and stores selling clothing and footwear due to the nature of the main waste types produced by these businesses (food waste and packaging materials respectively). The survey did not identify any guidelines on the type of bins that should be used in stores except for the standardised *Veolia* recycling bins for mixed paper provided by *WestQuay*, or whether there were any specific compatibility issues related to the onward treatment and disposal process.

It was found that in total, only 74 bins (14.9%) were considered by respondents to be used for recyclate, mainly being used for the disposal of mixed paper collected by *WestQuay*. This implies that further sorting of mixed waste may take place in-store before separation at the *WestQuay* collection points. On average, every business used 0.8 recycling bins but a higher proportion were used by businesses selling jewellery (2.5 bins/retail unit), electronics (0.86 bins/retail unit), bookstores and the travel agency (1 bin/retail unit respectively). The lowest recycling bin usage was recorded by the catering units (0.20). In most cases, businesses using dedicated recycling bins for mixed paper dealt with greater volumes of customer paperwork (travel agency, stores selling mobile phones and jewellery) and/or product returns (e.g. stores selling electronics) compared to restaurants/cafes. This is also supported by the fact that the travel agency and a store selling mobile phones were receiving specialised collections of confidential documents.

Table 35: Types waste packaging used by businesses in *WestQuay*.

Packaging Type*	Name	Material	Reusability	Waste Type
	Bins	Plastic/ Metal	Yes	Mixed Waste Materials
	Boxes (or containers)	Cardboard	No (exemptions may apply)	Flattened Cardboard Boxes
	Blue Sack	Polythene	No	Polythene Plastic Bottles
	White/Pink Sacks	Polythene	No	Paper Cardboard
	Yellow/Orange Sacks	Polythene	No	Clinical Waste
	Sharp Boxes	Plastic	Yes	Sharps (Clinical Waste)
	Boxes for Lamps	Cardboard	Yes/No	Lighting Tubes
	Battery Boxes	Cardboard Plastic	Yes	Batteries
	WEEE Totes	Plastic	Yes	WEEE
	Drums	Metal Plastic	Yes	Used Cooking Oil
	Roll Cage	Metal	Yes	Storage/Transport
	Pallet	Wooden Metal Plastic	Yes	Storage/Transport

*Illustrations may not relate to the actual packaging used

Transfer of the waste collected internally in bins to the 28 collection points at the back of the stores was made with the use of coloured polythene sacks. Black sacks were used for the collection of general waste (including non-separated food waste, plastic bottles and glass), white/pink sacks for mixed paper, blue sacks for polythene and plastic bottles and yellow/orange bags for medical waste. The capacity of standard black, blue and white/pink refuse sacks was 90 litres, while the capacity of a medium yellow/orange sack was 60 litres.

In addition, respondents stated that cardboard was disposed of in *WestQuay*'s roll cages located in the 28 designated collection points. Cardboard was bundled, flattened and stored on roll-pallet cages prior to collection by *WestQuay*'s staff. The size of a standard roll-pallet cage used for the collection of recyclables is 1.73x0.74x0.86m which equates to approximately 1,100 litres capacity. Medical waste was either disposed of in plastic boxes or special plastic bags and used cooking oil in special drums. Finally WEEE, confidential paper waste and lighting tubes were traditionally disposed of in boxed units. The following box types were identified:

- *Sharp Boxes*: Plastic disposable containers were used for storing and shipping sharp medical waste such as syringes. Sizes may vary, however the survey identified that *WestQuay* businesses were typically using 1 litre containers.
- *Cardboard boxes for batteries and WEEE*: Batteries were stored in small cardboard boxes not exceeding 5 litres. If WEEE was also collected, then larger boxes were used.
- *Cardboard boxes for fluorescent lighting tubes*: In most of the cases, end-of-life fluorescent lighting tubes were not removed from their fittings prior to an electricians routine maintenance visit. However, in some cases, store staff removed tubes and either asked *WestQuay*'s staff to safely dispose of them or provisionally stored them in their stock rooms until the next electrician's visit. Original packaging or special recycling cardboard boxes were used for their safe storage and collection. Typical sizes are 1.23x0.2x0.24m equating to 63.5 litres which can be used for the storage of 30 long or 50-60 medium length lamps.
- *Plastic Boxes for Batteries and WEEE:* Plastic containers were typically used for the safe storage and collection of WEEE. Sizes varied considerably dependent on the size of products collected. However, when WEEE was back-loaded to head offices or distribution centres, plastic totes used in delivery were utilised. A typical size of a re-usable plastic crate is 0.6x0.37x0.33m

which equates to 80 litres carrying capacity. Finally, stores selling bigger electronic units (e.g. fridges, computers etc) used pallets or roll cages.

All three restaurants producing used cooking oil collected it in special drums/barrels. Their capacity varied case by case from 5 to 80 litres. In addition another 18 respondents (20%) stated that their business owned and used shredders located in offices in order to destroy confidential documents and/or reduce the volume of the waste paper disposed of in the mixed paper recycling bins.

7.4.4.2 Re-usable Packaging

Another interesting area of waste logistics is the collection and shipping of re-usable packaging used for the delivery of core goods. The study identified that a large proportion of retailers (44 stores) used re-usable containers (on an exclusive basis or in combination with non-reusable packaging) for the delivery of core goods.

The types of re-usable containers varied among different business types due to the range of different products carried (Table 35). Restaurants and cafes for example used a significant combination of packaging types, while stores selling clothing, footwear, books and games were usually using either cardboard boxes or plastic totes. Dependent on the nature of the food, restaurants used trays (e.g. when serving freshly cooked food) or bags, cardboard and plastic boxes to enable freezing (e.g. ice-cream and other frozen/chilled food). Also drinks were usually delivered in packs of 12 or 24 bottles, while plastic totes or bags were used only for fresh product. The study also identified that cardboard boxes were utilised by the majority of the retailers; their re-usability was directly dependent on the product type. Footwear stores and the art gallery for example re-used cardboard boxes for the storage and return of shoes and paintings, while the rest of the stores were using one-off boxes. Stores selling clothing often used re-usable plastic totes, hanging rails or clips used for groups of items wrapped in polythene. In one case, where large quantities of electronics products were being delivered to a retailer, pallets were used and back-loaded back to the distribution centre.

7.4.5 Waste Production (by number of packaging units)

Respondents were asked to quantify the numbers of units used for the disposal of waste (bags, roll cages and boxes). The seasonal variations in waste production were also gauged by identifying periods when waste output typically increased by more than 50% over the non-peak norm. Finally, retailers were asked to estimate the quantities of reusable items delivered to their businesses in order to assess the transport implications associated with non-reusable packaging items along with the rest of waste/recyclables.

7.4.5.1 Seasonal Variation in Waste Generation

The busiest months in terms of increases in waste production by more than 50%, were the run up to Christmas (late October, November, December and early January) and the 'discount' sales periods (July and August), (Figure 63).

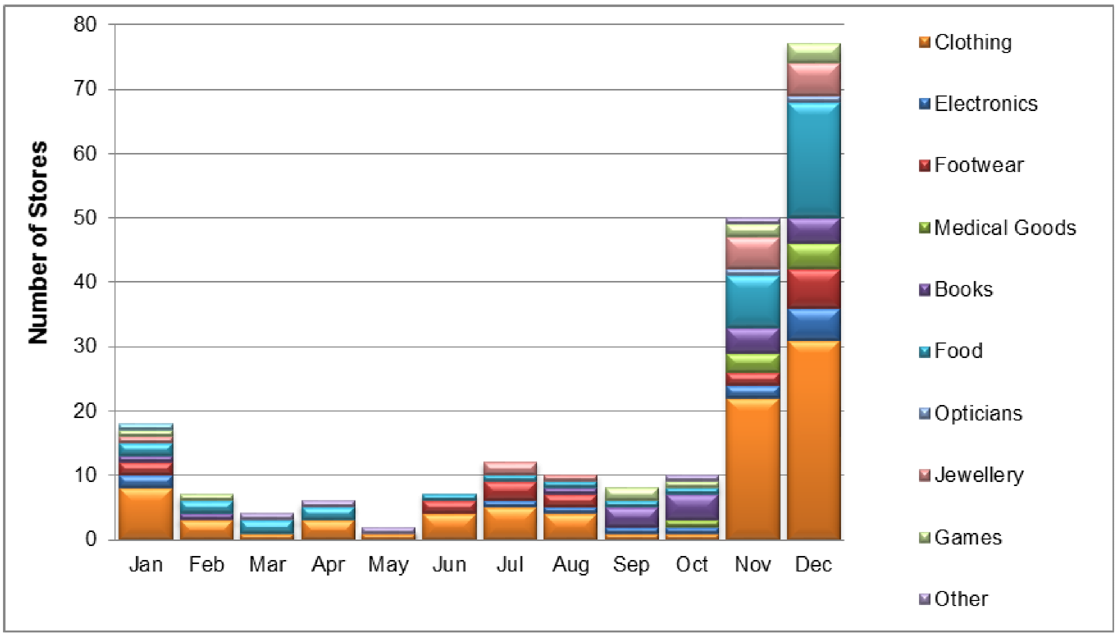


Figure 63: Busy months in terms of increases in waste produced by businesses operating in *WestQuay* by more than 50%.

The study identified that 83.7% of all the stores operating in *WestQuay* stated December was the busiest month for their business in terms of waste outgoings, increasing by more than 50%. Another 55% stated November, 18.5% January and around 12% July and August. The majority of these retail outlets were either catering units, stores selling clothing, footwear or electronics (Figure 64).

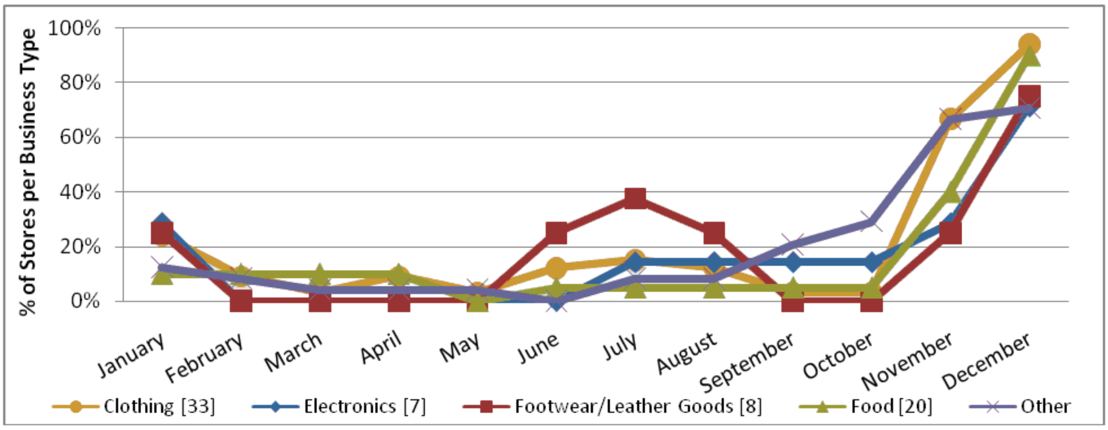


Figure 64: Percentage of *WestQuay* stores by business types stating busy months in terms of waste production.

Where in this report weekly estimates are made, busy periods are already considered. A detailed estimation of the waste volumes produced is made in Section 7.5.6.

7.4.5.2 Disposable Packaging Items

To quantify the volume of waste generated by the survey sample, it was necessary to estimate the number of packaging items disposed (bags, roll cages, boxes, drums/barrels). General waste, mixed paper, polythene and some types of medical waste were quantified by bag units, cardboard by roll cage units, other types of medical waste, WEEE and batteries by box units and finally used cooking oil by drum/barrel units. Figure 65 shows the breakdown of the packaging units for all waste types produced on a weekly basis by the different businesses operating in *WestQuay*.

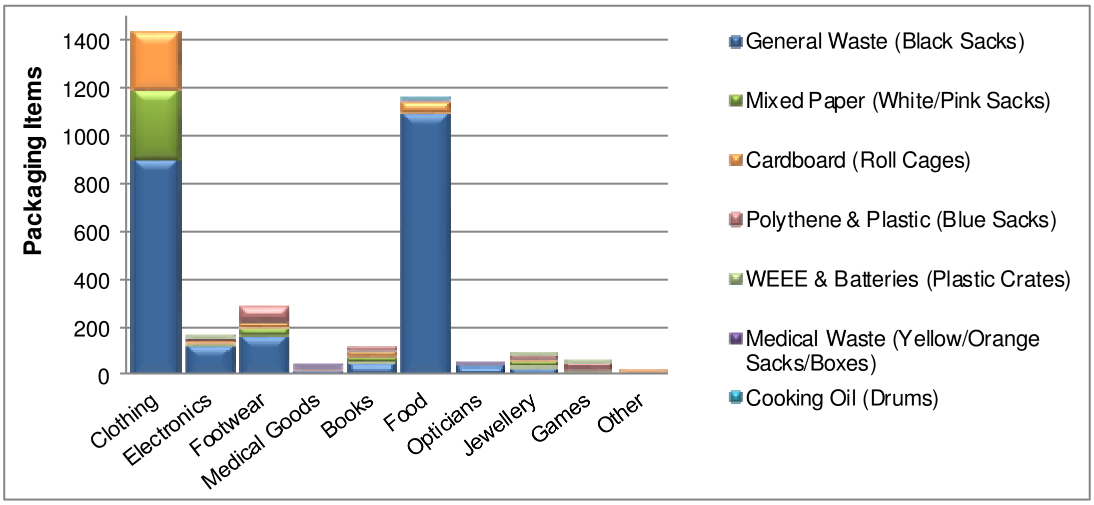


Figure 65: Number of packaging units/week used for the collection of waste produced by businesses operating in *WestQuay*.

Stores selling clothing, footwear, electronics as well as the catering units were the principal generators of the majority of the waste units. Across the months, the main increase in waste production results from black sacks containing mixed waste for disposal (Figure 66).

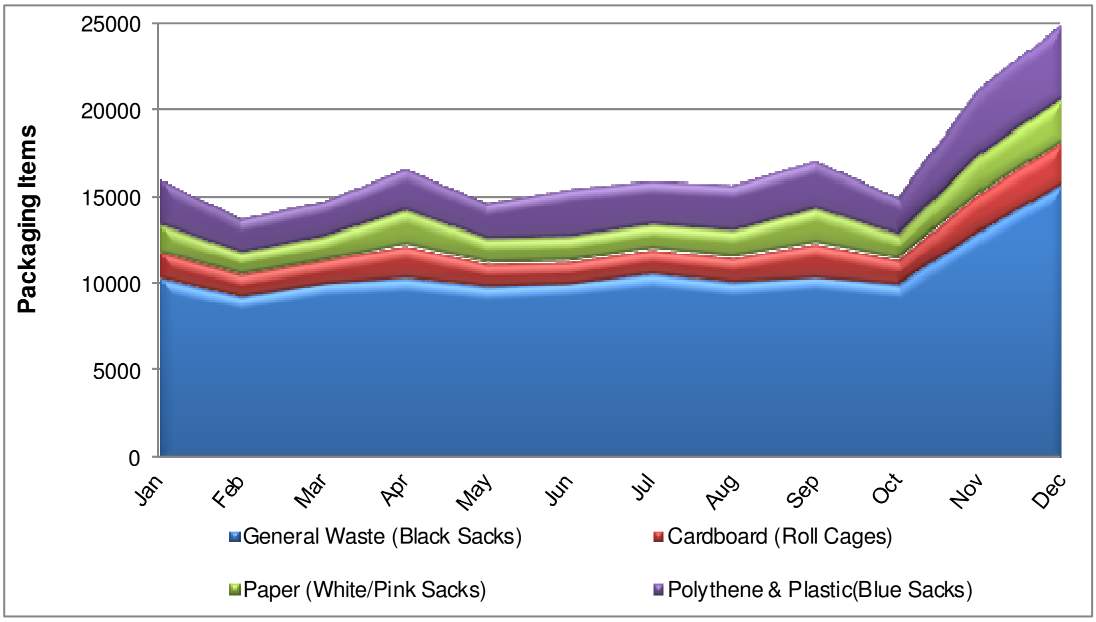


Figure 66: Monthly variation in number of packaging units used for the collection of waste produced by businesses operating in *WestQuay*.

On a daily basis, it was estimated that 362 black sacks filled with mixed waste, 55 white/pink sacks with mixed paper, 53 roll cages filled with flattened cardboard, 89 blue sacks with polythene, 0.6 blue sacks with plastic (hangers, bottles), 1.6 plastic totes with WEEE and batteries, 0.15 sharp boxes and/or yellow/orange sacks with medical waste and finally 0.2 drums filled with used cooking oil were generated by the retailers participating in the survey.

7.4.5.3 Filled Packaging Items

Reusable delivery items were also quantified to identify their contribution to the waste logistics of the centre. The results suggested that during a typical non-peak week, approximately 7,756 'items' were delivered to stores. The majority (67%, n=5,086) were cardboard boxes, 29% (n=2,207) plastic totes, 2% (n=139) hanging rails, 2% (n=164) bags, 6% (n=470) packs of drinks, 6% (n=485) food cases, 1% (n=64) trays, 1% (n=94) pallets and 2% (n=117) roll cages. Almost half of those (46%, n=3450) were delivered to stores selling clothing, while a third (35%, n=2647) were delivered to catering units. Regarding their reusability (Figure 67), 41% were considered by respondents as reusable (plastic totes, roll cages, trays, hanging rails, pallets and food cases) and the remaining 59% were considered non-reusable (cardboard boxes, bags and packs of drinks).

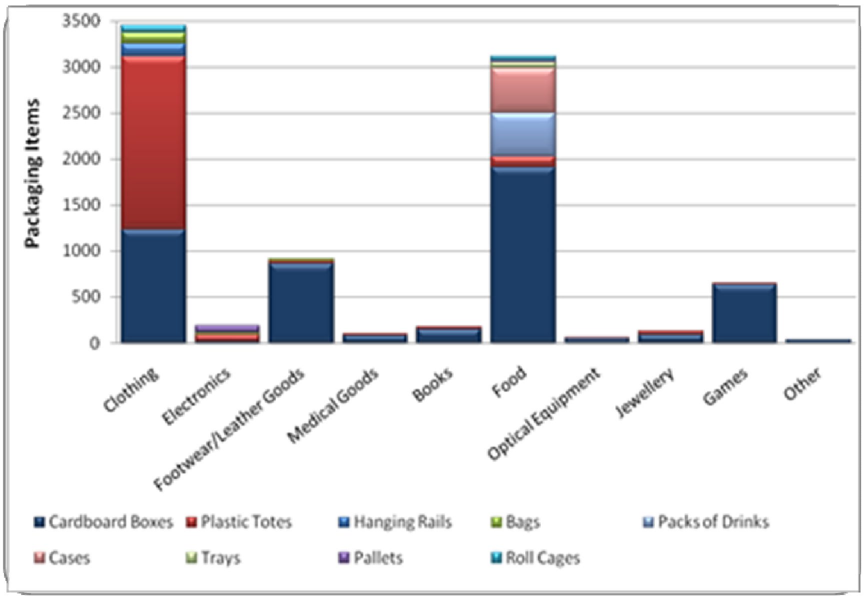


Figure 67: Re-usable packaging units delivered during a week by different business types operating in *WestQuay*.

Although the use of re-usable packaging can lead to a significant reduction in the levels of the packaging waste produced and the transport associated with disposal, this can be offset by the transport requirements linked to recovery, back through the supply chain. The food sector used the most non-reusable packaging followed by the clothing stores. In addition, in-house equipment (e.g. pallets and roll cages owned by the shopping centre) was often used to move products from the service bay to the stock rooms. This equipment was not considered in the analysis since its use does not imply any transport effort.

7.4.6 Waste Production (by Volume)

In order to gain an estimate of the waste volume generated by the sample stores, the mean sizes of storage units (bins, roll cages, drums, boxes) used for the disposal of general mixed waste, mixed paper, cardboard, polythene and plastic, WEEE and batteries, medical waste and used cooking oil were multiplied by the number of units produced during a specific period (e.g. day/week/month/year).

Cardboard accounted for more than half (56%) of the total waste volume produced by the 92 retailers participating in the survey (Figure 68). General waste volumes produced were equal to 31% of total waste arisings, while polythene/plastic and paper made up the remaining volume breakdown. Hazardous waste, (medical waste, WEEE and batteries and used cooking oil) made up a very small proportion (0.01%) of the total waste volume produced.

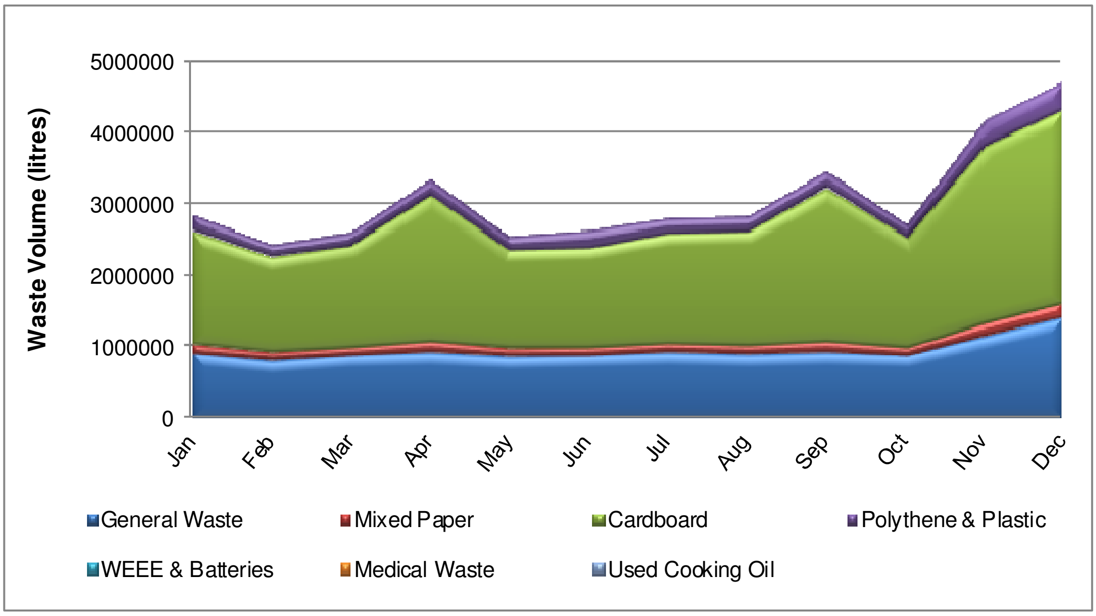


Figure 68: Breakdown of waste types by volume estimated to be produced by businesses operating in *WestQuay*.

Examining the monthly variation in the waste volumes generated through this analysis (Figure 68) highlighted some inconsistency between the production of waste and the number of stores stating specific months as being particularly busy in terms of waste generation. In general waste production associated was increased during the Christmas period, the Easter period and the end of summer sales period. A comparison with the number of deliveries received during these periods suggested that waste production by volume was directly connected with the number of deliveries received, especially during the Christmas period.

Respondents were also asked to comment on their overall level of satisfaction with the waste storage and disposal facilities available to them (Figure 69). Ninety percent of the retailers operating in *WestQuay* said that they were 'very satisfied' with the capacity of their internal waste management facilities and those found in *WestQuay*'s designated areas. The internal bins and other waste storage equipment provided by *WestQuay* were considered adequate for the current volumes of waste produced and the system managing their replenishment, using the two collection vehicles was also praised for its effectiveness. These issues however became more important during busy periods when 10% more respondents stated that they were not satisfied with the capacity of the bins for the general mixed waste and the roll cages for the recyclables provided by *WestQuay* in the 20 collection points.

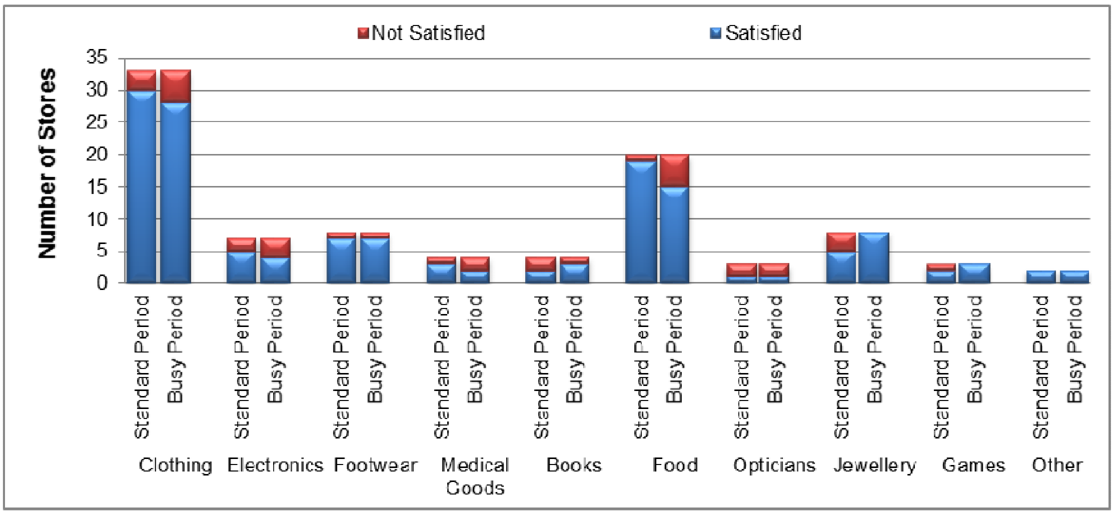


Figure 69: Satisfaction with the availability of waste storage facilities.

Figure 69 suggests that the business categories with a significant presence in the retail complex (catering units and stores selling clothing and electronics) were more affected by the reduction in capacity of the waste storage and disposal facilities due to seasonal increases in waste arisings.

7.4.7 Waste Collections

Respondents were also asked for details of the waste collection arrangements arranged by their business with other contractors in accordance with the legislative requirements. Waste collectors, frequency of collections, types of collection vehicles and final destinations were all investigated in the final parts of the survey.

7.4.7.1. Waste Collectors

Businesses were asked to provide information about their waste collection contracts and in 91 cases, general waste, cardboard and polythene were collected centrally by

WestQuay. Broken and excess hangers from stores selling clothing, if not back-loaded using delivery vehicles back to the respective distribution centres or head offices, were also consolidated centrally by *WestQuay* and then collected by *What a Waste* and sent to Derby. General mixed waste was collected by *Veolia* and cardboard and polythene/plastic by *Futur* and sent to Kent. *WestQuay* also arranged for the dedicated collection of fluorescent lighting tubes from 12 stores and from another 3 stores on an occasional basis which, along with other types of hazardous waste, were then collected by *Veolia*.

The survey also identified that 3 specialised waste contractors collected used cooking oil produced by catering units. Information was only available for two of them (*A&B Oil* based in Southampton and *Arrow* based in Heywood-Lancashire). Another 2 contractors collecting confidential waste were identified, but information was only available for one of them (Reisswolf based in Leighton-Buzzard, Bedfordshire), 59 electrical/maintenance companies replacing and collecting end-of-life fluorescent tubes during routine maintenance visits, 1 contractor collecting clinical waste (*Initial Medical Waste* based in Slough, Berkshire) and 3 contractors collecting WEEE and batteries (*Fonebak* based in Witney – Oxfordshire, *River and LDC*). A summary of all the waste contractors collecting waste on a dedicated basis and for which contact details were made available is shown in Table 36.

Table 36: Waste collectors of hazardous and confidential waste produced by businesses operating in *WestQuay*.

Waste Type	Waste Contractor (dedicated collections)
WEEE	Fonebak
	LDC
	River using DHL
Clinical Waste	Initial Medical Waste
Cooking Oil	A&B Oil
	Arrow Oils
Fluorescent Lighting Tubes	Microlights Ltd (Matthew Ricks)
	PLM Electrical
	Anabas Facilities Management
	MSL Property Care Services
	Weblight Ltd
	Parker Sell Lighting Ltd
	Connaught
Confidential Waste	Reisswolf

One business back-loaded end-of-life fluorescent lighting tubes, while 5 more stores producing WEEE and/or batteries were using their delivery vehicles to return these materials back to the distribution centres, head offices or other locations in the supply chain.

In 6 cases, recyclables (plastic and glass bottles) were collected by store personnel and disposed of in public recycling facilities and in 3 more cases, fluorescent lighting tubes were allegedly disposed of in public collection points used for general mixed waste which would be against the regulations. Regarding WEEE collected through customer take-back schemes, 2 stores provided customers with pre-paid postage labels to *Fonebak* (a company providing repair, recycling and reuse services for mobile phones and related accessories) enable the return of mobile phones. A breakdown of all waste contractors collecting waste produced by retail outlets and catering units operating in *WestQuay* is presented in Figure 70.

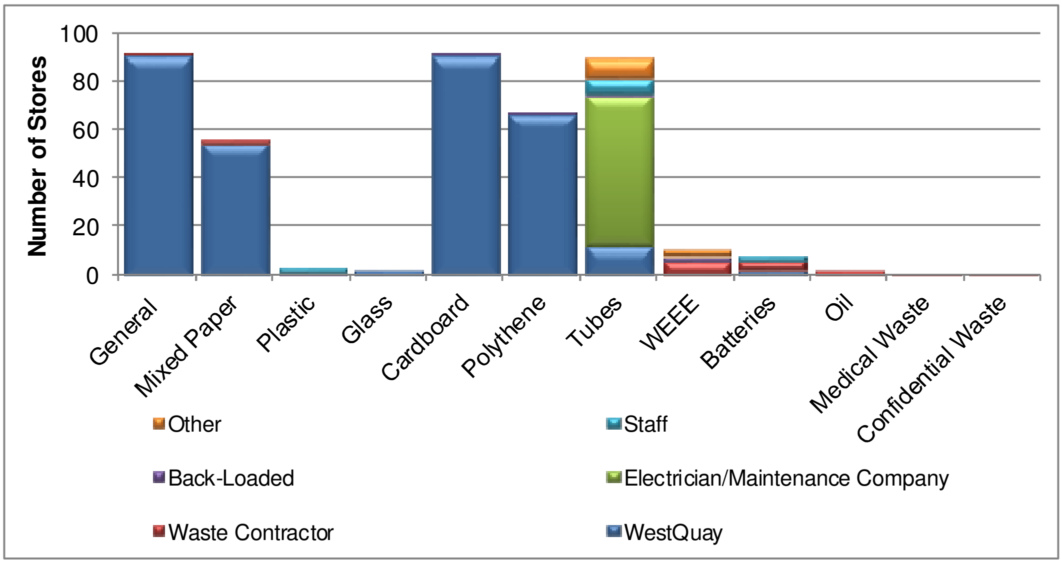


Figure 70: Type of waste collector by waste type produced by retailers operating in *WestQuay*.

It was estimated that in total 6,794 dedicated and 3,347 back-loaded collections of hazardous and confidential waste were made annually.

7.4.7.2 Collection Vehicles

Respondents were asked to classify the types of vehicles used to collect waste and recyclate by individual waste contractors. Generally, the interviewees were not well versed in these details as a result of the waste collections taking place in remote service bays away from the stores. A distinction between dedicated and back-loaded collections was made (Figures 71, 72).

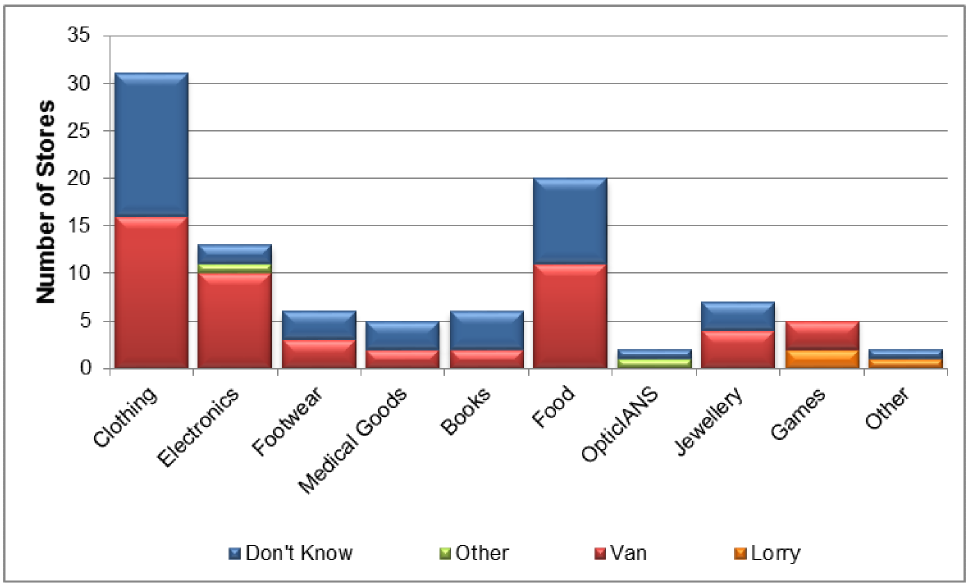


Figure 71: Type of vehicle collecting packaging/waste/recyclate on a dedicated collection contract for businesses operating in *WestQuay*.

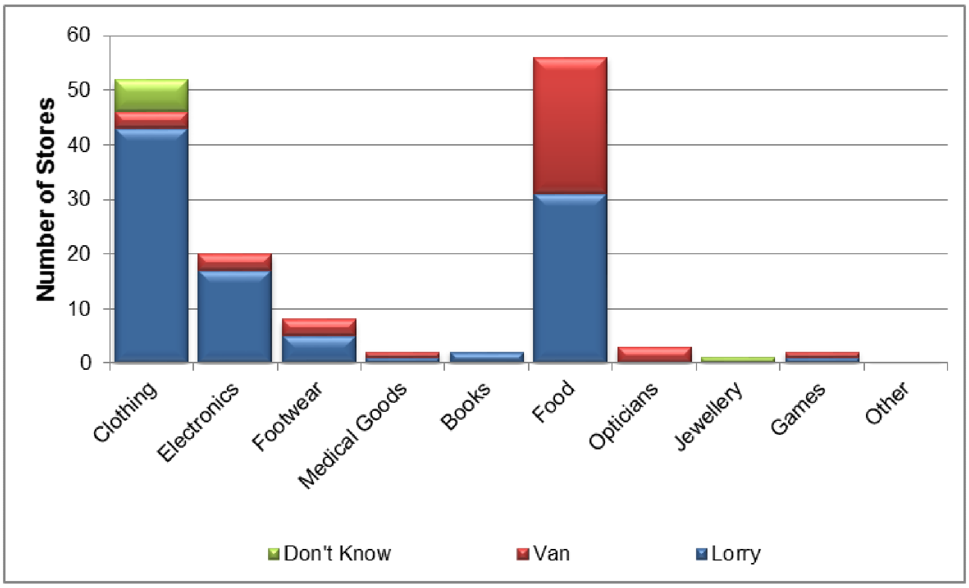


Figure 72: Type of vehicle back-loading packaging/waste/recyclate produced by businesses operating in *WestQuay*.

Figures 71 and 72 highlight the difference between the fleet types used to back-load waste on a dedicated basis. Larger vehicles were commonly used to back-load recyclate being the same vehicles used to deliver core goods to the stores. Waste produced by certain business types such as stores selling medical goods, jewellery and games was collected on a dedicated basis by registered waste carriers, particularly where the nature of the waste (hazardous or WEEE) dictated that a registered carrier was necessary.

7.4.7.3. Frequency of Collections

The frequency with which different waste types were collected was determined from details of the individual agreements made with the third party contractors. General waste, cardboard and polythene collections were made centrally by *WestQuay* on a daily basis, using 2 vehicles, transferring waste and recyclate to the 3 service yards from where they were collected by third party contractors. General waste, mixed paper and hazardous waste produced on site are collected by *Veolia* ranging from weekly collections for general waste consolidated in two of the service yards to fortnightly collections for general waste consolidated in the third service yard. Paper and cardboard bales were collected as consolidated batches of 42 bales (approximately one batch per month), with hazardous waste on a weekly basis. Plastics such as broken hangers produced by stores selling clothing were collected every 2 months, while mixed mall waste (recycling) was collected on a weekly basis.

With regards to individually arranged collections, the study identified that WEEE, clinical waste and cooking oil were typically collected on a fixed weekly basis contrary to confidential waste, batteries and lighting tubes that were mainly collected under request and a few times a year. Table 37 presents the frequency (per week equivalent) of waste collections of re-usable packaging and hazardous waste types, for collections taking place on a dedicated basis and those being back-loaded using delivery vehicles. It was estimated that on average, 132 delivery vehicles back-loaded re-usable packaging a week while 2 to 3 vehicles back-loaded WEEE and in some cases batteries. Only in one case was re-usable packaging collected by dedicated vehicles, while another 2-3 dedicated WEEE collections were made each week. Used cooking oil was collected once a week in two cases and once a month in a third case. Finally, lighting tubes were collected by electrical/maintenance companies occasionally (a few times a year). In general, it was found that due to the hazardous nature of the wastes involved, companies outsourced collection and disposal to specialised waste contractors having joined authorised compliance schemes.

Table 37: Weekly frequency of dedicated and back-loaded collections of specialised waste/recyclate produced by retailers operating in *WestQuay*.

Business Type	Back-loading					Dedicated Collections					Total Collections
	Reusable Packagin	WEEE	Batteries	Cooking Oil	Lighting Tubes	Packaging	WEEE	Batteries	Cooking Oil	Lighting Tubes	Total
Clothing	57.8					1				5.6	64.4
Footwear/Leather	6.0									0.5	6.5
Restaurants/Cafes	43.0								2.3	0.8	46.1
Electrical Goods	16.0	2.24					2.4	0.12		0.7	21.46
Games	1.0	0.04			0.05					0.07	1.16
Jewellery		0.04			0.07		0.04	0.12		0.84	1.11
Other	8.1									1.28	9.38

7.4.7.4 Types of Collection Services

It was found that 81% of waste collections were made on a dedicated basis (Figure 73). However, the vast majority of those (94%) were made by *WestQuay*'s staff (taking into account that a dedicated collection for each product type was made daily), while only 6% were made by specialised waste contractors. It was also found that a number of stores producing mixed paper, polythene/plastic and fluorescent lighting tubes, did not separate these wastes/recyclates from the general mixed waste (shown in the following figures under the description '*Non-separate Collections*').

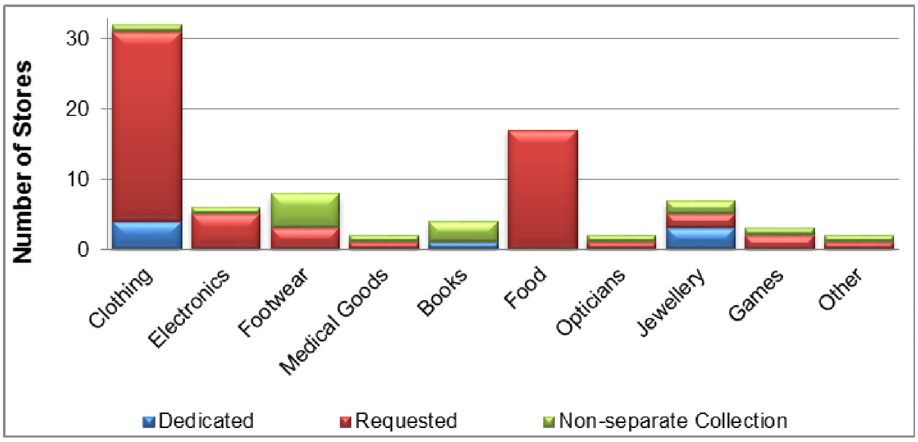


Figure 73: Types of collection services provided to businesses operating in *WestQuay*.

Confidential waste, used cooking oil and medical waste collections were all made on a dedicated basis in contrast to collections of fluorescent lighting tubes and WEEE/batteries that were made either on a dedicated basis (17.5%) or under request (82.5%). In the case of fluorescent lighting tubes, retailers had to make arrangements with individual electrical/maintenance companies to remove end-of-life tubes during their scheduled or on-demand maintenance visits (Figure 74).

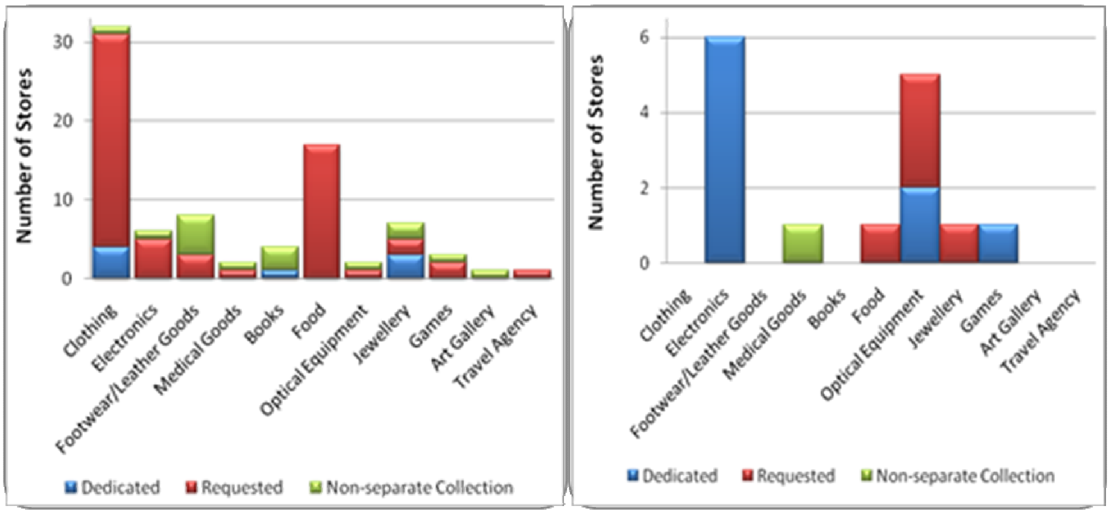


Figure 74: Types of fluorescent lighting tubes (left) and WEEE and batteries (right) collection services provided to businesses operating in *WestQuay*.

7.4.7.5 Destination of Collected Waste

Central waste collections organised by *WestQuay* (Section 7.4) were collected by a number of waste contractors. General mixed waste, mixed paper and hazardous waste/WEEE produced by retailers in individual stores, by customers in all public areas and by *WestQuay*'s staff (from offices) was collected by '*Veolia*'. General mixed waste is incinerated at Marchwood while cardboard and polythene are collected by '*Futur*' when 42 bales have been consolidated and sent to Kent for re-processing. Hangers are baled and collected by '*What a Waste*' and sent to Derby. In addition, a number of retailers producing hazardous and confidential wastes use the dedicated services of private waste contractors (Table 37).

Figure 75 presents the locations where dedicated waste collections of WEEE/batteries, end-of-life fluorescent lighting tubes, used cooking oil, clinical and confidential waste were transferred to.

Figure 75: Map presenting all the locations where collected hazardous and confidential waste produced by businesses operating in *WestQuay* is transferred to.

The study identified 59 electrical/maintenance companies collecting end-of-life fluorescent lighting tubes as part of their servicing activity for the stores and the majority of these were located in the wider Hampshire region. In many cases, vehicles undertaking back-loading of waste/recyclate were also handling customer returns, back to the relevant distribution centre. Figure 76 shows all the locations where product returns were back-loaded to.

Figure 76: Map presenting destinations of product returns from businesses operating in *WestQuay*.

The majority of the returns centres were the same distribution centres where deliveries originated. Re-usable packaging was also back-loaded through the same distribution centres but on a more frequent basis (usually the next days delivery vehicle). Figure 77 presents all the distribution centres where packaging was back-loaded.

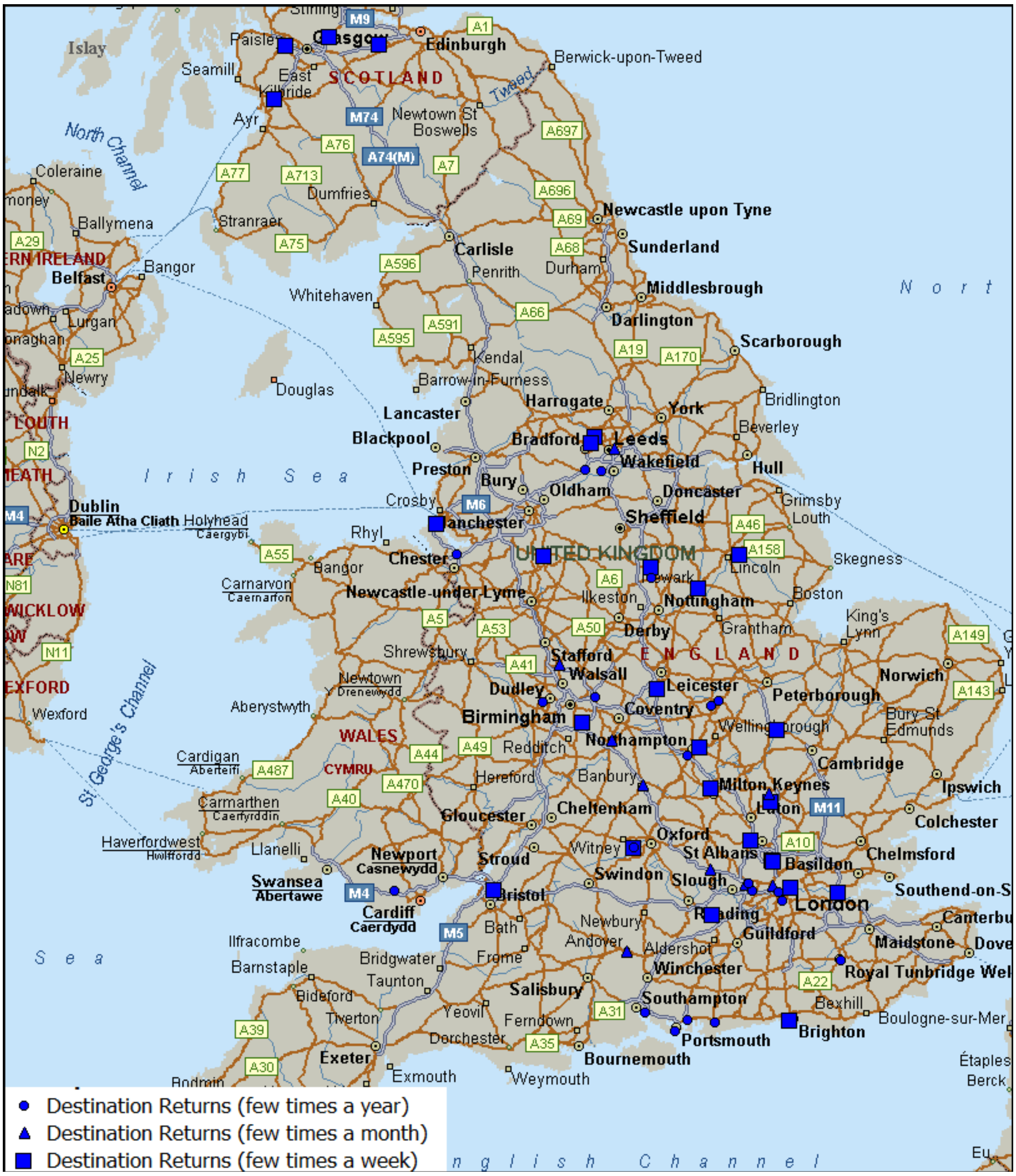


Figure 77: Map showing the destinations of packaging returns from businesses operating in *WestQuay*.

A large proportion of the stores (n=48) did not use re-usable packaging and in those cases, the majority of back-loading was related to product returns (customer returns and stock re-location).

7.5 Factors affecting Recycling Performance

In terms of factors impeding the retailers' recycling performance, a lack of space for separating out recyclate and holding it in-store (35% of respondents), a lack of specific plastic and glass collections and a general lack of awareness about alternative collection/recycling/waste management options were factors commonly cited in the survey (Figure 78). A third (n=29) of all businesses (n=92) expressed some dissatisfaction with the lack of suitable collections for elements of the waste that they generated. Half of these businesses were catering units producing food waste, glass and plastic bottles not being recycled by *WestQuay*. Fifteen businesses (16.3%) felt that the lack of separation storage in *WestQuay*'s designated collection points was an important factor affecting their recycling performance whilst another 12 (13%) felt unaware of the available recycling opportunities in the shopping complex (in nearly all of these cases, the businesses had recently opened and staff members had not yet attended the educational seminars provided by *WestQuay*.)

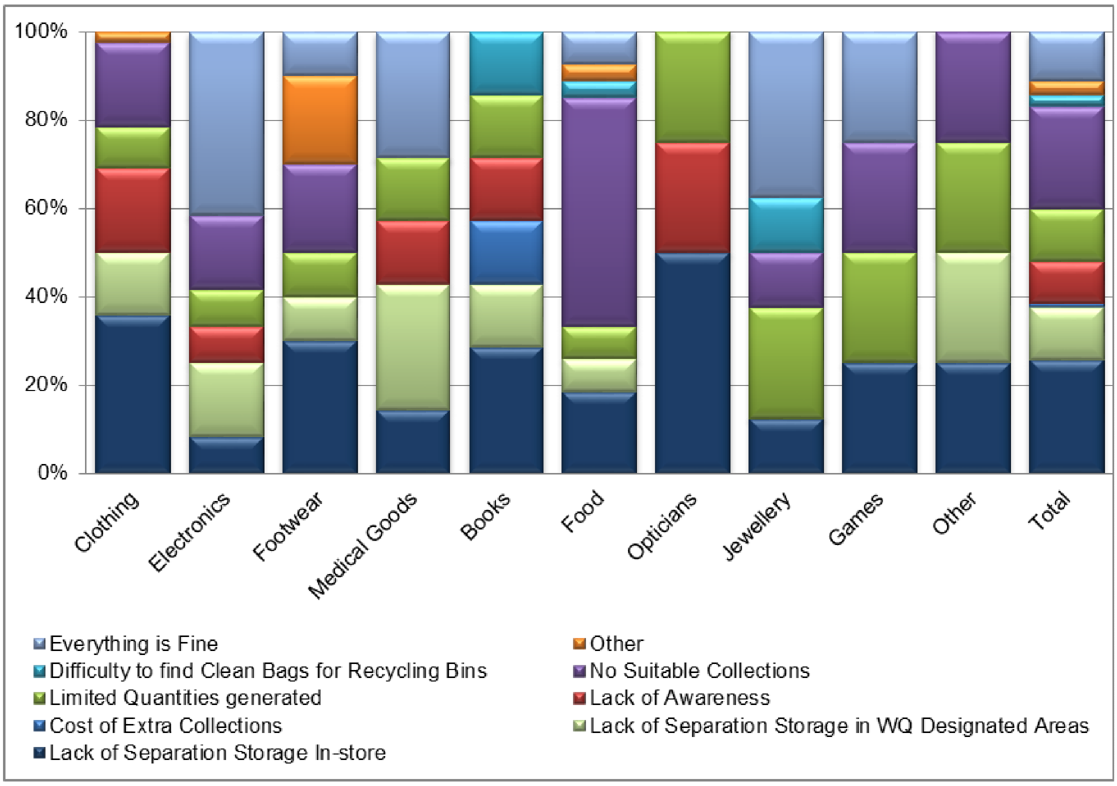


Figure 78: Factors affecting the recycling performance of businesses operating in *WestQuay*.

In total, a third of respondents stated that they were completely satisfied with their recycling performance and the associated services offered by *WestQuay* and expressed their willingness to participate in future recycling initiatives including the collection of glass and plastic units.

7.6 Sharing Services

WestQuay is an example of how waste collections can be co-ordinated across different retailers to help maximise recyclate and reduce transport impacts. Amongst the respondents, 76% stated that they all ready 'shared' waste collection services by using the centrally managed facilities provided by *WestQuay* but 30% considered that they would be happy to get involved in further co-ordinated consolidation activities in the future (Figure 79) if head office policy permitted.

With regard to the 21 retailers receiving specialised waste collections, 5 stores selling jewellery and another selling games expressed their willingness to participate in central collections of batteries and WEEE whilst the three catering units producing cooking oil all expressed interest in participating in a common collection system.

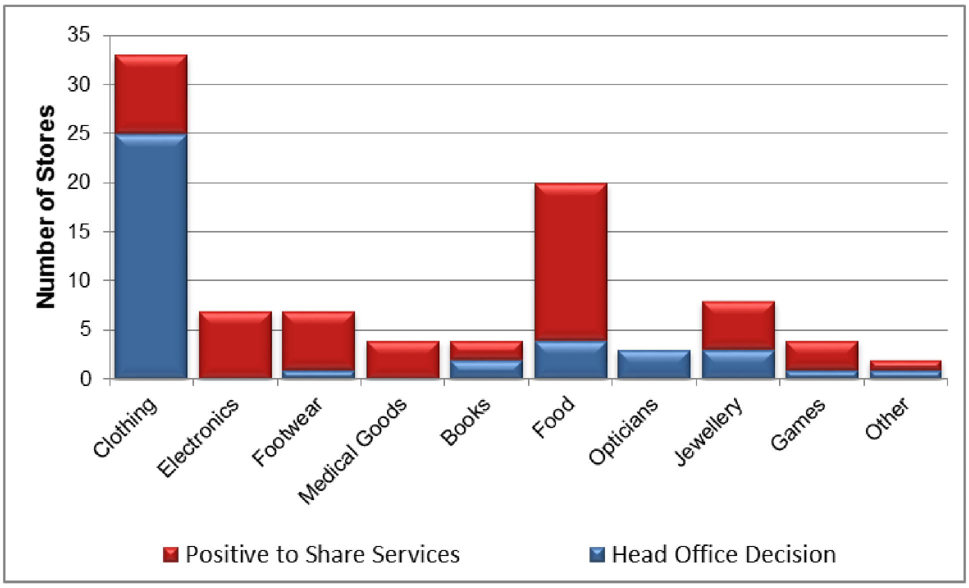


Figure 79: Level of interest for sharing services with other businesses operating in *WestQuay*.

7.7 Case Study Examples

As part of the research study, a thorough examination of the reverse logistics operations taking place in a number of *WestQuay* retail outlets and catering units was made to research the main characteristics of typical waste collection systems and identify best practice examples. A special focus is given to retail units producing hazardous wastes (e.g. WEEE, mobile phones, waste cooking oil, clinical waste and fluorescent lighting tubes).

7.7.1 Currys – Electrical and Electronic Equipment

Currys is a specialist electrical and computing retailer with 530 retail outlets across the UK, Scotland and Ireland. It belongs to *CurrysDigital* Group (former *Dixons*) which operates across several European countries and offers consumer products, related customer support packages, home delivery and product installation services. These services are provided through a network of customer service centres including computer inspection clinics operated within the group through one of its subsidiary companies (*PcWorld*), which also has its own retail outlets and related computer and TV centres. The main products that *Currys* sells include brown goods (e.g. TVsets, cameras and games consoles), white goods (e.g. washing machines, refrigerators, vacuum cleaners and irons), mobile phones and computing products (e.g. desktop computers, laptops and printers).

The variety of products and services offered has led to the development of a complex logistics system for the collection of defective and end-of-life products. *Currys* receives two large combined deliveries of different products per week originating from two main distribution centres located in Nottingham (300 km) and Bristol (120 km). Deliveries are processed through the use of a 3PL's fleet to ship TV sets from the distribution centre in Nottingham, transporting them to Bristol's distribution centre (270 km) in order to be sorted and consolidated with other electrical and electronic products prior to being delivered to several locations across the branch network. Deliveries are also made to local warehouses which process customer orders placed through the internet arm of *Currys* and provide stores in the region with frequent top-up stock deliveries. In addition, the warehouses operate as a transit collection point for many defective products and WEEE. Deliveries and collections from local warehouses to/from stores are processed using an in-house fleet of vans. WEEE collected and consolidated in local warehouses is back-loaded by Contractor A, the main logistics provider used for the delivery of products, to the main distribution centre located in Nottingham which also operates as the *Currys* main recycling centre (Figure 80).

The collection system for product returns largely conforms to '*Type A: integrated outbound and returns network*', processing a large amount of product returns occurring on a frequent basis using the back-load capacity of in-house and 3PL fleet in the various delivery legs. Although checks and software repairs may occasionally be made in-store or at the local *PcWorld*, the main gate-keeping operations are undertaken at the main distribution centre in Nottingham. The use of the back-load capacity of the delivery fleet as well as the operation of the distribution centre as a recycling centre has resulted in the reduction of unnecessary transport.

The business policy regarding the repairs and return of defective products varies across the different product types, brands and agreements with specific suppliers. Some of the main suppliers such as *Sony*, *Dell* and *Apple* offer their own collection and repair services from the store when defective products are returned up to 28 days after the product's purchase and as part of the typical one year product guarantee. Collections are processed by the product suppliers who make all the appropriate arrangements for the collection of the item by a 3PL and its onward transfer to their own repair centres. This is representative of '*Type D: return to suppliers' collection system*'. *Currys* assumes little responsibility for these brand-specific returns and runs no gate-keeping operations at store in relation to them.

Products returned by customers in-store during the initial 'no quibble' return period are replaced by *Currys* for new ones and the returned items are back-loaded up the supply chain to the main distribution centre in Nottingham along with products for which suppliers do not offer repair services (*Type A*). Exemptions apply when customers purchase an extended accident and repair cover plan from *Currys*. Under these circumstances, products are repaired in one of the *CurrysDigital* regional computer repair clinics or repair centre. Returned laptop computers are always sent initially to the local *PcWorld* repair outlet prior to being sent back to the relevant supplier if the outcome is 'non-repairable' and as long as they are under the basic or the extended warranty. In this case, a separate '*Type B: non-integrated outbound and returns network*' is adopted for managing customer returns on an 'as and when required' basis. Although this system is in general preferred when the returns volumes are low, in this particular case study the distance travelled is minimised due to the short distance between *PcWorld*'s local outlet and *Currys*.

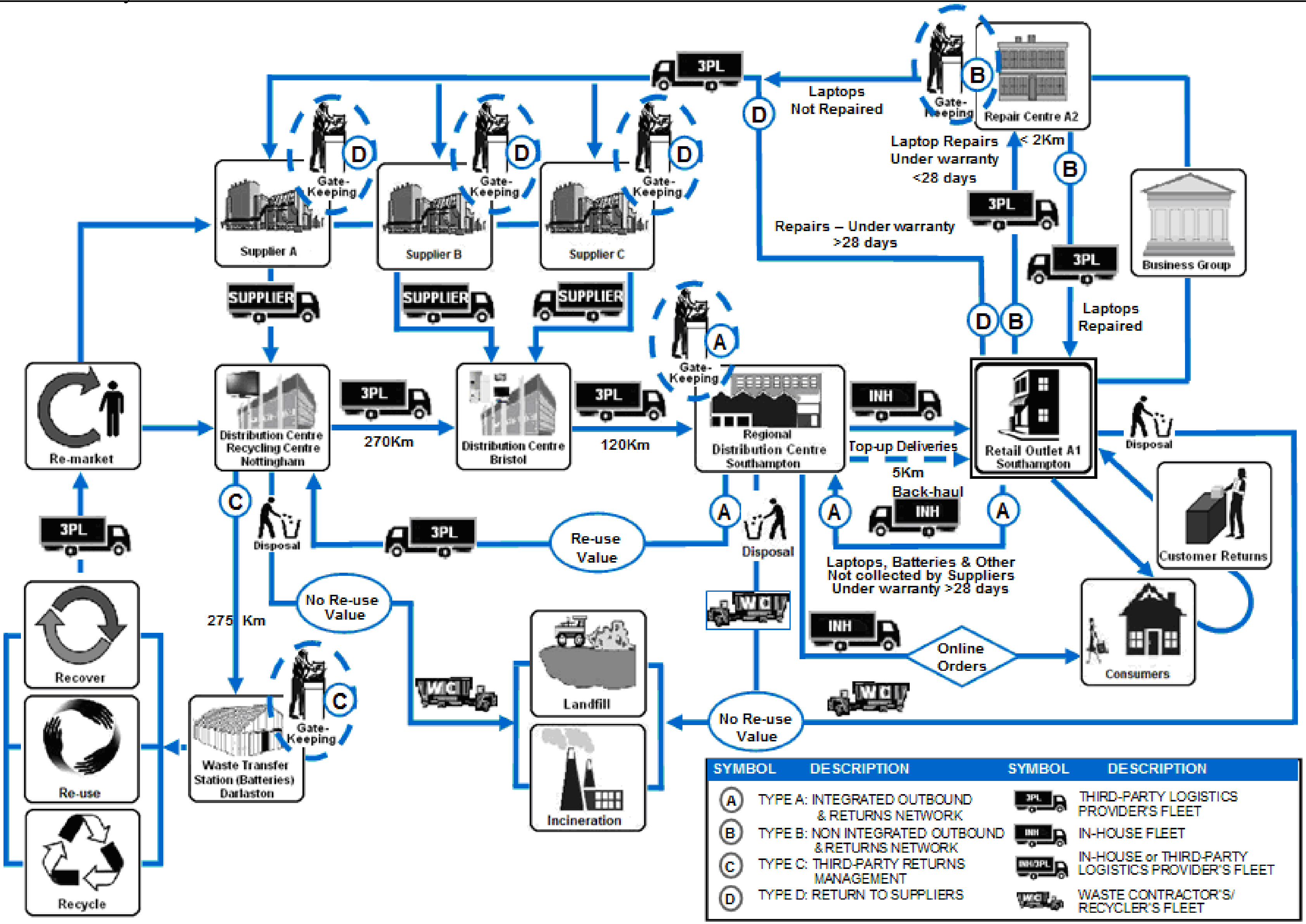


Figure 80: Physical network structures for recovery of WEEE produced by *Currys*.

Currys has also developed an in-store customer collection take-back system for small hazardous items such as batteries and mobile phones. End-of-life mobile phones are back-loaded in Contractor A's delivery vehicles and are sent to the main recycling centre in Nottingham to be sorted and further processed (*Type A*). In the case of batteries the business has a national contract with Waste Contractor A, who collects batteries under request using its own fleet and transports them to its licensed treatment and waste transfer station located in Darlaston (241 km). End-of-life battery collection, storage, transport, recovery and disposal are governed by the WEEE and the 'Batteries and Accumulators Directive 2006/66/EC'. Dependent on the type of waste batteries (lead acid, zinc-based, nickel–cadmium, nickel metal hydride, lithium ion, lithium primary silver oxide or mercuric oxide batteries), different components can be recovered and re-used in the steel, electronics, photographic and lighting industries among others. As soon as batteries are transported to the treatment and waste transfer station, they are identified, sorted and stored until an economical load is accumulated and sent to the appropriate recycling site. This recovery network falls under '*Type C: third party returns management*' where collection, gate-keeping and disposition processes are managed centrally by a specialised third-party contractor who has the potential to maximise the re-use potential and better coordinate transport through increased consolidation.

7.7.2 SportsWorld - The Case of the Centralised Return Centre for Waste

SportsWorld belongs to *SportsDirect* a network of 375 stores in the UK trading a range of sports and leisure merchandise. *SportsDirect* runs a fleet of 40 trailers and over 130 company cars travelling more than 8.7 million kilometres a year. The major source of waste production in *SportsDirect* is packaging used to protect products in transit. In 2008 the amount of landfilled waste amounted 1,400 tonnes. In attempting to reduce its carbon footprint, energy consumption and waste *SportsDirect* has developed a centralised waste collection system in its branch network to recycle waste paper, cardboard, plastic and occasionally hazardous materials such as ink toners, redundant IT equipment and fluorescent lighting tubes. In 2008 *SportsDirect* recycled 60 tonnes of waste paper, more than 5,500 tonnes of cardboard and 860 tonnes of baled plastic as a result of stores backfilling their waste to the National Distribution Centre located in Nottingham. Following the energy consumption at stores the fleet is the second largest producer of CO_2 within the business. Unnecessary mileage is avoided by having flexible delivery/collection routes optimised in such a way to ensure that the full capacity of trailers is always used. Finally *SportsDirect* provides energy training to all its employees as part of their employment induction and awards stores achieving specific recycling targets.

SportsWorld occupies one of the largest retail units in the shopping centre. The great variety of sports and leisure products offered to customers increases the need for storage and process capacity and has direct impacts on the volume and variety of waste/recyclates produced. *SportsWorld* has joined *SportsDirect*'s national waste collection system and therefore has separate equipment (e.g. roll cages) from the rest of the retail outlets in the shopping centre. General waste, mixed paper, cardboard, polythene used for packaging and plastic (e.g. broken hangers) are consolidated in a designated area in the stock room and left for collection at the back of the store. Waste and recyclables stored in plastic bags and loaded in roll cages are shipped back to the National Distribution Centre using the delivery fleet. *SportsWorld* receives 5 deliveries a week during standard trade periods and 7 deliveries during busy trade periods (e.g. Christmas) as part of 'milk-run' delivery trips calling in another three regional retail outlets. The service order alters per day of the week to enable waste collections from the last stop. This technique enables the usage of the full load capacity for waste collections without mixing forward and reverse flows. Despite its benefits, the efficiency of the system is minimised due to the load constraints in place because of the need to back-load reusable packaging and other equipment (e.g. roll cages, pallets and plastic totes). This adds additional burden on *SportsWorld* business especially during busy trading periods when service efficiency and storage capacity are determinants for the efficient operation of the business.

7.7.3 KFCs – The Case of De-Centralised Waste Collections of Used Cooking Oil

The retailer-survey identified that *KFCs* were serviced by *Arrow Oils*, a nationwide company with more than 15 UK oil collection points and 3 purpose built depots, currently considered as the largest vegetable oil management business in the country. *Arrow Oils* is fully licensed and insured as a waste contractor and carrier, while it manages the cooking oil cycle for a wide range of catering establishments from restaurants, to pub chains, hospitals and schools. Customers may return used cooking oil in its original container as long as it meets duty-of-care requirements, or they may use blue containers ranging from 15 to 1,000 litres supplied by the contractor.

Oil collections are made on a weekly basis by *Arrow Oil*'s own fleet of vans. During the fixed weekly visit, empty 50 litres blue bins are delivered in order to replace the full drums. Used cooking oil from the restaurant along with oil collected by other local restaurants and pubs is transferred to the main purpose-built depot in Norfolk (322 km) where it is heated, cleaned and then filtered before being transferred to a processing plant in Middlewich Cheshire (285 km) for conversion to bio-diesel (Figure 81). All packaging items including cardboard and tins are recycled, while bio-diesel is sold to several companies across the UK.

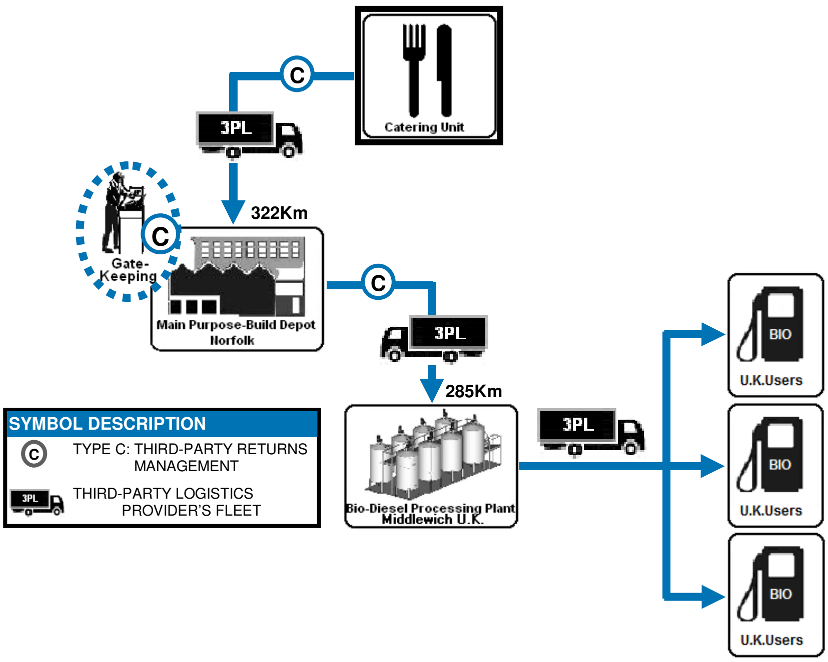


Figure 81: Flow diagram showing the different handling stages for used cooking oil collected by *Arrow Oils*.

7.7.4 Fonebak – The Case of De-centralised Waste Collections of Mobile Phones

During the interviews with *WestQuay* retailers it was identified that *Fonebak* was used by 4 retailers in the centre. *Fonebak* is the only company in the UK to be granted four key licenses under the WEEE legislation, being a licensed operator under the *Producer Compliance Scheme*, an approved authorised treatment facility and a designated collection facility and approved exporter. Their system allows customers to drop their unwanted handsets into retail outlets directly, or use the freepost service as the first stage in the take-back operation. A limited-size, in-house fleet of vans is available across *Fonebak*'s national operation, but are not normally used for waste collections, therefore a 3PL provider's fleet is employed when collections are internally organised. Collections made 'on-request' are processed through *Fonebak*'s service team, however, local collection schedules are organised by the logistics provider on the day prior to collection.

Two stores in the shopping centre provided their customers with pre-paid envelopes to ship mobiles to *Fonebak*'s processing hub located in Essex, another received *Fonebak*'s collections whenever requested, while the latter used third-party delivery vehicles to backload handsets. Mobile phones collected either by *Fonebak* or by the third-party contractor were initially transported to two depots (9.7 and 8.8 km correspondingly) located in Southampton (Southampton Depots A and B) where handsets were consolidated prior to being sent to the main processing hub located in Essex (175 km) (Figure 82).

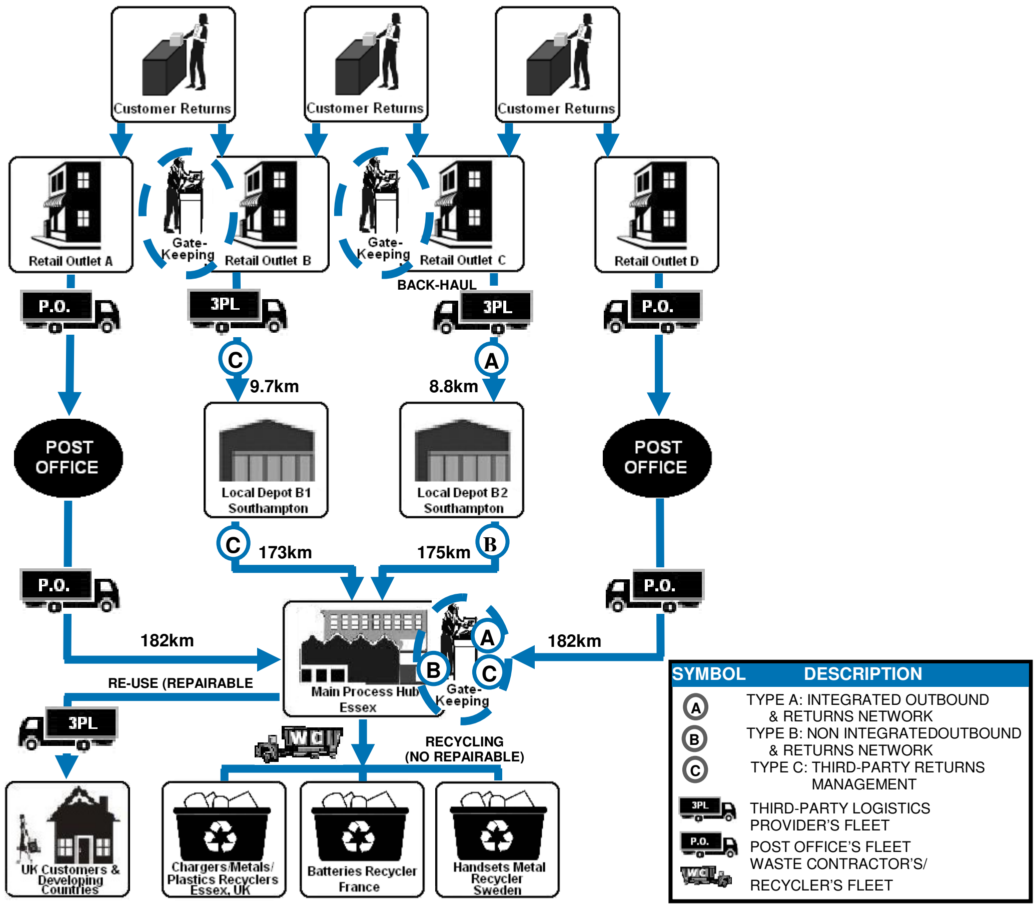


Figure 82: Flow diagram showing the different handling stages for mobiles collected by *Fonebak*.

7.7.5 Vision Express–The Case of De-Centralised Waste Collections of Clinical Waste

During the surveys with retailers, *Initial Medical Waste* was identified as the company collecting medical waste from Vision Express, a business selling eyeware and running minor eye operations such as laser treatments. *Initial Medical Waste* is a registered and licensed waste carrier using a sub-contractor's purpose-built vehicles. As soon as waste is collected it is placed onto one of sub-contractor's medical services vehicles, it is segregated and transported to the businesses licensed waste transfer depot in Middlesex (137 km) via the sub-contractor's local depot (24 km). Clinical waste is then transferred into large secure containers identifiable by bar codes and is sent to treatment of incineration (Figure 83).

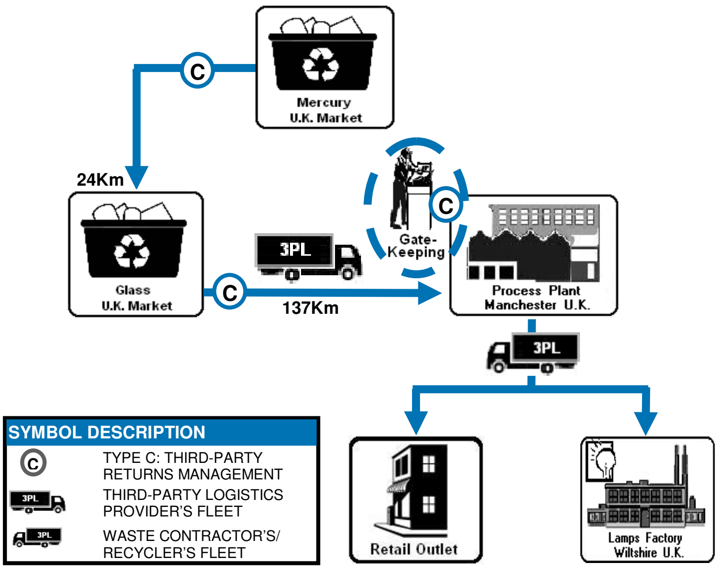


Figure 83: Flow diagram showing the different handling stages for clinical waste.

7.7.6 The Case of De-Centralised Waste Collections of Fluorescent Lighting Tubes

Through the surveys with *WestQuay* retailers it was identified that 87 retailers had in place individual maintenance contracts in place with lamps manufacturer *Microlights Ltd*., a global specialist in designing and manufacturing retail lighting that also offers maintenance and collection services for end-of-life tubes. Visits by *Microlights Ltd* staff are made on a requested basis. Using their in-house vehicle fleet, spent lamps are collected and moved to the lamps factory in Wiltshire (115 km) where they are placed in containers and stored. When containers are filled, *Luminom* who is a specialist in lighting equipment with its own compliance scheme, collects the containers and moves them using its own fleet to a process/recycling plant in Manchester (280 km). Capacitors and batteries which can be present in the tubes (e.g. in emergency lighting systems) are separated in order to remove the hazardous substances. The tubes are crushed in a shredder and the glass recovered, while the mercury contaminated phosphor powder is distilled to produce pure mercury for reuse. Metals and glass are put back into the market with metals often being exported to the Far East (Figure 84).

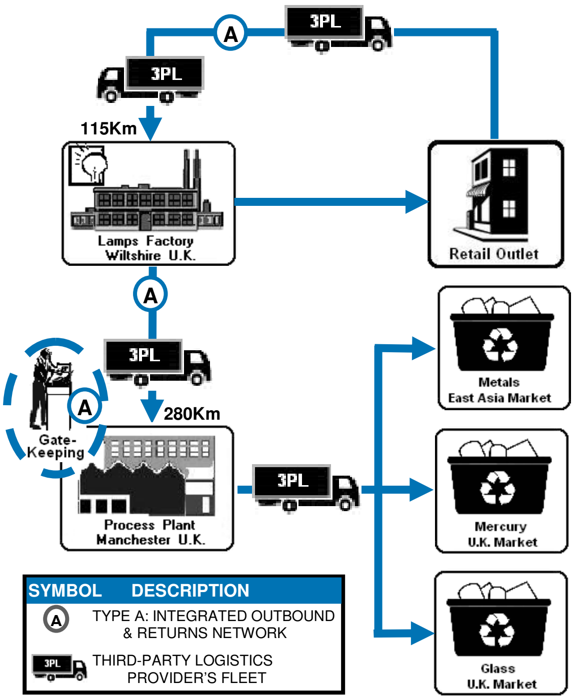


Figure 84: Flow diagram showing the different handling stages for end-of-life fluorescent lighting tubes.

7.8 Local Recycling Opportunities

The study identified that most of the retail businesses chose their recycling contractors on the basis of cost and not on proximity principles, resulting in unnecessarily long distances travelled. In many cases, recyclables such as plastics and metals were transported abroad in order to be processed despite the existence of a well-developed UK recycling industry providing a number of local, regional and national opportunities. According to the *Environment Agency*'s waste treatment and disposal sites directory, there are currently numerous WEEE treatment disposal facilities located in the wider Southampton area. In a review of the 10 sites nearest to the case study shopping centre, it was found that distances for WEEE recovery and disposal ranged from 4.5 to 17 km with half of these sites receiving white goods and fridges (Environment Agency, 2010b). However, the study revealed that when WEEE was internally managed by *Currys* (Type A), returned products had to be shipped back to the main distribution centre in Nottingham (300 km).

In the case of clinical waste, it was estimated that the 10 nearest clinical waste facilities for sharps ranged from 17 to 305 km from the shopping centre while the actual distance travelled in the case study example was 161 km. Similarly for waste cooking oil, potential destinations ranged from 145 to 415 km (the actual distance was 322 km), while for batteries, collection points were located from 11 to 55 km away (actual distance travelled was 241 km). These distances provide an indication of the potential logistics savings that could be achieved in the first leg of the recovery process if these local facilities were utilised.

The 10 recovery sites nearest to the shopping centre were interviewed to determine their process and storage capacities, collection services, minimum quality requirements for collected materials and the type and location of treatment processes used. In terms of processing capacity, there appeared to be few problems in catering for the weekly volumes produced by the retailers in the shopping centre. The vast majority provided free collection services using either in-house or 3PL fleets with only the WEEE recycling businesses having specific quality requirements for end-of-life computers.

The study revealed that this opportunity to reduce the overall logistics footprint of hazardous waste returns through the use of local recycling sites was more apparent than real, because most of the local sites merely operated as consolidation centres servicing a number of national and international recyclers. As an example, Waste Contractor F offered collection services for WEEE, batteries and fluorescent lighting tubes using an in-house fleet of 78 vans and lorries. Waste Contractor F could ship for storage up to 50WEEE items of any size and type, to a warehouse and a yard in Winchester (20 km). Up to 1000 fluorescent lighting tubes were shipped to another yard located in West Sussex (80 km). Using a 3PL, tubes were collected and shipped to a treatment plant for lamps in Sweden (>2000 km), where all the valuable components were removed and recycled. Glass cullet was sent back to the lamp manufacturer in Holland (>1500 km). The total distance travelled was estimated to exceed 3500 km. In comparison with the logistics involved for the recovery of the lamps collected by *Microlights Ltd* (Section 7.7.6), it was found that although lamps were processed in the UK, metals were sent to China (total distance travelled >3500 km). Local collection sites can merely serve as starting points of complex recycling networks and the impression that the logistics footprint is being reduced through a seemingly 'final disposition' local outlet is often not the case.

7.9 Discussion

The study identified that consolidation processes already take place in the shopping centre as a result of the centrally managed collections of general mixed waste, cardboard and polythene. Further opportunities to reduce the logistics impact exist through increased back-loading and consolidation of special waste types collected by individual waste contractors. The study identified 20 waste contractors collecting hazardous waste such as WEEE, batteries, clinical waste and used cooking oil and almost 90 electricians/maintenance companies collecting fluorescent lighting tubes on a dedicated basis. The following chapter investigates the use of the future consolidation centre in the outskirts of Southampton as a consolidation point for product deliveries (distribution) and hazardous materials (collection).

Chapter 8: Freight Consolidation Case Studies

8.1 Introduction

Following an extensive review of existing consolidation schemes in the UK and abroad and the identification of the elements that make them successful (Chapter 3), two case studies are discussed with the aim to examine their applicability in the UK context. The first is a scheme recently developed by the UK bookseller *Waterstone's* and refers to the establishment of a national distribution centre servicing the business's national branch network. This example describes the transition from Type A of a 'no consolidation' system (Type A, Figure 9) towards Type B of a 'direct – drop & pick' freight consolidation system (Type B, Figure 10). Analysis is made on the basis of a 'before and after' comparison of the mileage and GHG impacts using data gathered from the 2008 survey (before) and a follow-up survey in April 2011 (after) with *Waterstone's* manager in *WestQuay*'s outlet.

The second case study refers to a combination of Types A, B and C of freight consolidation (Types A, B, C, Figure 10) regarding the establishment of a UCC in the outskirts of Southampton as a means to solve the last-mile problem of urban freight facing the city. Various operating conditions are examined with the aim to evaluate the potential mileage and emissions savings. It should be noted that this scheme is backed by *Hammerson's* and Southampton's City Council and is very likely to be developed in the near future as a means to cut down costs and the transport and carbon footprint produced by a number of *WestQuay* and other *High Street* retailers.

8.2 *Waterstones* Book Hub

Waterstone's is a British book specialist established in 1982. In 1998 it became a subsidiary of *HMV Group*, a global entertainment (music and DVD) retail chain, which also owns a number of smaller book and music retailers (e.g. *Hatchards*, *Hodges Figgis*, *Fopp* and selected *Zavvi* outlets) across the UK, Canada, Ireland, Hong Kong and Singapore (www.waterstones.com).

8.2.1 Direct-to-Stores Deliveries

As of the time of the interviews with the managers of *WestQuay* businesses (April-May 2008), *Waterstone's* employed 4,500 booksellers across a total of 325 branch outlets in the country. The goods-in process at the time was managed independently in stores, with staff and managers having the autonomy to handle stock and place direct orders to over 2,500 suppliers (‘Type A’ of urban freight consolidation, Figure 9). This was resulting in multiple deliveries of hundreds of boxes daily and was leading to increased time spent on deliveries and related duties at stores.

Data provided by *WestQuay*’s management team suggested that *Waterstone’s* occupied one of the largest units (817.36 m²). In the 2008 interview with *Waterstone*’s store manager, it was found that the business was serviced by a wide spectrum of suppliers most of whom were located in England and Scotland (Figure 85-right map). At least seven suppliers were delivering stock on a daily basis and more than fifteen on a weekly basis. The majority of suppliers employed 3PL providers, predominantly *Parceline* (65% of deliveries), *DHL* (25%) and *FedEx* (<10%). Books, stationery and promotional materials were all packed and transported in cardboard boxes. Consignments were first transferred to local depots where they were further consolidated (Figure 85-left map). Besides, numerous orders, usually of small size, were processed through the Post Office. Due to the wide number of suppliers, it was deemed necessary to narrow down the survey sample and gather information only for the seven main suppliers.

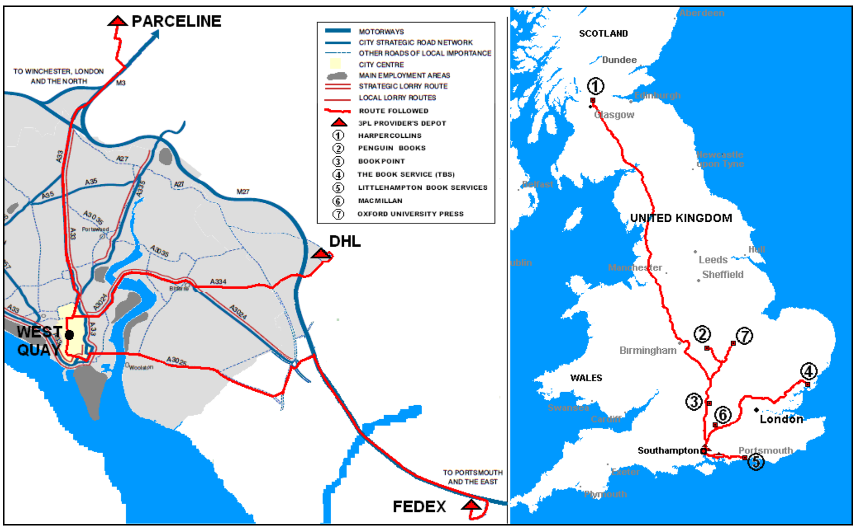


Figure 85: Map showing the routes followed by the 7 main suppliers of *Waterstone’s* (right map) and the locations of 3PL providers’ regional depots (left map).

Based on the data collected in the 2008 interview with *Waterstone*’s store manager, it was estimated that about 270 cardboard boxes (15.2 m³ a week) were delivered to

Waterstone's during a standard week via 31 delivery visits (on average 8.7 boxes per delivery). During October and November, the business was facing a 10% increase in the number of deliveries (from n=31 to n=34) and a 230% increase in the number of cardboard boxes (from n=271 to n=884). This equated to 6,357 km travelled during a standard week and 6,656 km travelled during a busy week following a 4.7% increase. According to the store manager, delivery vehicles were vans, but could be rigid lorries when more stores were visited and/or products were delivered as part of the same delivery round (Table 38).

Table 38: *Waterstone's* : Main 7 suppliers 'deliveries' weekly activity.

Weekly / Supplier	Deliveries No		Packaging No		Distance Travelled (km)	
	Standard	Busy	Standard	Busy	Standard	Busy
Penguin Books	5	6	45	157.5	648	777
HarperCollins	5	5	60	180	3,476	3,476
Bookpoint	5	6	30	105	455	546
The Book Service	3	3	69	207	787	787
Littlehampton Book Services	5	6	25	94	397	476
Macmillan Publishers	5	5	30	105	269	269
Oxford University Press	3	3	12	36	325	325
Total	**31**	**34**	**271**	**884**	**6,357**	**6,656**

The estimation of GHGs emissions was based on the use of DEFRA'S conversion factors (Chapter 5) and suggested that 1,714 kg of CO_2e were produced by the seven main suppliers during a standard week and 1,999 kg of CO_2e during a busy week (16.6% increase). The estimation of GHG emissions was based on the assumption that all suppliers were using vans (Table 39). In the unlike case that all delivery vehicles were rigid lorries then CO_2e levels would be equal to 6,349 kg during standard periods (3.7 times more CO_2e produced compared to using vans) and 6,649 kg during busy periods (3.3 times more CO_2e produced compared to using vans). However, the store manager stressed out that rigid lorries were used in rare occasions and therefore the above van-related figures were considered as closer and more relevant to the actual values.

Due to the usage of non re-usable packaging (cardboard boxes) and other cardboard promotional material a drastic rise of cardboard and packaging waste during October, November and December was also recorded. During those months the amount of mixed waste increased by 50%, while the quantities of other waste types were doubled. Increased waste arisings required increased efforts and time to deal with deliveries and waste management operations at the store level. Characteristically, during a standard week, the business was producing about 20 black sacks filled with general waste, 1 sack with mixed paper, 3 roll cages with flattened cardboard boxes and 7 sacks with packing material (polythene). *Waterstone*'s had joined *WestQuay*'s central waste collection system therefore all recyclables were collected by *WestQuay*'s staff on a daily basis; except for fluorescent lighting tubes that were processed by '*Brio plc*', a maintenance company contracted by *Waterstone*'s Head Office in order to offer its services in Southampton's and other regional branches.

Table 39: Estimated weekly CO_2e produced by the 7 main suppliers delivering MCGs to *Waterstone's*.

Supplier \ Weekly Estimates	GHGs-Standard Periods (Kg CO_2e)						GHGs-Busy Periods (Kg CO_2e)					
	Direct				Indirect	Grand	Direct				Indirect	Grand
	CO_2	CH_4	N_2O	Total	Total	Total	CO_2	CH_4	N_2O	Total	Total	Total
Penguin Books	162.1	0.1	1.1	163.3	31.3	194.6	194.4	0.1	1.3	195.7	37.6	233.3
HarperCollins	869.6	0.3	5.9	875.7	168.0	1,043.7	869.6	0.3	5.9	875.7	168.0	1,043.7
Bookpoint	113.8	0.0	0.8	114.6	22.0	136.6	136.6	0.0	0.9	137.6	26.4	163.9
The Book Service	196.9	0.1	1.3	198.3	38.0	236.3	196.9	0.1	1.3	198.3	38.0	236.3
Littlehampton Book Services	99.3	0.0	0.7	100.0	19.2	119.2	119.1	0.0	0.8	119.9	23.0	142.9
Macmillan Publishers	67.3	0.0	0.5	67.8	13.0	80.8	67.3	0.0	0.5	67.8	13.0	80.8
Oxford University Press	81.3	0.0	0.6	81.9	15.7	97.6	81.3	0.0	0.6	81.9	15.7	97.6
Total	**1,590.3**	**0.5**	**10.9**	**1,601.6**	**307.2**	**1,908.8**	**1,665.2**	**0.5**	**11.3**	**1,676.9**	**321.7**	**1,998.5**

8.2.2 Transition to the BookHub

In September 2008 *Waterstone's* replaced the existing 'direct-to-store deliveries' system with a new automated consolidation centre to simplify the goods-in process and enable more efficient and cost effective communication between stores and booksellers, while becoming more environmentally sound. The *Book Hub* is a new 14,700 m² warehouse and distribution centre in Burton-Upon-Trent, Staffordshire (Central England) able to handle up to 1.5 million shipments a week and receive an estimated 70 million books a year with a potential to process up to 100 million annually (Brooks, 2008). Since its opening, most of the 2,500 *Waterstone's* suppliers changed their delivery schedules and joined the scheme gradually with the exception of few suppliers who kept processing small consignments through the Post Office. Under the new regime, deliveries are made directly to the *Book Hub* where consignments are processed, consolidated and delivered to stores using *Waterstone*'s fleet. In the *Book Hub*, books are priced, packed, stickered and sorted in a cross-belt system with 100 chutes, each with 24 receiving locations for totes to match to up to 24 books categories (e.g. crime fiction, children's books, poetry and drama). Books are sorted by subject into bar-coded plastic boxes reducing the need to scan books one by one upon receipt at stores. Consignments are distributed to stores nationwide with larger stores receiving daily deliveries of up to 60 totes, and smaller outlets accepting 1 or 2 deliveries per week. A fleet of up to 60 rigid delivery vehicles is used and supplemented with sub-contractors on smaller routes (Brooks, 2008).

The *Book Hub* (Figure 86) is currently manned with 250 people on site, a number of whom are responsible for handling book returns. Returns were previously sent to suppliers through a contracted 3PL (*LYNX*) who used to visit stores on a daily basis. Under the new scheme, returns are back-loaded to the *Book Hub* where they are further processed. Slower moving titles are re-distributed within 24 hours around the chain using the available capacity of the delivery fleet, while unwanted items are recycled using an on-site pulping system. The *Book Hub* is also used to fulfil online orders with some 150,000 lines built for the internet business. Previously, online orders were processed by *Bertrams,* but under the new regime *Unipart Logistics* has been appointed as supply chain partner on a 10-year contract. As part of its duties, *Unipart Logistics* processes both store deliveries and online orders (Neill, 2007).

In addition, the transition towards the centralised distribution system suggested that potential mileage and environmental savings could arise. The new centralised supply chain falls under 'Type B' of urban freight consolidation as it enables stock concentration at the *Book Hub* cutting down the total number of weekly store deliveries to five during standard periods and six during busy periods. As a result, a reduction in the last-mile distance travelled to 1,280 km a standard week and 1,536 km a busy week was noted, while increased opportunities lie into consolidating the consignments and reducing the number of trips made from suppliers to the *Book Hub*.

Further optimisation of scheduling and dispatching activities is achieved through defined delivery routes, in which specific stops are planned and executed in terms of quantities and time. More specifically, *WestQuay*'s outlet receives 30-35 plastic totes per delivery, while it forms part of a delivery route that includes five stops including

Winchester (1), Eastleigh (1), Southampton (2) and Limington (1). Deliveries are received on a defined time-window (14:00-15:00) and totes are carried from Service Yard B2 to *Waterstone's* outlet by the driver, rendering unnecessary the recruitment of a staff member designated to receive deliveries. On top of that, returns are back-loaded reducing the need to process daily dedicated collections using LYNX.

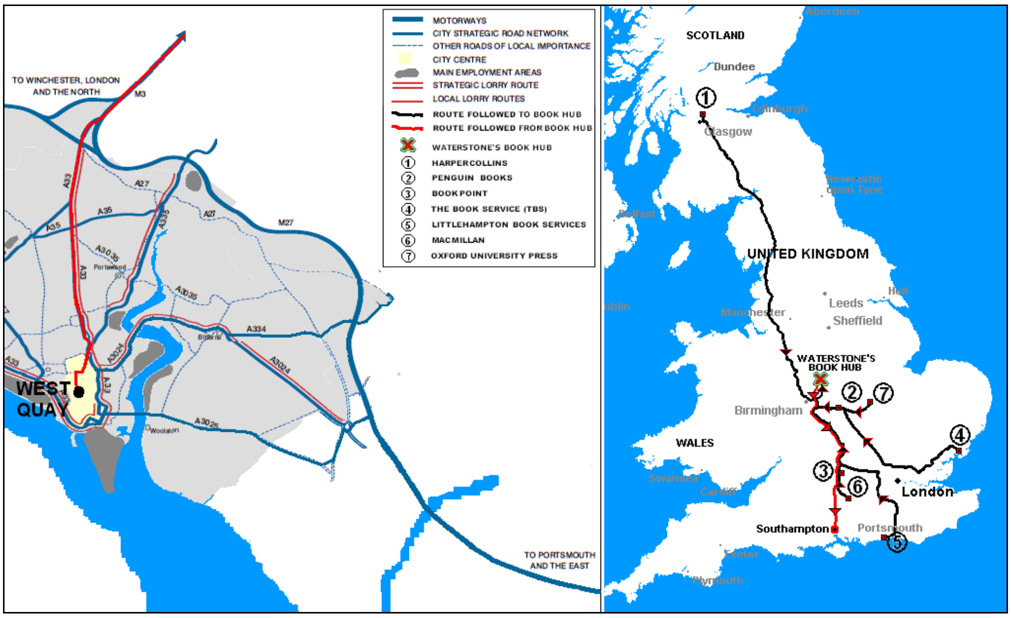


Figure 86: Map showing the routes followed by the 7 main suppliers of *Waterstone*'s delivering to the Book Hub and the route followed from *Waterstone*'s fleet from the *Book Hub* to *WestQuay*.

From an environmental perspective, the introduction of new, reusable pallets and boxes, filled with 'shelf-ready' stock which can be pushed straight onto the shop floor, leads to drastic reduction of the cardboard and packaging waste produced (Neill, 2007). The biggest savings in waste arisings are noted in cardboard boxes (fill half a roll cage during a week) and polythene (almost zero production). In addition significant savings are made in terms of the total emissions produced.

8.2.3 'Before-After' Comparison – Last-mile Distance

Although no clear evidence is available for the system-wide mileage and the emission impacts of the new distribution system due to lack of knowledge about the actual number of trips made by suppliers to the *Book Hub*, major savings are noted in the last-mile (Table 40).

Table 40: *Waterstone's*: Estimated weekly amount of CO_2e produced in the last-mile (one-way trip) of deliveries passing through the *Book Hub*.

	Period	Trips	Distance Travelled (km)		GHGs-Last-mile (Kg CO_2e)					
					Direct				Indirect	Grand
			Total	Last-mile	CO_2	CH_4	N_2O	Total	Total	Total
No Consolidation	**Standard Week**	31	7,592	186	320.2	0.1	2.2	322.5	61.9	**384.3**
	Busy Week	34	8,025	204	384.2	0.1	2.6	387.0	74.2	**461.2**
Consolidation	**Standard Week**	5	1,280	30	51.6	0.0	0.4	52.0	10.0	**62.0**
	Busy Week	6	1,536	36	67.8	0.0	0.5	68.3	13.1	**81.4**

In total, although the transition to the new supply chain has reportedly affected *Waterstone's* 2009-10 performance with profits slumping by more than 70% to £2.8 million, significant mileage and environmental gains were noticed from the commencement of the new scheme. Experienced supply chain problems were linked to the significant challenges in retail due to the current economic crisis, as well as to delays in the implementation of changes which resulted in reduced stock availability and weakened stores proposition (Neill, 2010). As a result *Waterstone's* kept relying on third-party wholesalers, usually *Gardners*, delivering goods when available stock was low (Taylor, 2009). Despite the apparent initial difficulties, *WestQuay*'s store manager highlighted the satisfactory progress of the scheme and its function as a platform from which the company has already started to re-build profitability, while achieving significant transport and environmental benefits.

8.3 *WestQuay* Consolidation Centre

As of 2007 and 2008, Southampton's City Council ran two studies regarding the establishment of an urban freight consolidation centre in the city's outskirts. Research into the concept and the establishment of the scheme led the Council into the decision that at the time this scheme would not be feasible for Southampton (Southampton City Council, 2008). Recently there has been a re-surge of interest towards the scheme as a means to reduce local and sub-regional congestion, pollution and intra-modal conflicts, and create a platform for both public and private profits. Although the current distribution activities do not cause any obstruction to the City's strategic road network, often deliveries made from road sides block carriageways whilst goods are unloaded (TfSH, 2009). At the same time the constant growth of the port and the relevant freight activities adds pressure on improving the network's accessibility and increasing its capacity. On top of that, the production of excessive levels of NO_2

resulting from traffic increase the need to reduce any unnecessary transport and improve the City's environmental quality (Southampton City Council, 2010).

Although Southampton's City Council currently plans to develop a consolidation scheme for both *WestQuay* and *High Street* retailers, the current study limits its scope to potential *WestQuay* participants due to data availability reasons. The outputs of the current study could potentially provide an indication about the operational requirements of *WestQuay* retailers and their contribution to the overall transport and environmental footprint in the final scheme.

8.3.1 Operational Characteristics of WestQuay UCC

Based on previous studies (Chapter 3), as the ones run by Browne *et al* (2005) and Lewis *et al* (2010), and considering the special operational requirements and conditions in *WestQuay* (e.g. access areas and times, volume of goods shipped) the following assumptions about the operation of the UCC were made:

- *Opening Times*: The UCC will be open to receive deliveries 24 hours a day, 7 days a week.
- *Service Hours*: Deliveries and collections will be made to/from stores 7 days a week from 05:30 to 20:30 from Monday to Friday, from 05:30 to 19:30 on Saturday and from 09:00 to 17:30 on Sunday considering the current access times to the three service yards (A2, A3 and B2) servicing *WestQuay*.
- *Size*: The size of the UCC in Nursling will depend on the exact space requirements of the participating businesses. In this study it is assumed that 10 m^2 will be sufficient for each retail unit, as suggested by Lewis *et al* (2007).
- *Location*: The optimal location of the UCC is a matter of debate. Considering that UCCs are normally located within a 6 miles (9.7 km) radius from the target area, and are well-linked to the national highway network on sites that already host other distribution facilities, then one of the few possible strategic locations is the Nursling Industrial Estate in the outskirts of Southampton (6 km). The site (Figure 87) is already home to numerous distribution centres (e.g. *Coca Cola* and *Tesco*) and provides a number of available facilities. Any alternative site would not affect greatly the total activity levels (mileage and pollution).

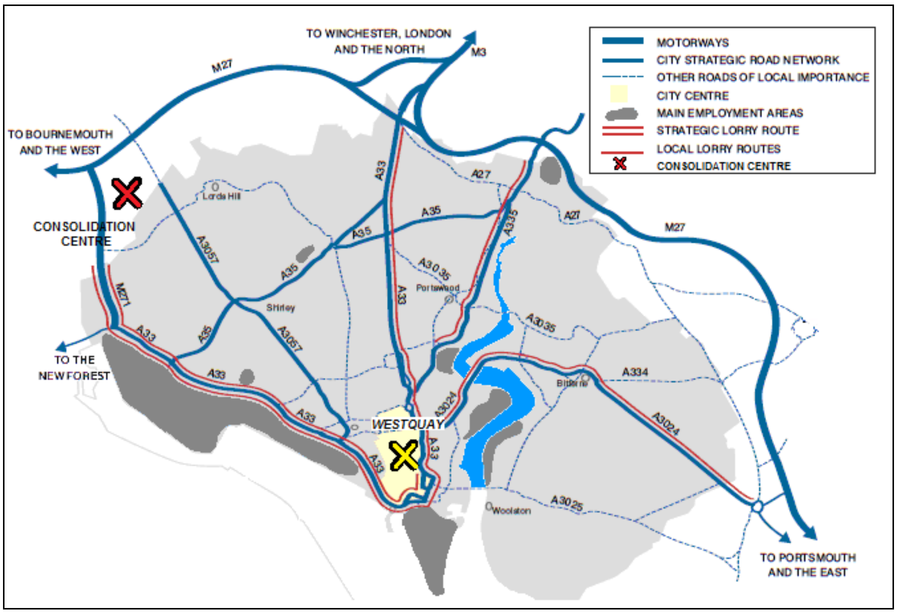


Figure 87: Map showing the location of the consolidation centre servicing *WestQuay*.

- *Participation*: Two scenarios will be examined: a) mandatory participation to the scheme (Section 8.3.2), with analysis being made on the basis of the retail mix and the business profile of the 92 stores operating in *WestQuay* as of the time of the interviews (2008), b) voluntary participation to the scheme (Section 8.3.3) considering that only a small percentage of the 92 businesses will in fact join the scheme. Analysis will consider the freight activity of 13 *WestQuay* shops which seem more likely to participate in the scheme as it was revealed that they have same-business branches in Bristol already participating in *Broadmead*'s UCC scheme.
- *Vehicle Delivery Mix*: The vehicle delivery mix for the long distance 'trunking' mileage (from suppliers to the UCC) reflects the actual profile of the vehicles delivering directly to *WestQuay* businesses as of the time of the interviews. All mileage and GHG estimations will refer to the last-mile 'trunking' mileage (from UCC to *WestQuay*). Seven main scenarios (A to G) will be developed to consider different take up combinations among vans, articulated and rigid lorries (described in Table 17).
- *Vehicle Fill Rates*: The above scenarios are further analysed to consider different weight laden factors for each vehicle category. Considering the availability of GHGs conversion factors for specific weight laden values (50%, UK average and 100%), a set of 19 scenarios are finally produced and examined in the study (A1, A2, A3, B1, B2, B3, C1, C2, C3, D1, D2, D3, E1,

E2, E3, F1, F2, F3, G1; described in Table 17). These scenarios are compared against the baseline scenario which reflects the actual *WestQuay* freight activity as described in Chapters 6 and 7. This requires the conversion of the actual weekly and seasonal MCGs volume into precise weight estimates which are linearly interpolated in order to produce the precise GHGs conversion factors (as explained in Section 5.5.2).

- *Number of Trips/Vehicles*: The number of vehicles required to transport MCGs from UCC to *WestQuay* depends on the fill rate and the capacity (m^3) of the vehicle type used case by case. It is assumed that the total volume (m^3) of MCGs transported will remain same to 2008 figures and that the maximum volumetric capacity of an articulated lorry is $80m^3$, a rigid lorry $60m^3$, a van $10m^3$ and an unknown type of vehicle is $30m^3$.
- *Distance Travelled*: The number of trips needed to carry the *WestQuay* destined loads (m^3), are multiplied with the last-mile distance (6 km) to find the weekly and seasonal variations in the distance travelled (km).
- *GHGs Emissions*: The estimation of the direct (CO_2, CH_4 and N_2O), indirect and overall GHGs emissions will be made by multiplying the estimated weekly and seasonal distance travelled by the GHG conversion factor that corresponds to the exact vehicle mode and weight laden (Tables 14 and 16).

8.3.2 Mandatory Participation

This case examines the full participation of the 92 *WestQuay* businesses in the UCC scheme in Nursling. It estimates the mileage and environmental footprint for each of the 19 scenarios and compares them against the baseline scenario.

The baseline scenario reflects the actual situation as it was recorded at the time of the interviews and is described in Chapters 6 and 7. Analysis suggested that a third of deliveries (34.8%) were made by vans, another third (35.3%) by rigid lorries, a quarter (25%) by undefined (unknown) vehicle type, while only a 4.9% of deliveries were made by articulated lorries (Table 41). A slight increase in the use of articulated lorries (from 4.9% to 5.2%) followed by a decrease in the number of vans servicing *WestQuay* businesses (from 34.8% to 34.4%) was noted during busy periods indicating a trend towards the increase of the size of consignments rather than the number of delivery visits. These changes corresponded to a 14.2% increase in total distance travelled (from 98,067 km during a standard week to 111,975 km during a busy week). Instead a much greater increase (434%) in the total volume of MCGs transported was marked (from 901.2m^3 during a standard week to 3,917m^3 during a busy week). On average, each store was receiving 9.8 m³ of MCGs through 4.9 deliveries during a standard week, while delivery vehicles were travelling on average a total of 1,066 km (218.6 km per trip).

Table 41: Weekly estimates of the freight activity of the 92 *WestQuay* businesses.

Freight Activity / Vehicle Mode	Deliveries No				Volume of Goods (m^3)				Distance Travelled (km)			
	Standard		Busy		Standard		Busy		Standard		Busy	
	n	%	n	%	V	%	n	%	S	%	n	%
Vans	156	34.8	166	33.0	117.9	17%	1,105	28.2	28,580	29.1	30,413	27.1
Rigid Lorries	159	35.3	179	35.6	451.6	50.2%	1,414	36.1	39,815	40.6	45,413	40.6
Articulated Lorries	22	4.9	30	6.0	153.5	13.1%	381	9.7	4,458	4.5	7,505	6.7
D/K → Average HGVs	112	25.0	128	25.4	178.2	19.8%	1,016	25.9	25,215	25.8	28,645	25.6
Total Weekly	**449**	**100**	**503**	**100**	**1,188**	**100**	**3,424**	**100**	**98,068**	**100**	**112,066**	**100**
Weekly per Store	**4.9**	**1.1**	**5.5**	**1.1**	**12.9**	**1.1**	**37.2**	**1.1**	**1,066**	**1.1**	**1,218**	**1.1**

A summary of the delivery vehicle trips and the emissions impact for the 19 operational scenarios considering different vehicle take-up and weight laden combinations for the mandatory scenario (92 participants) are summarised in Tables 42 and 43 and Figures 88 and 89. The results suggested that:

- *The scenario that provided the best return* (Scenario A3) in terms of number of trips and GHGs produced assumed 100% usage of articulated lorries and 100% of their loading capacity. Instead *the scenario that provided the worst return* (Scenario G1) assumed 100% usage of vans at 40.3% of their fill capacity. However the use of electric vans instead of diesel vans could reduce significantly the GHGs produced as electric vans present their best performance at the point of use. However they may have to run additional trips due to the slightly slower pay load.
- As shown in Table 42 the monthly trip reduction figure peaks at around 90% (e.g. from January to August the Scenario A3 results approximately at 10% of the number of trips that correspond to the baseline scenario). This figure highlights the great potential to consolidate loads, especially smaller retailers currently receiving many small deliveries.

- *Significant reductions both in the number of vehicle trips and the level of emissions can be achieved through the use of larger vehicles***:** More particularly, in the baseline scenario the level of articulated lorries is very low (4.8-6.3% throughout the year; Figure 42), while the rigid lorries and the vehicles of unknown mode run about a third of the total number of trips each. The scenarios that have assumed a higher utilisation (take-up and fill rate) of articulated lorries (Scenario A), or combination of articulated and rigid lorries (Scenarios B and C) or a high fill utilisation of rigid lorries (D3 and E3) generate less trips than the baseline scenario. As expected the GHGs produced in these cases are less than those generated in the baseline scenario.
- In examining the seasonal performance of the baseline scenario against the other 19 scenarios, and most particularly against Scenarios G1 (only use of vans) and F2 and F3 (combined use of rigid lorries and vans) it is revealed that during Autumn the number of trips made under the baseline scenario becomes significantly lower than the number of trips generated under those three scenarios. This happens because while the vehicle take-up for these three cases is fixed, in the baseline scenario (actual situation) the take-up of the larger vehicles increases significantly towards the coming of Christmas sales (articulated lorries take up from 4.9% to 6% of overall trips and rigid lorries from 35.3 to 35.6%; Figure 38).
- In examining the seasonal generation of GHGs emissions (Figure 88), it is shown that a very high level of GHGs emissions is produced under the baseline scenario. Notably, the level of GHGs emissions produced under scenarios F3, E3, D3, F1, E1 increases significantly in July against the emissions produced under scenarios A3, B1, B2, B3, E2 and F2 which present a steady decrease. In comparing the vehicle delivery mix of these two groups, it was found that the first included smaller vehicles (e.g. rigid lorries and vans, while the latter included larger vehicles (e.g. articulated lorries and combinations of articulated and rigid lorries).
- Although the sensitivity analysis suggested that the scenarios with the best return are the ones run by the largest vehicles, these cannot be realistically implemented for a number of reasons. First, not all *WestQuay* businesses will participate to the UCC therefore the opportunities to consolidate loads will be lower, second even after the establishment of the UCC many businesses will keep receiving separately high-value, perishable and fast-selling goods, among others, and third many loads due to their nature (e.g. frozen food) cannot be consolidated with other products .

Table 42: Seasonal variation in the number of trips made by the 92 businesses (mandatory participation) under a number of vehicle and load mix scenarios.

Scenarios for 92 Businesses		Vehicles Mix				Fill Rates (tonnes)			Total Number of Trips (One-way – only vehicles entering Southampton)											
		Art	Rigid	Van	D/K	Art	Rigid	Van	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SCENARIO A' Articulated lorries	A1	100%				50%			441,4	336,8	378,9	407,6	324,2	428,3	455,2	406,6	671,0	659,3	985,6	956,2
	A2	100%				60%			367,9	280,7	315,7	339,7	270,2	356,9	379,3	338,8	559,1	549,5	821,3	796,8
	A3	100%				100%			220,7	168,4	189,4	203,8	162,1	214,1	227,6	203,3	335,5	329,7	492,8	478,1
SCENARIO B' Articulated &Rigid lorries	B1	40%	60%			50%	50%		749,3	571,7	643,1	691,9	550,4	727,1	772,7	690,2	1139,0	1119,3	1673,1	1623,2
	B2	40%	60%			60%	52%		652,4	497,7	559,9	602,4	479,2	633,0	672,7	600,9	991,6	974,4	1456,6	1413,1
	B3	40%	60%			100%	100%		374,7	285,9	321,6	346,0	275,2	363,5	386,4	345,1	569,5	559,6	836,6	811,6
SCENARIO C' Vans, articulated &Rigid lorries	C1	30%	60%	10%		50%	50%	40.3%	887,0	676,7	761,2	819,0	651,5	860,6	914,6	817,0	1348,1	1324,8	1980,4	1921,2
	C2	30%	60%	10%		60%	52%	40.3%	780,9	595,8	670,2	721,1	573,6	757,7	805,3	719,3	1187,0	1166,5	1743,7	1691,6
	C3	30%	60%	10%		100%	100%	40.3%	447,3	341,3	383,9	413,1	328,6	434,0	461,3	412,0	679,9	668,2	998,8	969,0
SCENARIO D' Rigid lorries	D1		100%				50%		1400,7	1068,7	1202,2	1293,4	1028,9	1359,1	1444,5	1290,2	2129,1	2092,2	3127,5	3034,2
	D2		100%				52%		1346,9	1027,6	1155,9	1243,7	989,3	1306,8	1388,9	1240,6	2047,2	2011,8	3007,2	2917,5
	D3		100%				100%		700,4	534,3	601,1	646,7	514,5	679,5	722,2	645,1	1064,5	1046,1	1563,8	1517,1
SCENARIO E' Rigid lorries & Vans	E1		90%	10%			50%	40.3%	1510,5	1152,5	1296,4	1394,8	1109,6	1465,6	1557,7	1391,4	2296,0	2256,2	3372,7	3272,0
	E2		90%	10%			52%	40.3%	1454,1	1109,4	1248,0	1342,7	1068,1	1410,8	1499,5	1339,4	2210,2	2171,9	3246,7	3149,7
	E3		90%	10%			100%	40.3%	766,6	584,8	657,9	707,8	563,1	743,8	790,5	706,1	1165,1	1145,0	1711,6	1660,5
SCENARIO F' Rigid lorries & Vans	F1		40%	60%			50%	40.3%	2484,3	1895,4	2132,1	2293,9	1824,8	2410,4	2561,8	2288,3	3776,0	3710,6	5546,8	5381,2
	F2		40%	60%			52%	40.3%	2415,7	1843,1	2073,3	2230,6	1774,5	2343,8	2491,1	2225,1	3671,8	3608,2	5393,7	5232,7
	F3		40%	60%			100%	40.3%	1453,3	1108,8	1247,3	1341,9	1067,5	1410,1	1498,7	1338,6	2208,9	2170,7	3244,8	3148,0
SCENARIO G' Vans	G1			100%				40.3%	5129,5	3913,5	4402,4	4736,5	3767,8	4976,9	5289,6	4724,8	7796,6	7661,7	11452,9	11111,0
Current Situation Last mile	Base line	4.8-6.3%	34.5-36%	32.9-35%	24.5-25.5				2008,6	1826,2	1995,3	1935,2	1986,4	1943,8	2008,6	1990,9	1965,2	2044,0	2085,2	2172,4

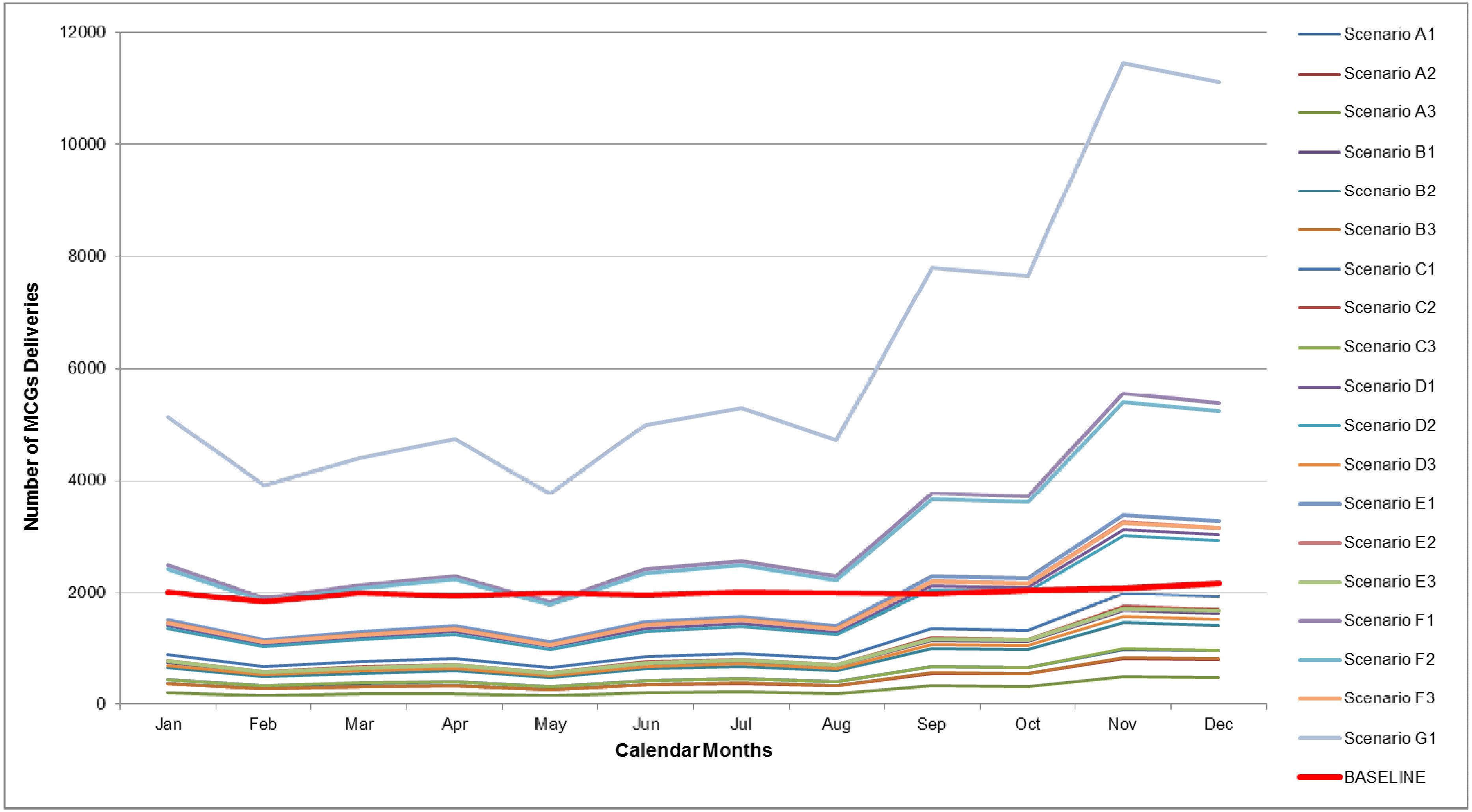


Figure 88: Seasonal variation in the number of trips made by the 92 businesses (mandatory participation) under a number of vehicle and load mix scenarios.

Table 43: Seasonal variation in the level of GHGs produced by the 92 businesses (mandatory participation) under a number of vehicle and load mix scenarios.

Scenarios for 92 Businesses		Vehicles Mix				Fill Rates (tonnes)			Total Number of GHGs (kg CO_2e) (One-way – only vehicles entering Southampton)											
		Art	Rigid	Van	D/K	Art	Rigid	Van	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SCENARIO A' **Articulated lorries**	**A1**	100%				50%			2973,2	2268,4	2551,7	2745,4	2183,9	2884,7	2477,7	1890,3	2126,4	2287,8	1819,9	2403,9
	A2	100%				60%			2578,4	1967,2	2212,9	2380,8	1893,9	2501,7	1547,0	1180,3	1327,7	1428,5	1136,4	1501,0
	A3	100%				100%			1853,8	1414,3	1591,0	1711,8	1361,7	1798,6	2517,5	1920,7	2160,6	2324,6	1849,2	2442,6
SCENARIO B' **Articulated &Rigid lorries**	**B1**	40%	60%			50%	50%		4511,7	3442,2	3872,1	4166,0	3314,0	4377,5	3927,8	2996,7	3371,0	3626,9	2885,2	3811,0
	B2	40%	60%			60%	52%		4174,9	3185,3	3583,1	3855,1	3066,7	4050,7	2397,8	1829,4	2057,9	2214,1	1761,3	2326,4
	B3	40%	60%			100%	100%		2659,3	2028,9	2282,3	2455,6	1953,4	2580,2	5550,4	4234,7	4763,6	5125,2	4077,0	5385,3
SCENARIO C' **Vans, articulated &Rigid lorries**	**C1**	30%	60%	10%		50%	50%	40.3%	4902,6	3740,4	4207,6	4527,0	3601,2	4756,8	4316,6	3293,3	3704,7	3985,9	3170,7	4188,2
	C2	30%	60%	10%		60%	52%	40.3%	4591,0	3502,7	3940,2	4239,3	3372,3	4454,4	2629,9	2006,5	2257,1	2428,4	1931,8	2551,6
	C3	30%	60%	10%		100%	100%	40.3%	2880,0	2197,3	2471,7	2659,3	2115,5	2794,3	8726,8	6658,1	7489,8	8058,3	6410,3	8467,2
SCENARIO D' **Rigid lorries**	**D1**		100%				50%		7766,4	5925,3	6665,4	7171,4	5704,7	7535,3	7467,7	5697,4	6409,1	6895,6	5485,3	7245,5
	D2		100%				52%		8072,1	6158,6	6927,8	7453,7	5929,3	7831,9	4197,5	3202,5	3602,5	3875,9	3083,2	4072,6
	D3		100%				100%		4363,4	3329,1	3744,9	4029,1	3205,1	4233,6	8469,8	6462,1	7269,2	7821,0	6221,5	8217,9
SCENARIO E' **Rigid lorries & Vans**	**E1**		90%	10%			50%	40.3%	7809,8	5958,5	6702,7	7211,5	5736,6	7577,5	7517,9	5735,8	6452,2	6942,0	5522,3	7294,3
	E2		90%	10%			52%	40.3%	8105,2	6183,9	6956,3	7484,3	5953,6	7864,1	4272,8	3260,0	3667,2	3945,5	3138,6	4145,7
	E3		90%	10%			100%	40.3%	4436,3	3384,7	3807,4	4096,4	3258,7	4304,3	8876,2	6772,1	7618,0	8196,2	6520,0	8612,2
SCENARIO F' **Rigid lorries & Vans**	**F1**		40%	60%			50%	40.3%	8194,9	6252,3	7033,2	7567,1	6019,5	7951,1	7968,8	6079,8	6839,1	7358,3	5853,4	7731,7
	F2		40%	60%			52%	40.3%	8402,4	6410,6	7211,3	7758,7	6171,9	8152,4	5054,8	3856,6	4338,3	4667,6	3713,0	4904,5
	F3		40%	60%			100%	40.3%	5192,6	3961,7	4456,5	4794,8	3814,2	5038,1	9241,0	7050,4	7931,1	8533,1	6787,9	8966,1
SCENARIO G' **Vans**	**G1**			100%				40.3%	9241,0	7050,4	7931,1	8533,1	6787,9	8966,1	9529,5	8511,9	14046,0	13802,9	20633,0	20017,0
Current Situation **Last mile**	**Base line**	4.8-6.3%	34.5-36%	32.9-35%	24.5-25.5%	11361,7	10337,8	11418,8	11058,1	11428,5	11040,8	11415,8	11436,4	10922,5	11317,1	10968,1	11337,0	11361,7	10337,8	11418,8

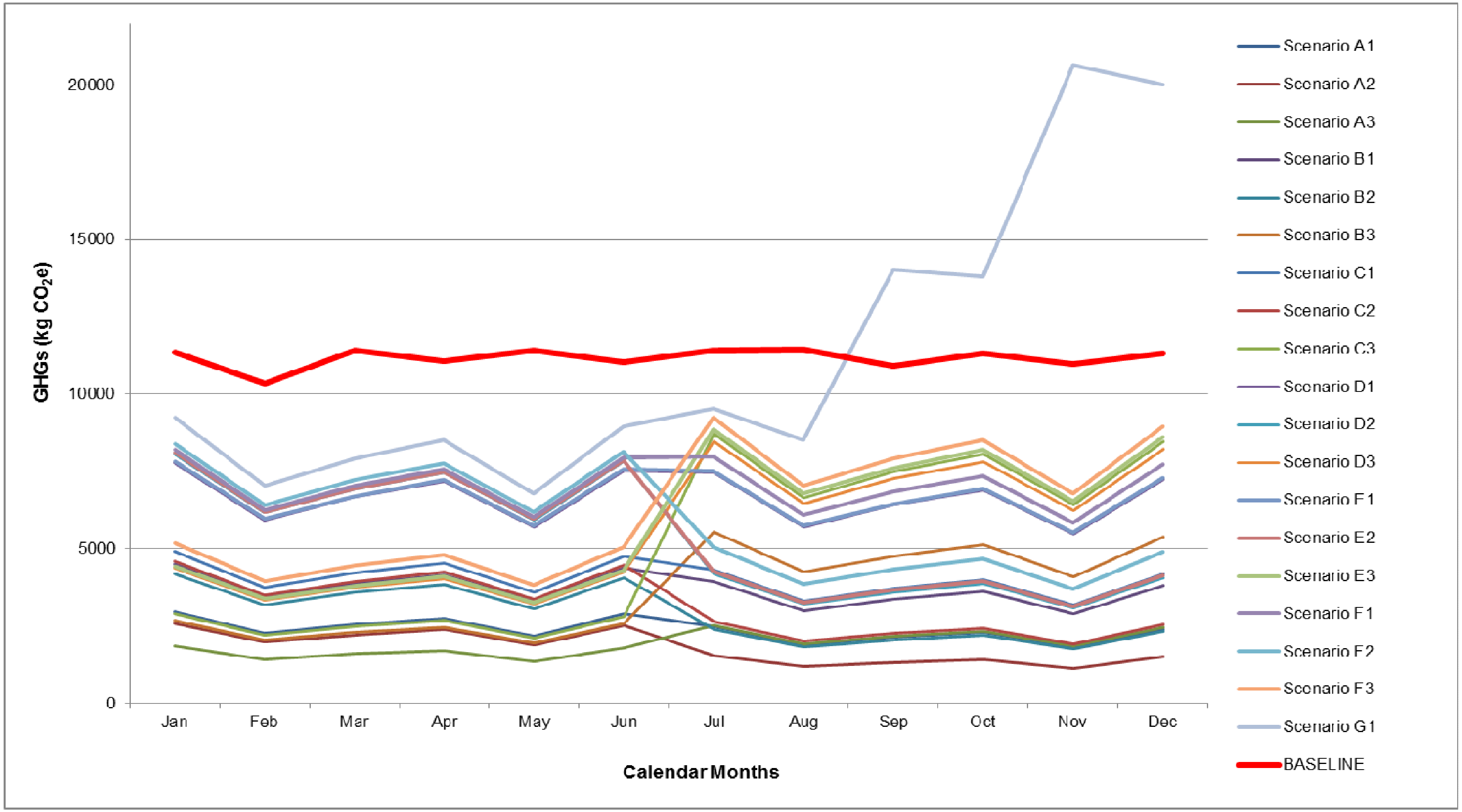


Figure 89: Seasonal variation in the level of GHGs produced by the 92 businesses (mandatory participation) under a number of vehicle and load mix scenarios.

8.3.3 Voluntary Participation

This scenario examines the participation of only 13 *WestQuay* retail/catering units in the UCC scheme in Nursling. All of them belonged to major businesses with nationwide branch networks and with at least one outlet already participating in *Broadmead*'s consolidation centre in Bristol. Having already experienced the benefits of a successful consolidation scheme, these businesses were expected to be among the first to participate in *WestQuay*'s consolidation project. They included nine stores selling clothing (*Karen Millen*, *Coast*, *Oasis*, *Monsoon*, *Principles*, *Wallis*, *Dorothy Perkins*, *Warehouse* and *Burtons*), two confectionaries (*Julian Graves* and *Thorntons*), one store selling jewellery (*Accessorize*) and one store selling medical goods (*Body Shop*). All of them were medium-size businesses ($200m^2<A<500m^2$).

As before, the baseline scenario for the 13 businesses reflected the actual situation as it was recorded at the time of the interviews. Analysis suggested that none of these businesses was receiving deliveries via an articulated lorry. Instead, the vast majority of MCGs deliveries were processed by rigid lorries (80.7%) with only 6.4% of them being made by vans and 12.9% by undefined (unknown) vehicle modes (Table 44). All extra MCGs deliveries (n=4) taking place during a busy week were processed by rigid lorries. This resulted to a 13% increase in the overall distance travelled (from 8,858 km during a standard week to 10,007 km during a busy week). Instead the weekly volume of goods carried by each of the three vehicle modes used increased by 350% during busy periods (in total from 149.2 m^3 to 529.9 m^3). Most of it (96.3%, 510.1 m^3) was carried by rigid lorries. On average, each store was receiving 3.64 m^3 of MCGs through 3.15 deliveries during a standard week, while delivery vehicles were travelling on average a total of 681.4 km (216.3 km per trip).

Table 44: Weekly estimates of the freight activity of the 13 *WestQuay* businesses.

Freight Activity / Vehicle Mode	Deliveries No				Volume of Goods(m3)				Distance Travelled			
	Standard		Busy		Standard		Busy		Standard		Busy	
	n	%	n	%	V	%	V	%	S	%	S	%
Vans	4	9.8	4	8.9	1.2	0.8	4.2	0.8	570.4	6.4	570.4	5.7
Rigid Lorries	32	78.0	36	80.0	143.5	96.2	510.1	96.3	7144.5	80.7	8293.9	82.3
Articulated Lorries	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D/K → Average HGVs	5	12.2	5	0.11	4.5	3.0	15.6	2.9	1142.6	12.9	1142.6	11.4
Total Weekly	**41**	**100**	**45**	**100**	**149.2**	**100**	**529.9**	**100**	**8857.5**	**100**	**10006.9**	**100**
Weekly per Store	**3.15**	**7.7**	**3.46**	**7.7**	**11.5**	**7.7**	**40.8**	**7.7**	**681.3**	**7.7**	**769.8**	**7.7**

The comparison of the freight activity of the 13 businesses against the freight activity of the 92 *WestQuay* businesses showed that the former were receiving fewer deliveries a week (standard: 3.15 against 4.9 deliveries, busy: 3.46 deliveries against 5.5 deliveries). Although each of the 13 businesses was receiving less volume of goods than the 92 businesses during a standard week (11.5 m^3 against 12.9 m^3), this was not the case for the busy periods (40.8 m^3 against 37.2 m^3). In estimating the average volume of goods moved per delivery trip it was found that the 13 businesses were receiving larger deliveries than the 92 stores (standard: 6.76 m^3/trip against 2.63 m^3/trip, busy: 11.8 m^3/trip against 3.65 m^3/trip). The distance travelled was the same (standard: 217 km, busy: 222 km). Therefore the 13 businesses were receiving overall fewer but more consolidated deliveries than the 92 businesses.

A summary of the results for the 19 operational scenarios based on different vehicle delivery mix and vehicle weight laden combinations under the voluntary scenario (13 participants) are summarised in Tables 45 and 46 and Figures 90 and 91. The results suggested that:

- Again, *the scenario that provided the best return* (Scenario A3) in terms of number of trips and GHGs produced assumed 100% usage of articulated lorries and 100% of their loading capacity. Similarly, *the scenario that provided the worst return* (Scenario G1) assumed 100% usage of vans at 40.3% of their fill capacity. Considering that the results of the mandatory and the voluntary scenario agree, it is therefore confirmed that s*ignificant reductions both in the number of vehicle trips and the level of emissions can be achieved through the use of larger vehicles***.**
- As shown in the columns of Table 45 the monthly trip reduction figure peaks at around 85% (e.g. from February to March the Scenario A3 results approximately at 15% of the number of trips that correspond to the baseline scenario). This figure, as before, highlights the great potential to achieve a high level of consolidation, especially those retailers who receive a high frequency of part loads or small consignments. Considering that the 13 retailers under the voluntary scenario already receive fewer but larger deliveries that the 92 retailers as a whole but achieve smaller increases in the levels of consolidation, it is suggested that *when delivery vehicles with already large loads pass through a consolidation centre then the overall degree of consolidation achieved in the centre reduces and the level that the vehicle trips fall*

is less great. Especially businesses already operating close to fully consolidated loads should not expect any significant benefits due to the loss of control over the supply chain and most importantly due to the double handling costs.

- In examining the seasonal performance of the baseline scenario against the 19 scenarios, it was found that Scenarios G1 (only vans), F1, F2 and F3 (combination of rigid lorries and vans) presented a significant increase in the number of trips needed to transport inbound flows between October and Christmas. The main reason for this was the low payload of the vehicles running under these scenarios therefore more vehicles of the same category would be needed in order to transport the increasing volume of MCGs towards the coming of Christmas. That would come, though, in opposition with one of the most important objectives of consolidation which is the reduction of the congestion in urban environments. In response, the high usage of HGHVs such as articulated lorries would lead to the reduction in the number of the vehicles needed to enter the city. However the use of vans in historic centres and high street districts is often compulsory. Shopping centres, on the other hand, allow larger vehicles to enter their loading/unloading areas freely but at the same time the conflicts between the larger vehicles and other road users increase.
- In examining the seasonal generation of GHGs, emissions (Figure 91) it is shown that the 13 businesses generate less emissions than the 92 businesses. This may accrue from the fact that the 13 businesses receive less and more consolidated deliveries than the 92 businesses. Again the scenarios that provide a worse return are E1, F1, F2 and G1, while the ones that provide a better return are scenarios A1, A2 and E3 (larger vehicles).
- The vehicle utilisation for the 13 businesses could get further improved by incorporating waste and recycling plans into the operating structure of *WestQuay's* consolidation centre. That would require delivery vehicles to backhaul the packaging, recyclables and waste to the consolidation centre either at a discounted price or free. That would be an excellent opportunity for *WestQuay* to reduce the number of visits to the complex for the collection of hazardous wastes such as fluorescent lighting tubes which although account for 0.01% of the total waste volume produced by the 92 businesses generate 6,794 dedicated and 3,347 back-loaded collections a year.

Table 45: Seasonal variation in the number of trips made by the 13 businesses (voluntary participation) under a number of vehicle and load mix scenarios.

Scenarios for 92 Businesses		Vehicles Mix				Fill Rates (tonnes)			Total Number of Trips (One-way – only vehicles entering Southampton)											
		Art	Rigid	Van	D/K	Art	Rigid	Van	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SCENARIO A' Articulated lorries	**A1**	100%				50%			80,3	47,4	66,4	73,8	59,6	59,5	63,7	52,5	50,8	65,5	148,6	136,2
	A2	100%				60%			66,9	39,5	55,3	61,5	49,7	49,6	53,1	43,7	42,3	54,6	123,9	113,5
	A3	100%				100%			40,1	23,7	33,2	36,9	29,8	29,7	31,8	26,2	25,4	32,7	74,3	68,1
SCENARIO B' Articulated &Rigid lorries	**B1**	40%	60%			50%	50%		136,3	80,5	112,7	125,2	101,1	101,0	108,1	89,1	86,2	111,1	252,3	231,3
	B2	40%	60%			60%	52%		118,7	70,0	98,1	109,0	88,1	87,9	94,1	77,6	75,0	96,8	219,7	201,3
	B3	40%	60%			100%	100%		68,1	40,2	56,4	62,6	50,6	50,5	54,0	44,5	43,1	55,6	126,2	115,6
SCENARIO C' Vans, articulated &Rigid lorries	**C1**	30%	60%	10%		50%	50%	40.3%	161,3	95,2	133,4	148,2	119,7	119,5	127,9	105,4	102,0	131,6	298,6	273,7
	C2	30%	60%	10%		60%	52%	40.3%	142,0	83,9	117,5	130,5	105,4	105,2	112,6	92,8	89,8	115,8	262,9	241,0
	C3	30%	60%	10%		100%	100%	40.3%	81,4	48,0	67,3	74,7	60,4	60,3	64,5	53,2	51,5	66,4	150,6	138,1
SCENARIO D' Rigid lorries	**D1**		100%				50%		254,8	150,4	210,7	234,0	189,1	188,7	202,0	166,5	161,1	207,8	471,6	432,3
	D2		100%				52%		245,0	144,6	202,6	225,0	181,8	181,5	194,3	160,1	154,9	199,8	453,5	415,7
	D3		100%				100%		127,4	75,2	105,4	117,0	94,5	94,4	101,0	83,3	80,6	103,9	235,8	216,2
SCENARIO E' Rigid lorries & Vans	**E1**		90%	10%			50%	40.3%	274,7	162,2	227,2	252,4	203,9	203,5	217,9	179,6	173,8	224,0	508,6	466,2
	E2		90%	10%			52%	40.3%	264,5	156,1	218,7	242,9	196,3	195,9	209,7	172,9	167,3	215,7	489,6	448,8
	E3		90%	10%			100%	40.3%	139,4	82,3	115,3	128,1	103,5	103,3	110,6	91,1	88,2	113,7	258,1	236,6
SCENARIO F' Rigid lorries & Vans	**F1**		40%	60%			50%	40.3%	451,8	266,7	373,7	415,1	335,3	334,7	358,3	295,3	285,8	368,5	836,5	766,7
	F2		40%	60%			52%	40.3%	439,4	259,4	363,4	403,6	326,1	325,5	348,4	287,2	277,9	358,3	813,4	745,5
	F3		40%	60%			100%	40.3%	264,3	156,0	218,6	242,8	196,2	195,8	209,6	172,8	167,2	215,6	489,3	448,5
SCENARIO G' Vans	**G1**			100%				40.3%	933,0	550,8	771,6	857,0	692,3	691,1	739,8	609,8	590,1	760,8	1727,1	1583,1
Current Situation Last mile	**Base line**	4.8-6.3%	34.5-36%	32.9-35%	24.5-25.5				181,6	164,0	186,0	180,0	181,6	184,3	190,4	181,6	175,7	181,6	192,9	199,3

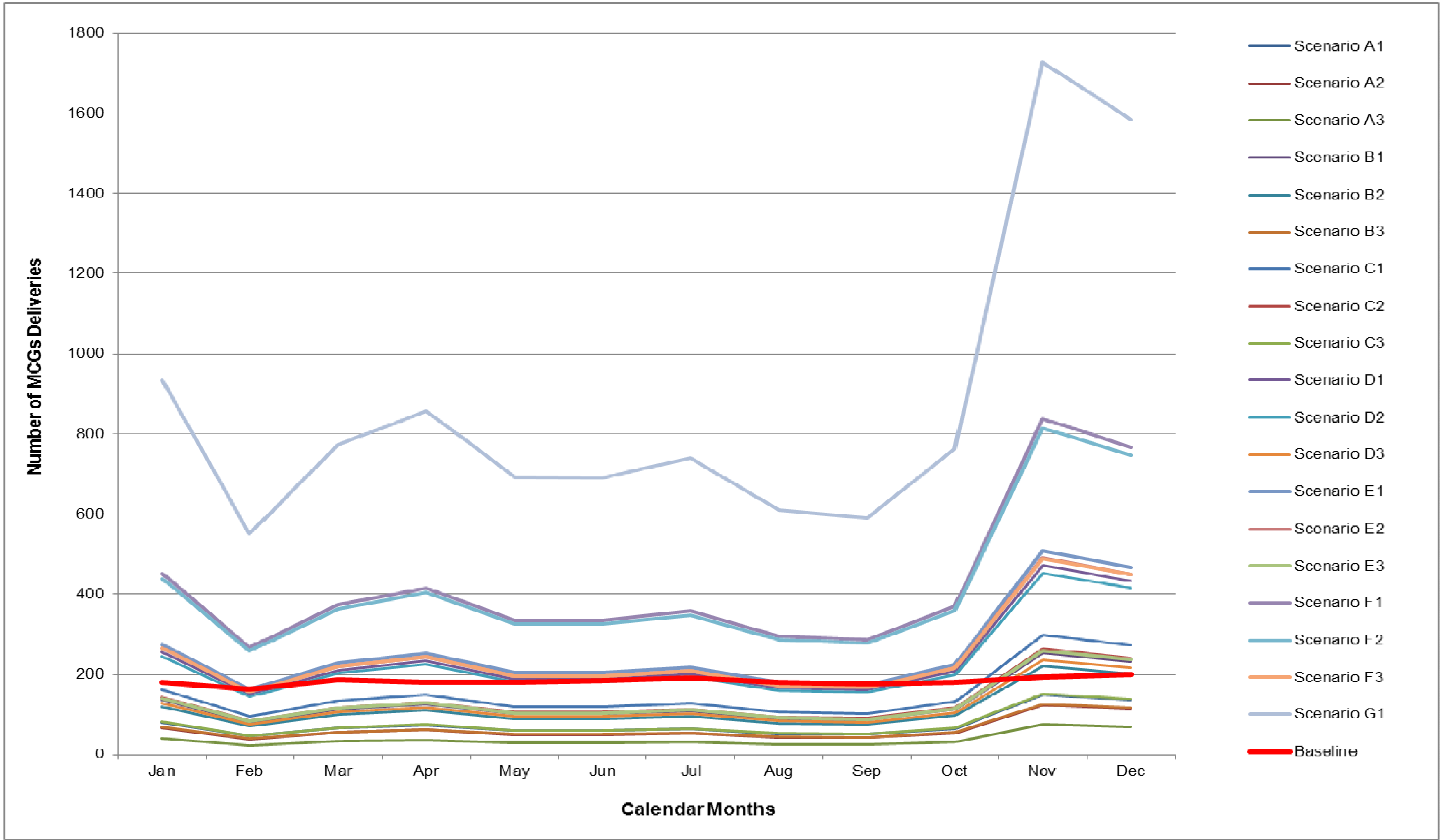


Figure 90: Seasonal variation in the number of trips made by the 13 businesses (voluntary participation) under a number of vehicle and load mix scenarios.

Table 46: Seasonal variation in the level of GHGs produced by the 13 businesses (voluntary participation) under a number of vehicle and load mix scenarios.

Scenarios for 92 Businesses		Vehicles Mix				Fill Rates (tonnes)			Total Number of Trips (One-way – only vehicles entering Southampton)											
		Art	Rigid	Van	D/K	Art	Rigid	Van	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SCENARIO A' Articulated lorries	**A1**	100%				50%			540,8	319,2	447,3	496,7	401,3	400,6	450,6	266,0	372,7	414,0	334,4	333,8
	A2	100%				60%			469,0	276,8	387,9	430,8	348,0	347,4	281,4	166,1	232,7	258,5	208,8	208,4
	A3	100%				100%			337,2	199,0	278,9	309,7	250,2	249,7	457,9	270,3	378,7	420,6	339,8	339,2
SCENARIO B' Articulated &Rigid lorries	**B1**	40%	60%			50%	50%		820,6	484,4	678,7	753,8	608,9	607,8	714,4	421,7	590,9	656,2	530,1	529,2
	B2	40%	60%			60%	52%		759,4	448,3	628,0	697,5	563,5	562,5	436,1	257,4	360,7	400,6	323,6	323,0
	B3	40%	60%			100%	100%		483,7	285,5	400,0	444,3	358,9	358,3	1009,5	595,9	834,9	927,3	749,1	747,8
SCENARIO C' Vans, articulated &Rigid lorries	**C1**	30%	60%	10%		50%	50%	40.3%	891,7	526,4	737,5	819,1	661,7	660,5	785,1	463,5	649,3	721,2	582,6	581,5
	C2	30%	60%	10%		60%	52%	40.3%	835,0	492,9	690,6	767,0	619,7	618,5	478,3	282,4	395,6	439,4	355,0	354,3
	C3	30%	60%	10%		100%	100%	40.3%	523,8	309,2	433,2	481,2	388,7	388,0	1587,3	937,0	1312,8	1458,0	1177,9	1175,7
SCENARIO D' Rigid lorries	**D1**		100%				50%		1412,6	833,9	1168,3	1297,6	1048,2	1046,3	1358,2	801,8	1123,4	1247,7	1007,9	1006,1
	D2		100%				52%		1468,2	866,7	1214,3	1348,6	1089,5	1087,5	763,5	450,7	631,4	701,3	566,5	565,5
	D3		100%				100%		793,6	468,5	656,4	729,0	588,9	587,9	1540,5	909,4	1274,1	1415,1	1143,2	1141,1
SCENARIO E' Rigid lorries & Vans	**E1**		90%	10%			50%	40.3%	1420,5	838,5	1174,8	1304,8	1054,1	1052,2	1367,4	807,2	1130,9	1256,1	1014,7	1012,8
	E2		90%	10%			52%	40.3%	1474,2	870,3	1219,3	1354,2	1094,0	1092,0	777,2	458,8	642,8	713,9	576,7	575,7
	E3		90%	10%			100%	40.3%	806,9	476,3	667,3	741,2	598,8	597,7	1614,4	953,1	1335,2	1483,0	1198,0	1195,8
SCENARIO F' Rigid lorries & Vans	**F1**		40%	60%			50%	40.3%	1490,5	879,9	1232,7	1369,2	1106,1	1104,0	1449,4	855,6	1198,7	1331,4	1075,6	1073,6
	F2		40%	60%			52%	40.3%	1528,3	902,2	1264,0	1403,8	1134,1	1132,0	919,4	542,7	760,4	844,5	682,3	681,0
	F3		40%	60%			100%	40.3%	944,4	557,5	781,1	867,6	700,8	699,6	1680,8	992,2	1390,1	1543,9	1247,3	1245,0
SCENARIO G' Vans	**G1**			100%				40.3%	1680,8	992,2	1390,1	1543,9	1247,3	1245,0	1332,9	1098,5	1063,1	1370,6	3111,5	2852,0
Current Situation Last mile	**Base line**	4.8-6.3%	34.5-36%	32.9-35%	24.5-25.5				696,2	628,8	699,4	676,8	696,2	672,2	694,6	696,2	673,8	696,2	687,4	710,3

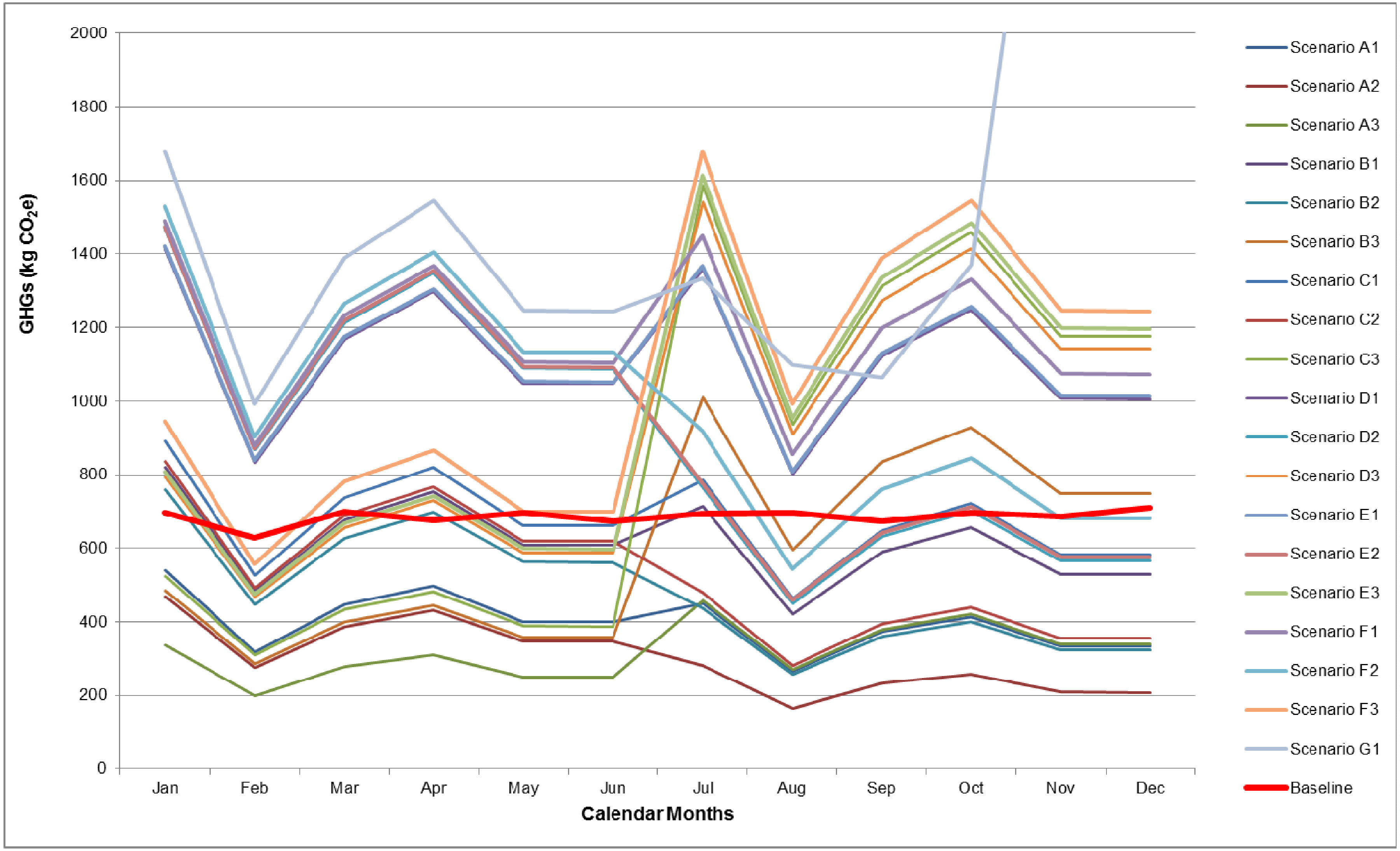


Figure 91: Seasonal variation in the number of GHGs produced by the 13 businesses (voluntary participation) under a number of vehicle and load mix scenarios.

8.4 Challenges

The review of existing consolidation schemes showed that the most critical success factors when considering the establishment of a consolidation centre were to secure stakeholder support, establish public/private partnerships between the City Council and the logistics provider and utilise initial external funding. On the other hand, the most important issues that impeded the successful operation of the UK schemes were lack of funding and participation.

8.4.1 Integrate Public-Private Vision

Government can play a four-fold role to this:

a) Plan according to private sector investments and support private initiatives that help reduce urban congestion and emissions and enable Local Authorities to reach their sustainability targets (e.g. the consolidation centre scheme in Southampton). This can be achieved through the provision of clear guidance to private investors and developers and changes in regulation.
b) Change regulations to facilitate the efficient and effective operation of the scheme. For example, Local Authority may amend access routes, access times and speed limits, and support a switch towards double-decked lorries to reduce congestion or electric vans to reduce emissions.
c) Introduce taxes to promote specific policies. For example, road user charging could reduce empty-running. On the other hand, the introduction of tax incentives for the use of bio-fuels and low-emission vehicles could lead in the improvement of local/regional air quality.
d) Invest public money to a private scheme to mainstream it during its initial stages.

8.4.2 Secure Funding

Funding is very important during the initial stages of a scheme as it forms a strong incentive for retailers who want to participate in the trial scheme. Funding could be secured through EU and national funds, private investments or public money.

8.4.3 Increase Participation

Several incentives should be given to local/regional retailers including free participation during the trial periods, discounted prices, and free usage of secondary activities e.g. storage. Norwich example showed that lack of central cohesion and control can create a general apathy to the scheme and finally lead to its cease.

8.5 Summary

The freight consolidation concept, although it is still in its infancy in the UK, is increasingly promoted by Local Authorities, the retail sector and the logistics industry as a means to reduce business costs, increase the load balance of freight transport and cut down urban traffic and emissions. In examining the network structures of existing consolidation schemes, two main forms were identified: a) vertically integrated supply chains of large retail groups consolidating consignments in regional or national distribution centres with the aim to minimise the long distance ‘trunking’ mileage, and b) cross-supply chains consolidating part-loads in urban consolidation centres to address the last-mile issue. Both forms presented a great potential for consolidation centres to augment the effects of creating strategic partnerships and alliances along a particular supply chain or among cross-supply chains by sharing facilities and transport resources.

Chapter 9: Conclusions and Discussion

9.1 Introduction

This chapter presents an overall evaluation of the findings and recommendations that flow from the analysis of the nature, volume and pattern of freight movements taking place in *WestQuay* shopping centre. The aim is to explore the diverse operational and logistics practices while considering any individual interests, initiatives and methods developed in order to get a holistic picture on the various requirements and challenges facing *WestQuay* businesses. Through this process a framework of strategies and logistics best practices is addressed with the aim to optimise the last mile and minimise the associated carbon footprint. The purpose is to examine the operation of a UCC servicing *WestQuay* retailers with the aim to increase back-load rates and reduce urban congestion and pollution. An examination of the limitations of the study is made to critically evaluate whether the second set of research questions introduced in Chapter 1 has been fully met. The thesis closes with a set of recommendations for future research directions on retail logistics.

9.2 Analysis Results and Discussion

The following sections summarise the findings from the multi-level analysis that was conducted in Chapters 6 to 8.

9.2.1. Forward Logistics

Analysis was focused on MCGs deliveries processed from up to seven suppliers for each business and distinguished between different types of economic activity (SIC coding) and sizes of retail floor ($A<200m^2$, $200m^2<A<500m^2$, $A>500m^2$). The following findings were derived from the analysis of the results. Initially, the study examined the number of MCGs deliveries in relation to the size of delivery vehicles and the spatial distribution of more than 200 national and international MCGs distribution centres servicing *WestQuay* businesses. A direct linkage between the type of the distribution system adopted and the number of MCGs deliveries received was identified, as notably the businesses that had embraced a de-centralised system were receiving more deliveries than those being serviced by a single distribution centre. Although the bigger businesses were receiving more deliveries during a week ($A>500m^2$: n=10.21 opposed to $A<200m^2$: n=4.15 and $200m^2<A<500m^2$: n=3.66), when estimating the average number of weekly deliveries per m^2 it was shown that the smaller businesses were the ones that generated a considerable freight activity as they were receiving less consolidated deliveries (part loads) via smaller vehicles ($A<200m^2$: $n=0.04/m^2$ opposed to $A>500m^2$: $n=0.007/m^2$ and $200m^2<A<500m^2$: $n=0.012$ deliveries/m^2 a week). Similarly, the largest businesses accounted for three times longer distances travelled on average when compared to the smaller businesses, however this was not the case when estimating the distance travelled per m^2 of retail floor. Analysis revealed that the smaller businesses, especially those lacking storage space and those trading perishable goods, were receiving a considerable number of frequent part-load deliveries from local suppliers who ensured faster replenishment of stock. To this end, vans were mostly used by catering units receiving a significant amount of locally-sourced perishable foods, while stores selling clothing were receiving fewer but more consolidated deliveries from longer distances using larger vehicles.

In examining the vehicle modes used to carry MCGs, it was found that rigid lorries were the ones mostly used by *WestQuay* businesses as they performed over a third of the total weekly deliveries to carry half of the total MCGs volume. Although vans were used to carry 24.1% of the total number of packaging units delivered a week, they processed only 13% of the total MCGs volume suggesting that vans were primarily carrying small-size packaging units such as trays. Articulated lorries, on the other hand, carried only 2.6% of the total number of packaging units which though were mostly in the form of pallets, roll cages and large plastic/cardboard boxes with a total volume equal to the 17% of the overall MCGs volume delivered to the 92 *WestQuay* businesses during a week. The majority of the carriers performing MCGs deliveries were 3PL providers, with in-house and suppliers own fleet being used only in the 13% and the 14% of the total MCGs deliveries, correspondingly. In examining the seasonal variation of MCGs delivery visits in relation to the size of the delivery vehicles employed, it was found that the businesses receiving top-up deliveries during the weekends (e.g. perishable goods) were mostly serviced by vans. Instead, a slight increase in the overall take-up of articulated and rigid lorries was noted in the case of businesses receiving additional deliveries towards the run-up to Christmas and the summer sales period (e.g. restaurants, stores selling clothing and electronics) or the start of the academic year (e.g. bookstores and stores selling computers).

In order to determine the available fill capacity and usage of delivery vehicles, the fill rate was estimated and found relatively low (7.5-8.5% from January to August and 13-20% from September to December) when compared to the average fill rates reported in the *Freight Best Practice* project survey results (DfT, 2003; Section 2.2.2.7). Although the study lacked information about potential milk-run truckloads, the statistical analysis on freight and goods traffic suggested that there is a considerable vehicle fill capacity which can be used to enable further consolidation in order to reduce overall freight activity and emissions. Such opportunities were found to be minimal for more than half of *WestQuay* businesses (60%, n=55, n_{tot}=92) as they were already receiving highly consolidated deliveries from a single distribution centre. Similarly, the largest bookstores, restaurants and stores selling games were already receiving mixed deliveries from consolidation platforms bringing together products from a number of national and international suppliers. To this end, the businesses that appeared to present the most opportunities to further consolidate their MCGs deliveries were the ones that had embraced a de-centralised system and were not located at the close vicinity of *WestQuay* shopping centre in Southampton.

9.2.2. Waste Management and Product Returns

WestQuay's integrated waste management plan was examined to identify best practice examples and detect opportunities to collect, move and recycle waste constituents in a more efficient and effective way. It was found that the waste management and waste logistics practices developed by *WestQuay* businesses are strongly driven by the current European and domestic regulatory framework. In many respects, the recycling initiatives operated by *WestQuay* and many of the individual businesses in the complex are exceeding the national guidelines and targets. This was largely attributed to the retailers waste management training offered by *WestQuay*.

The study revealed that *WestQuay* has developed a well organised, centrally managed collection service for the main waste types generated (general mixed waste, cardboard and polythene). Using a range of equipment to store and consolidate waste (pallets, roll cages, bins, balers and compactors) and through coordinating the collection across retailers, *WestQuay* has improved its recycling rates and has increased the mean waste tonnage being diverted from landfill. However the survey with retailers showed that the recycling performance of individual businesses was often compromised because of a shortage of personnel, lack of available time for material management, insufficient storage space or lack of equipment for in-store treatment.

In general, the waste management procedures of *WestQuay* businesses were aligned to the individual characteristics of the waste types produced and the legislation related to their storage, collection, transfer and disposal. Customer take-back schemes also contributed to the volumes of waste requiring special handling. The study identified 20 stores which had contracts in place with specialised waste contractors collecting confidential documents and hazardous end-of life materials such as WEEE, batteries, fluorescent lighting tubes, clinical waste and cooking oil. Their collection was made in 130 dedicated and 822 back-loaded visits a year despite the fact that their volume accounted for only 0.01% of the overall waste arisings. This highlighted the advantages of centralised waste collections against go-it-alone approaches.

The study identified that the main waste generators were the stores with a significant presence in the complex (catering units and stores selling clothing, footwear and electronics). The principal waste streams were general mixed waste and cardboard which was recycled extensively by most businesses. The storage systems used for waste containment varied across waste types to meet specific operational and legislative restrictions. It was estimated that the businesses surveyed generated 507 sacks, 53 roll cages, 1.6 plastic totes, 0.15 sharp boxes and 0.2 drums a week. The study also found that the use of reusable packaging (e.g. plastic containers, trays, cases and pallets) in almost half of the cases not only contributed to the reduction of the waste volume generated, but also enabled back-loading reducing the number of dedicated collection trips needed. Back-loading practices were found to impact on the type of vehicles used to collect waste and recyclables with larger articulated vehicles being typically used in such cases. The frequency of collection varied by waste type and type of business with clinical waste, used cooking oil and WEEE being collected on fixed weekly visits, and fluorescent lighting tubes and batteries a few times a year. The final destinations of waste collected from the retailers were across the UK.

The examination of individual case studies of *WestQuay* businesses producing hazardous wastes demonstrated the complex nature of the interactions existing between the many players involved. Waste collection and transport were found largely dictated by waste characteristics and the legislation governing its handling, treatment and disposal, with many specialist contractors providing fully managed services to retailers to help them meet their '*Producer Responsibility'* requirements. Given the reliance on road movement, the study concluded that there could be considerable benefits from coordinating hazardous waste take-back where competing retailers would identify common waste categories that require managed return and processing. Considering the apparent advantages of *WestQuay*'s centralised waste collection system for general waste and recyclables, the study concluded that the development of a centralised reverse logistics system that regulates and integrates hazardous waste management across competing retail businesses can lead to significant freight and emission reductions in urban environments. This could be achieved through the consolidation and onward treatment of hazardous wastes either on-site or in a consolidation platform located close to the shopping centre.

9.3 Shopping Centre Models

Based on the analysis of *WestQuay* freight activities the following operational models were identified. Typical urban shopping centres, such as *WestQuay*, are dominated by a large proportion of multi-purpose outlets usually occupied by chain organisations and department stores. Modern complexes provide sufficient infrastructure for loading and unloading operations in designated areas with increased accessibility and extended access times. Through the examination of *WestQuay* businesses it was revealed that a number of distribution models may be developed by the tenant businesses dependent their strategic and operational plans.

- ***Single-Drop Deliveries*:** Usually the largest stores that belong to businesses with nationwide networks and have their own distribution divisions receive large consolidated deliveries from national or international distribution centres on fixed quantities and pre-determined days of the week (e.g. *Benetton* and *SportsDirect*). These businesses embrace more push-supply chain methods and offer often to their customers own-labelled products and long discount sales. In those cases, the following issues should be considered:

    - Most of these businesses require large stock rooms close to their shops to store, check and sort the stock received. Modern shopping centres offer equipment and a number of storage rooms within or near their establishment however a significant rent may be imposed.

- Massive orders often include a significant number of defective items, therefore there is need to run preliminary checks before placing goods into the sales floor. To this end, businesses need to have in place specialised staff and special equipment.
- The existence of a significant number of defective items in massive orders multifies the staff effort and increases the need for businesses to put in place a well organised reverse supply chain system. Although this case offers increased opportunities to backload waste and returns by using the empty return load space, often this turns uneconomic for many businesses which either prefer to dispose of or donate defective and unsold products rather than passing them back to the supply chain.

➢ ***Multi-Drop Deliveries*****:** In this case inbound goods are delivered by numerous suppliers to each store in small quantities and usually under request (pull-supply chain model). Deliveries are usually processed by the suppliers or contracted 3PL providers as part of milk-runs. The businesses that usually embrace this system are small retailers with limited on-site storage capacity, businesses receiving their goods from many suppliers/producers (e.g. bookstores) and catering units receiving perishable goods (e.g. milk, bread and fruits). The following issues should be considered:

- All drivers must have permission to access the shopping centre's unloading bays and ensure that will arrive to the shopping centre within specific access times and time-windows.
- Retailers are usually responsible for key logistics processes (e.g. collect orders from the unloading areas and move them to the stores). This distracts them from their core business activities. Often shopping centres have dedicated staff to transport deliveries from unloading areas to retail outlets.
- The multi-drop distribution model including the case of just-in-time deliveries, especially when it is adopted by many businesses within the complex, may cause inconvenience to local population and result in increased urban congestion noise and pollution.

- ***Regionally Consolidated Deliveries*:** Following *Broadmead*'s UCC successful example many urban shopping centres consider the establishment of suburban consolidation centres to streamline the centre's delivery processes and reduce its total carbon footprint. This is achieved by shifting freight activity away from peak traffic hours allowing customers to access the complex easier. This model, as described in detail in Chapters 3 and 8, has the following main characteristics:

  - It gives the opportunity to retailers to share services and reduce costs.
  - Increases the on-site sales and storage floor area as businesses may keep their stock in the consolidation centre and get frequent top-up and just-in-time deliveries.
  - It allows smaller retailers with limited storage room to order in bulk.
  - It uses a single logistics provider to service the tenant businesses while dislocating GHVs traffic away from the city's commercial centre.
  - It reduces the last-mile freight activity and increases accessibility.
  - It offers to retailers extended delivery and collection times.
  - It offers additional services such gate-keeping operations and long-time storage among other services at a low cost for retailers.

With regard to the waste management processes and the opportunities available to retailers who operate within a shopping centre, the following models were identified:

- ***Centrally Coordinated Waste Collections***: *WestQuay*'s successful central waste collection system highlights the increased opportunities that businesses may enjoy when operating within an integrated retail complex.

  - The businesses have the legal right to transfer their *Duty of Care* to the manager of the shopping centre. This is usually done as part of an official agreement between the two sides (green clause in tenancy contract) and under a small fee.
  - The waste services within the centre are well aligned with the individual needs of retailers who are also systematically informed about their duties and responsibilities.

- Waste collections within the centre are made by dedicated cleaning staff that collects regularly waste from the designated areas at the back of the stores. This reduces the input required by the retailers.
- The shopping centre offers all the equipment needed to store, transport and treat waste within the complex. This enables full consolidation at source and reduces the transport and environmental footprint of collection vehicles.
- Waste collectors are employed by the managers of the centre on a long-time basis and therefore they are aware of the wide range of waste types produced as well as the seasonal fluctuations in the waste flows.
- Overall all the businesses participating in the central waste collection system have improved significantly their recycling performance.
- However the recycling performance of individual retailers may be compromised because of lack of time needed for waste assortment, insufficient storage space for the different waste streams inside retail outlets and lack of in-store equipment (e.g. recycling bins).
- Of paramount importance is the role of a coordinator who will be responsible to coordinate the waste collection processes in the centre, will monitor all waste management procedures taking place in the complex, will record their performance, will identify any issues and will ensure that all legislative requirements are met.

➢ ***Waste Back-loading Opportunities in Single Drop Deliveries*****:** This case offers increased opportunities to take back waste and recyclate by using the maximum available back-load capacity of the delivery vehicles. In this case, the following limitations should be considered:

- Whether the visiting frequency of delivery vehicles can meet the collection requirements for the specific nature and volume of waste and returns that have been accumulated considering any seasonal fluctuations.
- Whether the stores have enough spatial capacity to store waste and returns until the next collection date.
- Whether the retail business and the carrier delivering goods are licensed to store, collect and transport wastes that require specialised storage, collection, treatment and disposal (e.g. hazardous materials).

- Whether the individual retail business owns the equipment needed to collect, store, consolidate and manage waste and recyclates (e.g. specialised bins, pallets, roll cages, balers, shredders etc).
- Whether it is practicable and financially viable for a delivery vehicle to drop waste and returns in facilities other than its final destination which is normally the business' or the 3PL provider's distribution centre.
- Whether the delivery fleet is licensed to back-load and carry specific waste streams and whether these streams are according to the relevant legislation compatible with the forward flows carried by the same vehicle (e.g. whether a vehicle delivering food products can take-back WEEE).
- Whether the final destination, especially if this is the distribution centre, has the special equipment, the specialised staff and the operational capacity to receive, store, manage and pass waste and returns back to the reverse supply chain (e.g. processing stations and recycling facilities).

➢ ***Waste Back-loading Opportunities in Multi-Drop Deliveries*:** In this case the opportunities to take-back waste are reduced compared to the single drop deliveries because of the following reasons:

- The delivery vehicles have limited capacity to take-up product returns and waste as they are already loaded with goods destined to follow-up stops.
- There are increased load-mix restrictions due to potential cross-contamination of products from hazardous substances potentially contained in the reverse flow of products or waste.
- To avoid conflicts in loading-unloading activities it is required to separate the forward and reverse stream and prioritise movements. There may be specific time-windows during which a delivery vehicle can call in a stop and be loaded/unloaded.

9.4 Challenges

During the course of this project it was identified that the organisation and the development of reverse logistics in the retail sector may be impacted by several market and economic issues.

9.4.1 'Collaboration' Issues

The development of liaisons among rival businesses can enable retailers to improve key supply chain issues such as product availability, cost and cycle times. The nature of collaboration is though influenced by a variety of factors including the business type, the nature of products sold and the business ownership and therefore can be developed among businesses having matching needs and matching financial, technological and human resources. At the same time relationships and agreements among trading partners limit the feasibility of potential partnerships among rival businesses.

To realistically achieve collaborative practices among rival businesses apart from examining all the financial, operational and marketing barriers, it is very important to have a third party controller, as in the 'landlord-tenant' arrangement prevalent in most dedicated shopping centres, who will coordinate goods consolidation and transport. The real challenge would lie in ensuring effective 'gate-keeping' activities at source, to guarantee the separation of potential waste contaminants and whether this could be done effectively before different retailer loads were combined. Local authorities could be best placed to act in this role and create waste 'service plans' to serve retailers in an urban setting, to reduce waste service vehicle impacts.

While synergies among retailers are largely developed to enable the forward movement of goods, a great potential to increase operational and economic gains lies into the establishment of collaborative associations in the reverse path. Such opportunities must be researched and exploited taking into account several market mechanisms that might limit a balanced operation of local markets. The use of specific logistics providers and waste contractors for the collection of products and/or waste/recyclates may create monopolistic competition for a closed economy. Therefore a careful design of the reverse logistics networks must be ensured taking into account other financial and social attributes. These issues have been taken into account in this study through direct contacts with all key actors including *WestQuay* managers and retailers, waste contractors, logistics providers, recyclers, head offices, researchers as well as Southampton's City Council.

9.4.2 Recycling Markets

The development of recycling markets is an essential part of the drive to a more sustainable way of managing waste and has direct impacts on the development of the logistics networks. As EU and UK policies and targets press towards further increases of the diversion of recyclable material from landfill and the enhancement of waste recovery, retail businesses must assess the market availability and capacity and overview prices in order to match the supply of recyclable materials with the available recycling outlets. It is very important to have in place a number of alternative outlets which can respond to the needs as and when needed and to secure outlets for non-recyclable or hazardous waste, where safe disposal is of paramount importance.

In addition global forces such as the recent economic turndown have direct impacts on the availability of markets to buy and process recyclables, while at the same time there is requirement for increased quality and lower material prices. For instance in 2008 considerable reductions in the price of cardboard, mixed paper and steel were noted in the UK (PTEWOSP, 2009). Such supply-demand and price imbalances can lead to increases in the use of alternative recycling outlets in the UK or abroad and cause increases in the volumes of recycling materials disposed of in landfills. This has direct impacts on the transport patterns generated, the resources required, the emissions produced and the congestion caused, while it reduces the potential to plan and organise the associated logistics systems and increases the requirement to develop more complex and responding collection mechanisms. Clear and efficient processes for reverse logistics must be established to respond in the lowest possible cost and in a controlled manner.

To achieve the best balance among low cost, resource availability and environmental impact, network optimisation and collaborative practices must be supported by best practice themes such as modal switch, cube maximisation and alternative fuels usage. It is also important to optimise the recovery of waste materials from central processing especially where there are increased opportunities for shared and centrally coordinated services such as in the case of *WestQuay* shopping centre.

9.4.3 Vans are a Disproportionate Contributor to Congestion and Emissions

The latest statistics on UK freight activity (Section 2.2.2.6), revealed the rapid growth of the van sector (currently >1 million vans carrying freight) and the decline in the activity of HGVs (currently 415,000 vehicles). Despite these figures, HGVs account for 90% of overall freight moved by road and vans for about 5%, while at the same time they produce around 25% of total freight emissions. Vans also contribute disproportionately to congestion when considering that a lorry equals three car equivalents (Braithwaite, 2011). These figures suggest that higher utilisation of HGVs would result in the reduction of congestion, while a higher utilisation of low carbon vans would lead in the minimisation of emissions. In both cases, it is of paramount importance to increase the vehicle fill rate, minimise the number of empty-running and reduce the distances travelled.

9.5 Research Weaknesses

During the course of the study the following issues were identified.

- ***Lack of Comparative Studies*:** Although the *WestQuay* managers surveys elicited responses from a very large percentage of the target population (96%) increasing the accuracy of the findings, lack of relative studies using a standardised classification technique (SIC and floor area business classifications and fixed thresholds for the examined classes) limited the ability of the study to draw comparisons with other relevant studies and ascertain the validity of the data. This was due to a general lack of comparative logistics studies in the literature review, the absence of coherence between international studies, the existence of conceptual differences (e.g. different businesses breakdown due to different business profiles such as in Cherrett *et al*, 2009). More comparative studies using a common classification system and a clear marked delimitation would therefore expand understanding on current forward and reverse logistics practices across different groups of retail businesses in order to identify the different roles, functions and needs within the overall retail spectrum with the aim to help businesses improve their capabilities, reduce costs and cut down environmental externalities through better organisation of their logistics activities.

- **Deficiencies in Statistical Data on Volumetric Loading of HGVs/LGVs:** One of the main issues faced in this study was the lack of available data about the cubic volume of freight moved and the volumetric capacity of vehicles (in m^3). Statistical data on the loading of HGVs in the UK is available through the '*Continuous Survey of Road Goods Transport (CSRGT)*'. However the '*CSRGT*' provides vehicle fill capacity data only by weight (in tonnes). The review of UK freight studies revealed that only one *Freight Best Practice* case study had in fact measured vehicle fill capacity by volume. However this was based on a sample of 22 large non food retail distribution companies (DfT, 2003; Section 2.2.2.7) whose profile presented significant differences from *WestQuay*'s business profile.

  To aid analysis it was deemed necessary to assume that each vehicle servicing *WestQuay* was carrying a load with a total weight equal to the UK average load figures provided by DEFRA (2010; Tables 14 and 15). Also it was assumed that this load presented uniform weight distribution across its volume therefore any change in the magnitude of one estimate (e.g. 20% increase in volume) would cause analogous change in the magnitude of the other estimate (20% increase in weight). Since the volume (m^3) of products carried were estimated using the data collected from the interviews with retailers, this equivalence could provide evidence about the corresponding weight and enable the calculation of GHGs. In reality though, a vehicle may upload and offload products of similar size but of completely different weight, and vice versa. Therefore, a consignment may reach its legal maximum volume limit before it reaches its weight limit. To reduce such uncertainties it is essential to conduct systematic surveys on the vehicle fill capacity by volume, ideally for a number of different product streams.

- ***Deficiencies in Statistical Data on Emission Factors:*** The emission factors provided by DEFRA (2010; Tables 14 and 16) do not distinguish between primary (strategic networks), secondary and tertiary routes. Each road type presents different patterns of freight movement (e.g. congestion conditions and speed limits) and different configurations of supply chain networks (e.g. intermediate stops) which in turn impact on the amount of emissions generated. A sectoral analysis of freight activity and GHGs generation from road freight transport would supplement existing data.

9.6 *WestQuay* Consolidation Scheme Recommendations

Following a detailed review of UK commercial consolidation schemes and the examination of *Waterstone*'s and *WestQuay'*s case studies (Chapters 3 and 8), the study concluded that the participation in a consolidation scheme can be beneficial for retailers receiving low vehicle loads, logistics providers making wide-spread multi-drop deliveries, and retail businesses co-locating in high streets, historic town centres or shopping centres. No significant benefits should be expected for businesses receiving highly time-sensitive and high-value products, full vehicle loads and consolidated shared-user deliveries. The most critical factors impacting the operation of a UCC included the support from stakeholders, the availability of funding and the level of participation. Accordingly, lack of funding and low participation were among the most critical risks threatening the viability of a UCC scheme. In considering the above findings, the following recommendations should be taken into account:

9.6.1 The Way Forward for Commercial Consolidation Schemes in the UK

As the concept of UCCs attracts increasing attention from the retail sector, Government and carriers, the following recommendations should be considered in planning a new scheme:

A. Recommendations for the Government
- Create a legal framework to support the operation of UCC schemes and oblige carriers and operators to collaborate. Publish information about new regulations.
- Promote the use of various forms of UCCs by producing planning guidances and best practice guides and develop supportive local transport measures to achieve a higher degree of acceptance.
- Provide support and funding for pilot schemes.
- Encourage UCC operators to keep a record of details relating to the operation of UCCs through the development of a specific reporting framework which will enable critical evaluations and comparisons between schemes.

B. Recommendations for Local Authorities
- Incorporate the UCCs concept into local transport plans, sustainable distribution strategies, air quality standards and other policy initiatives.

- Run consultations with other Local Authorities and UCC operators to share important information on the steps needed to be taken and the obstacles needed to overcome to ensure the suitability and the success of a UCC scheme.
- Agree with transport operators and retailers on HGVs routes, signage, access times and loading/unloading zones.
- Raise public awareness and support on the scheme by publishing information about the potential benefits of a UCC (e.g. reduced traffic, congestion, emissions, noise).

C. Recommendations for UCC Operators

- Carry out thorough evaluations of older and existing UCC schemes in order to assess the suitability and the operational characteristics of the new development.
- Collect information on laws and regulations that impact a UCC's operation.
- Explore state-of-the-art technologies that enable more efficient transport planning, web-based coordination, access to real-time information and communication between retailers, UCC operators and logistics providers.
- Ensure sufficient support and funding, especially during the initial stages of a scheme.
- Secure the participation of a minimum number of businesses and take all appropriate steps to attract more local/regional participants in the future.
- Select an existing infrastructure with expanding potential able to fit future demand.
- Produce or get access to existing audits of traffic flows and goods in transit to allow evaluations and comparisons with other schemes.
- Develop a good communications strategy with all key stakeholders e.g. through the creation of a steering committee which will be responsible for the organisation of meetings and workshops and the taking of decisions on basic elements of the scheme.

D. Recommendations for Research Institutions and Universities:

- Participate actively in feasibility studies, data collection activities, technical, financial, social and environmental studies, and critical evaluations of the outputs.

- Create a detailed database of the characteristics of past and existing UCC schemes in the UK and abroad taking into account the different forms and activities of UCCs (e.g. construction and retail sites, airports).
- Examine the effectiveness of UCCs when implemented in conjunction with wider transport measures.
- Estimate the total costs/gains of a UCC scheme by internalising the transport external costs and benefits (e.g. environmental degradation/improvement).
- Use simulation modelling to examine spherically the supply chain impacts that may arise from the establishment of numerous UCCs rather than isolated cases.
- Support the dissemination of best-practice examples and promote information exchange between research institutions, politicians and businesses.

9.6.2 The Way Forward for WestQuay's Consolidation Scheme

For the operation of a consolidation centre in the outskirts of Southampton the following actions should be taken:

A. Conduct a Feasibility Study:
   - Use the current report as an initial feasibility study which determines the potential for a UCC scheme to serve *WestQuay* retailers. This study has already reviewed extensively the literature related to retail logistics including a number of UCCs studies, has delved into numerous case studies and freight statistics, has explored a plethora of retail operations taking place in *WestQuay*, has suggested a series of solution options and has examined the operation of a UCC in the outskirts of Southampton as a means to mitigate the freight transport and environmental issues facing the city.
   - Review the current feasibility study to validate its findings and update its content to consider the current business situation. The new study must be jointly produced by all key stakeholders (Local Authority, carriers, retail businesses, funding bodies), define the target area (e.g. *WestQuay*, high street, regional businesses), the size and the location of the UCC, the types of the services provided (e.g. basic, value-added), operating scenarios (e.g. vehicle modes, retailers mix, level of participation), additional transport measures (e.g. access restrictions, time windows), service costs for each supply chain member

(e.g. retailers, carriers), available funding sources (e.g. public, private, combination), as well as the form of a reporting and evaluation framework.

B. Run a Trial Consolidation Scheme: A trial consolidation scheme should be put forward to understand in practice the suitability, the impacts and the measures needed to move towards the full implementation of a UCC. To this end, the following actions should be taken:

- Secure the support of the City Council, *Hammerson*'s and a number of local/regional retail businesses.
- Allow *WestQuay* and other high street retailers to sample and experience the benefits arising from the use of the trial consolidation centre without incurring a charge.
- Develop a standard and consistent framework to record, monitor and compare urban traffic and emissions with data collected prior the operation of the trial scheme. Real time traffic and road condition data could be taken from the Southampton ROMANSE website (http://southampton.romanse.org.uk). Evaluations should be conducted against the objectives of the current Local Transport Plan and key performance indicators such as the number of vehicle trips, mileage, pollutants emissions and retailers satisfaction.
- Identify potential funding sources especially for the initial stages of the consolidation scheme (e.g. Government funds, EU grants, private investments).
- Assess the actual demand of local/regional retailers for consolidated deliveries, collections and other services (e.g. storage, gate-keeping, recycling) and identify the complementary measures that would be needed to run the scheme in an on-going basis.
- Run consultations with local stakeholders on setting a service cost that would not discourage retailers' participation.

9.7 Contribution to Research Knowledge

Only few studies have so far examined the logistics activities of a shopping centre. This study aimed at contributing to the following:

- ***The literature and knowledge pertinent to green logistics*:** The study provided an in-depth review of the most recent literature on forward and reverse logistics practices in the retail sector highlighting current supply chain and logistics trends, problems and advances facing the sector. It provided a spherical picture of the progress of logistics throughout years and examined the state and the performance of the logistics sector today by covering a wide range of research works, case studies and national statistics which were not reported in previous literature reviews. It recorded the progress towards the coverage of research gaps identified in previous studies and suggested areas to be further examined (e.g. gate-keeping and online shopping).
- ***Development of an evaluation framework for the selection of the optimal emissions assessment method*:** The study collected and compared a broad range of emissions assessment methods used in a range of international and national freight studies. Although many projects have examined the environmental impact of logistics operations, it is not always clear the method selected, the assumptions made and the accuracy attained. Through the review of numerous studies, classification techniques and assessment methods this thesis attempted to shed light into these issues while forming a practical framework for the selection of the best emissions assessment method in accordance to the varying requirements of freight studies. Following these reviews and comparisons, the study described and suggested the use of a recently developed emissions assessment method by DEFRA for similar UK freight studies.
- ***The field of spatial and sectoral empirical research in green logistics*:** In 1996 Mc Kinnon highlighted the need to conduct more survey-based analysis to improve knowledge and understanding in reverse logistics trends. Although since then several surveys have been conducted, the review of the literature identified the lack of surveys made on businesses operating within a shopping centre. The study developed a four-stage survey model as it identified the need to corroborate and supplement freight-related data through interviews with retailers, logistics providers, waste contractors and head offices. It also described in detail the special operational and logistical characteristics of businesses operating in integrated retail environments and highlighted the available opportunities to improve their traditional reverse logistics operations

through well-organised and shared on-site storage, treatment, consolidation and collection practices. *WestQuay*'s exceptional environmental performance which was achieved through a centrally coordinated system could serve as a best case example for other shopping centres as well as high street districts.

- ***The knowledge about the legislative implications on commercial supply chain operations*****:** The study exhibited in detail how several drivers and especially legislation fuel supply chain changes across different businesses. It described the obligations of commercial businesses under various legislative tools, it showed how the different businesses interpret and integrate these requirements within their existing supply formations and it reviewed a number of case studies to present the variations among different supply chains, the difficulties met and best case examples.
- ***The knowledge about the freight activities of businesses of different sizes*****:** This study is one of the few existing studies that explore and compare the logistics operations of small, medium and large businesses. After reviewing a number of previous studies that attempted to run logistics analysis using retail floor size classifications, this study identified the absence of any comparative studies. On this basis, it proposed a classification framework that could enable the comparison between similar studies. In addition, through detailed floor-size analysis this study revealed that the smaller businesses were often more responsible for increased freight activity as they were receiving many small deliveries from a range of different suppliers against the largest deliveries which were receiving fewer and more consolidated deliveries.
- ***The knowledge about the special management requiring various hazardous wastes*****:** The study offered an in-depth investigation of the variety of hazardous waste characteristics and the diverse environmental regulations in place and explored how these affected the development of variable reverse logistics networks. Previous logistics studies had overlooked this area and had developed a special focus on optimisation of traditional networks for hazardous wastes.
- ***The knowledge about the potential logistics gains when using local recycling markets*****:** Through the review of a number of case studies on hazardous wastes, the study identified that most of the retail businesses chose their recycling contractors on the basis of cost and not proximity principles. The

study examined the potential transport benefits that could be achieved through the use of more localised recycling outlets but though the in-depth examination of case studies examples concluded that local collection sites can merely serve as starting points of complex recycling networks. It showed that the mileage and environmental footprint are not always reduced through a seemingly 'final disposition' of recyclables in local recycling facilities and highlighted the need to develop fully-integrated recycling markets at a local level to absorb the regional production of recyclables.

- ***The knowledge about the successful operation of commercial consolidation schemes*:** Through the review of numerous commercial consolidation schemes in the UK and abroad, the study collected evaluated and created a planning framework considering any operational, logistical, financial and organisational issues that can affect the successful operation of a UCC. The review of existing schemes and their operational characteristics is a contribution to the relevant literature and can be used as guidance in real-life projects.
- ***The understanding of the trade-offs between reforms on supply chains and their performance through the implementation of comparative studies*:** Through *Waterstones* 'before-after' comparisons and *WestQuay*'s UCC scenario analysis, the study exhibited how the reform of a supply chain can lead to significant operational, environmental and financial gains. Not many freight studies in the retail sector have examined the logistics and environmental gains that a business can enjoy through the transition towards a vertically integrated supply chain (*Waterstones*) and a horizontally integrated supply chain (*WestQuay*).

9.8 Directions for Future Work

The following research steps associated with the current study should be undertaken:

- ***Follow-up Surveys*:** As part of an ongoing transportation planning process at an individual, corporate or government level, the conduct of ongoing surveys would be imperative to track potential operational, inventory, regulatory and technological changes and consider an expanded geographical and modal coverage of the consolidation scheme. In addition the analysis method should be reviewed over time to ensure consistency with evolving research and national freight statistics.

- ***More Comparative Studies*:** Upcoming research should include the conduct of further rigorous logistics studies in the retail sector introducing a widely accepted classification system to help draw comparisons across different surveys and between similar business profiles.
- ***Larger Survey Sample*:** Future research may extend the survey to cover a larger sample (e.g. include the two department stores and other High Street and regional businesses) so as to investigate the wider regional mileage and environmental benefits that may arise from a wider participation in the UCC scheme.
- ***Further Sensitivity Tests*:** Sensitivity analysis was limited to the examination of various participation regimes to the scheme and different vehicle fill rates and delivery mixes. Although the seasonal variation of the MCGs volume was determined and the relevant scenarios were undertaken more sensitivity tests should be examined to consider overall increases in the volume processed in the consolidation centre each day.
- ***Estimation of the Breakeven Point of the UCC Operation*:** To determine the breakeven point of the UCC operation, it would be essential to conduct a benefit-cost analysis for each of the operational scenarios examined in the study. This would require a sufficient throughput to ensure operational profitability. To make the activity commercially viable, the relevant calculations should consider a normal profit margin for the UCC operators.

9.9 Recommendations

In addition the following recommendations aim to address policy and technical issues that affect the road freight transport sector:

- ***Fundamental Supply Chains Re-shape to address Congestion & Carbon Issues:*** The current study demonstrated the complexity of supply chain networks connecting raw material sources with final points of consumption and disposal. To cut down the carbon footprint of retail logistics, it would be essential to reduce the number of links and the overall distance travelled. A rationalisation of current logistics patterns could be achieved through a better match between available transport infrastructure and supply chain structures. This would potentially demand higher consolidation rates in long-haul trips and greater traffic dispersal in secondary transport links. Localisation of forward and reverse logistics activities would be advantageous considering the capacity of the network and the local strategic transport plans. Such regional development priorities should fall under a wider national policy supplemented by a full sectoral database where data would be consistent and complete.

- ***Usage of Sophisticated Routing and Communication Tools*:**
  Further environmental gains could be attained through the use of improved computerised vehicle routing and scheduling systems by taking into account traffic conditions and modifying routing plans dynamically. In addition the use of interactive platforms for freight or auction-based allocation of loads could reduce the number of empty-running and increase the average payload of vehicles. Both present a significant potential to reduce GHGs and costs, therefore a special focus should be given by the Government and the industry to such technological innovations.

9.10 Discussion

Through the examination of *WestQuay* case study the study examined traditional logistics practices taking place in the retail sector. It was found that vehicle utilisation was often poor with vehicles travelling half-empty leading to excessive traffic activity and emissions. It was found that considerable opportunities to reduce the overall transport and environmental footprint lie into the higher consolidation of core goods and the better vehicle mix and load rates. To achieve this synergies among rival businesses must be developed and coordinated centrally by the shopping centre’s management team.

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Glossary

A

After-Sale Services: Services provided to the customer after products have been delivered. These include repairs, maintenance and telephone support (CSCMP, 2010).

Atmospheric Lifetime: The approximate amount of time it would take for the anthropogenic increment to an atmospheric pollutant concentration to return to its natural level (assuming emissions cease) as a result of either being converted to another chemical compound or being taken out of the atmosphere via a sink.

B

Backhaul: The portion of a transport trip that is incurred when returning a vehicle to its point of origin. Ideally the carrier with find some sort of freight to carry back, if the trip is empty it is called deadhead (CSCMP, 2010).

Ballast (light): An electrical device for starting and regulating fluorescent and discharge lamps.

Best Practicable Environmental Option (BPEO): A procedure that emphasises the protection and conservation of the environment across land, air and water and establishes for a given set of objectives, the option that provides the most benefits or the least damage to the environment, as a whole, at acceptable cost, in the long term as well as in the short term.

Best Practice: A specific process or group of processes which have been recognised as the best method for conducting an action. They may vary by industry or geography depending on the environment being used. Best practices methodology may be applied with respect to resources, activities, cost object, or processes (CSCMP, 2010).

Brokers: Firms specialising in products that are at the end of their sales life. Often, they are willing to purchase any product, in any condition, given a low enough price. Often they are the last resort for many returns.

Busy Periods: Periods during which products delivered, returns arisings and waste production increase by more than 50% when compared to standard periods.

C

Carbon Dioxide Equivalent (CO_2e): The amount of CO_2 by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another GHG. CO_2e are computed by multiplying the weight of the gas being measured by its estimated GWP.

Carrier: A firm which transports goods or people via land/sea/air (CSCMP, 2010).

Cash and Carry: Options strategy in which a futures contract is sold and a matching cash contract is bought to profit from their price discrepancy.

Catering Waste: All waste food including used cooking oil originating from restaurants, catering facilities and kitchens including central kitchens and household kitchens (excluding sandwich making kitchens). Raw meats are also included.

Chain Stores: Retail outlets that share a brand and central management, and usually have standardised business methods and practices. They are a form of franchising and are most commonly department, grocery, limited-price variety, ready-to-wear apparel (e.g. *Gap*) and drug stores.

Clinical Waste: Any waste which poses a threat of infection to humans (e.g. human or animal tissue, blood or other bodily fluids, drugs or other pharmaceutical products, syringes, needles or other sharp instruments).

Closed Loop: A production system in which the waste or by-product of one process or product is used in making another product.

Commercial Waste: Waste produced by any premises which are used wholly or mainly for trade, business, sport recreation or entertainment, excluding municipal and industrial waste.

Commodity: Any physical item that is traded in commerce. It usually implies an undifferentiated product competing primarily on price and availability (CSCMP, 2010).

Consignee: Any hazardous waste receiver (in the context of hazardous waste).

Consolidation: The process of combining two or more shipments in order to realise lower transportation rates. Inbound consolidation from vendors is called make-bulk consolidation; outbound consolidation to customers is called break bulk consolidation (CSCMP, 2010).

Controlled Waste: Waste from households, commerce or industry and includes hazardous/special wastes.

Core Goods: Products of fundamental importance to each business activity (e.g. for retail stores this would be those goods sold to final customers and for restaurants the essential supplies of food and drink).

Corporate Social Responsibility: The continuing commitment by business to behave in an ethical and environmentally responsible manner and to contribute to economic development, while improving the quality of life of the workforce and their families, as well as that of the local community and society at large.

Corrosive: Substances and preparations which may destroy living tissue on contact.

Courier Service: A fast, door-to-door service for high-valued goods and documents; firms usually limit service to shipments of 50 pounds or less (CSCMP, 2010).

Cradle to Grave: A term used to include logistics planning, design, and support taking into account logistics support throughout the entire system or product life cycle (LogisticsWorld, 1999).

Criteria Pollutants: These include pollutants that are common and found all over the United States. EPA uses these "criteria pollutants" as indicators of air quality. They include: carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), lead (Pb) and particulate matter (PM).

Cross Docking: A distribution system in which merchandise received at the warehouse or distribution center is not put away, but instead is readied for shipment to retail stores. It requires close synchronization of all inbound and outbound shipment movements. By eliminating the put-away, storage and selection operations, it can significantly reduce distribution costs (CSCMP, 2010).

Customer: a) In distribution, the Trading Partner or reseller, b) In Direct-to-Consumer, the end customer or user (CSCMP, 2010).

Customer Service: All activities between the buyer and seller that enhance or facilitate the sale or use of the seller's products or services (CSCMP, 2010).

Cytotoxic and Cytostatic Medicines: Medical products that have one or more of the following hazardous properties: toxic, carcinogenic, mutagenic, or toxic for reproduction.

D

Direct Emissions: GHG emissions produced at the point of use of a fuel/energy carrier (DEFRA, 2010).

Disposition Option: The decision about what is to be done for the returned product next. There are three types of disposition options for products returned: resell directly at the collection centre, repair and refurbish and remanufacture.

Distribution: The activities associated with moving materials from source to destination. Can be associated with movement from a manufacturer or distributor to customers, retailers or other secondary warehousing/distribution points.

Distribution Center (DC): The warehouse facility which holds inventory from manufacturing pending distribution to the appropriate store

Distributor: Any business who provides EEE on a commercial basis to a consumer.

Drive Cycle: A series of data points representing vehicle speed versus time.

Duty of Care: A legal obligation imposed on an individual requiring that they adhere to a standard of reasonable care whilst performing any acts that could foreseeably harm others. With regards to waste it applies to 'holders' of 'controlled waste'.

E

Empty-Running: The proportion of vehicles per kilometre that run empty.

End-of-Life: The planning and execution at the end of a product's life. The challenge is making just the right amount to avoid ending up with: a) excess which has to be sold at great discounts or scrapped b) shortages before the next generation is available.

Energy Recovery from Waste: It includes a number of established and emerging technologies, though most energy recovery is through incineration technologies. Many wastes are combustible, with relatively high calorific values – this energy can be recovered though, for example, incineration with electricity generation.

Environmental Impact Assessment: A process for carrying out an appraisal of the full potential effects of a development project on the physical environment.

E-retailer: A business that uses an electronic network such as the Internet to sell its goods or services.

Explosive: Substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.

F

Facilities: All installations, contrivances, or other things which facilitate something; a place for doing something: commercial or institutional buildings, including offices, plants and warehouses.

Factory Gate Pricing (FGP): A supply chain initiative that has been gaining popularity among retailers in England. With FGP, retailers buy goods at the suppliers' 'gate' and take care of getting it to their stores or distribution centres, either with their own trucks or those of their contracted carriers.

Fast Moving Goods: A type of good that is consumed every day by the average consumer. The goods that comprise this category are ones that need to be replaced frequently, compared to those that are usable for extended periods of time.

Fast Moving Industry: A type of industry which corresponds to fast moving goods and in which lead time, accuracy, availability and reliability are of critical importance.

Fill Rate: The percentage of order items that the picking operation actually fills within a given period of time.

Flammable: Liquid substances and preparations having a flash point equal to or greater than 21 °C and less than or equal to 55 °C.

Footfall: The number of people visiting a shop or a chain of shops in a period of time. It is an important indicator of how successfully a company's marketing, brand and format bring people into its shops.

Freight: All goods being transported from one place to another.

Freight Carriers: Companies that haul freight, also called "for-hire" carriers. Methods of transportation include trucking, railroads, airlines, and sea borne shipping.

Freight Consolidation: The act of combining individual shipments into a single lot in order to reduce costs or improve transport equipment utilization. Consolidation can take a variety forms by customer, geography, shipping land or schedule and may occur at the shipping facility or may be a service of a third party.

Freight Village: A concentration (or a cluster) of freight related activities within a specific area, commonly built for such a purpose, master planned and managed. These activities include DCs, warehouses and storage areas, transport terminals, offices and other facilities supporting those activities, such as public utilities, parking spaces, hotels and restaurants. Although a freight village can be serviced by a single mode, intermodal facilities can offer direct access to global and regional markets.

G

Global Warming Potential (GWP): It is a measure of how much a given mass of GHG is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of CO_2 (GWP=1). A GWP is calculated over a specific time interval because the gases have different lifetime in the atmosphere (international practice: 100-year horizon). GHGs are measured in tonnes of CO_2e by multiplying their estimated emissions with their GWP.

Goods: a) Movable property, merchandise, or wares, b) All materials used to satisfy demands, and c) Whole or part of the cargo received from the shipper, including any equipment supplied by the shipper.

Goods Lifted: The total weight of goods loaded (in tonnes) regardless the distance for which products are carried. This means that if goods carried on one HGV are later loaded onto another HGV, they will be counted as being lifted twice.

Greenhouse Gas Emissions: Gases as water vapour, carbon dioxide, methane, nitrous oxide, and ozone, emitted to the atmosphere by human activities.

Green Logistics: Supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution. It focuses on material handling, waste management, packaging and transport.

Gross Weight: The total vehicle weight and the payload of freight or passengers.

H

Haulage: The inland transport service which is offered by the carrier under the terms and conditions of the tariff and of the relative transport document.

Hazardous Waste: Any waste that has properties that may make it harmful to human health or the environment.

Healthcare Waste: Waste from natal care, diagnosis, treatment or prevention of disease in humans/animals (e.g. infectious/anatomical/sharps/medicinal waste, laboratory cultures/chemicals, offensive/hygiene waste from wards or other health care areas).

Holder: A person who imports, produces, carries, keeps, treats, or disposes of ‘controlled waste’ or, as a broker, has control of it.

Hub: Central point for the collection, sorting, trans-shipment and distribution of goods and passengers for a particular area. This concept comes from a term used in air transport for passengers as well as freight. It describes collection and distribution through a single point such as the ‘Hub and Spoke’ concept. Hubs tend to be trans-modal (transfers within the same mode) locations.

I

Inbound Logistics: The movement of materials from suppliers and vendors into production processes or storage facilities.

Indirect Emissions: GHG emissions produced prior to the use of a fuel/energy carrier e.g. as a result of extracting and transforming the primary energy source (DEFRA, 2010).

Infectious Waste: All substances containing viable micro-organisms or toxins which are known or reliably believed to cause disease in man or other living organisms.

Information Systems (IS): Managing the flow of data in an organization in a systematic, structured way to assist in planning, implementing, and controlling.

Integrated Logistics: A comprehensive, system-wide view of the entire supply chain as a single process, from raw materials supply through finished goods distribution. All functions that make up the supply chain are managed as a single entity, rather than managing individual functions separately.

Inventory: Components, raw materials, work in process, finished goods and supplies required for the creation of goods and services; It can also refer to the number of units and/or value of the stock of goods held by a company.

Inventory Management: The process of ensuring the availability of products through inventory administration.

J

Just-in-Time (JIT): An inventory control system that controls material flow into assembly and manufacturing plants by coordinating demand and supply to the point where desired materials arrive just in time for use (Blickstein, 2000).

L

Lading Factor: The ratio of the actual goods moved to the maximum tonne-km achievable if the vehicles, whenever loaded, are loaded to their maximum carrying capacity.

Lead Time: The total time that elapses between the placement of an order and its receipt including the time required for order transmittal, processing, preparation and transit.

Load Factor: A measure of operating efficiency used by air carriers to determine the percentage of a plane's capacity that is utilised, or the number of passengers divided by the total number of seats.

Loading Range: A range of weight laden values showing the extent to which a vehicle may be loaded (e.g. 0-25%, 25-50% etc.).

Logistics: The process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements. This definition includes inbound, outbound, internal, and external movements.

Logistics Management: That part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfilment, logistics network design, inventory management, supply/demand planning, and management of 3PL providers. It also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. It is involved in all levels of planning and execution, operational, and tactical. It is a function which coordinates and optimises all logistics activities, and integrates logistics activities with other functions (e.g. marketing, sales, manufacturing, finance, and information technology).

M

Manufacturer: Entity that makes a good through a process involving raw materials, components, or assemblies, usually on a large scale with different operations divided among different workers.

Midpoint: A point equidistant from the ends of a line or the extremities of a figure.

Milk Run: The delivery method for mixed loads from different suppliers. Instead of individual suppliers sending a vehicle every week to meet the weekly needs of a customer, one vehicle visits each supplier on a daily basis and picks up deliveries for that customer. It gets its name from the dairy industry practice where one tanker collects milk daily from several dairy farmers for delivery to a milk processing firm.

Mixed Loads: The movement of both regulated and exempt commodities in the same vehicle at the same time.

Modal Split: a) The proportion of total person trips that uses each of various specified modes of transportation, b) The process of separating total person trips into the modes of travel used, c) A term that describes how many people use alternative forms of transportation.

N

Network: Framework of routes within a system of locations, identified as nodes. A route is a single link between two nodes that are part of a larger network that refers to tangible routes such as roads and rails, or less tangible routes such as air/sea corridors.

Network Optimisation: A process or methodology to make a network as fully perfect, functional, effective or efficient as possible. The use of mathematics may be involved to find the best solution.

Non-Compliance: Failure or refusal to do as requested by higher authority or as prescribed by a set of rules that describe correct procedure to follow (e.g. rules on hazardous waste disposal).

Not In My Back Yard (NIMBY): Opposition to the locating of something considered undesirable (e.g. an incinerator) in one's neighbourhood.

O

Optimisation: The process of making something as good or as effective as possible with given resources and constraints.

Order Cycle: The time and process involved from the placement of an order to the receipt of the shipment.

Original Equipment Manufacturer (OEM): The rebranding of equipment and selling it under another name, or as a component of another product. OEM refers to the company that made the products (the "original" manufacturer), but with the growth of outsourcing, eventually became widely used to refer to the organisation that buys the products and resells them. This term has two generally acceptable definitions which are actually opposites of each other and may vary by industry: 1) The OEM reseller is often the designer of the equipment, and 2) Companies that make products for others to repackage and sell, or to incorporate into a final assembly.

Outbound Consolidation: Consolidation of a number of small shipments for various customers into a larger load. The large load is then shipped to a location near the customers where it is broken down and then the small shipments are distributed to the customers. This can reduce overall shipping charges where many small packet or parcel shipments are handled each day.

Outbound Logistics: The process related to the movement and storage of products from the end of the production line to the end user.

Outsource: To utilise a third-party provider to perform services previously performed in-house. Examples include manufacturing of products and call center/customer support.

Oxidising: Substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.

P

Pallet: The platform which cartons are stacked on and then used for shipment or movement as a group. Pallets may be made of wood or composite materials. Some pallets have electronic tracking tags (RFID) and most are recycled in some manner.

Payload: Weight of commodity being hauled. Includes packaging, pallets, banding, etc., but does not include the truck, truck body, etc.

Peak Period: Represent a time period of high usage of a transport system. For transit, it refers to morning and afternoon time periods when ridership is at its highest.

Physical Distribution: The movement and storage functions associated with finished goods from manufacturing plants to warehouses and to customers; also, used synonymously with business logistics.

Point Of Sale (POS): a) The time and place at which a sale occurs, such as a cash register in a retail operation, or the order confirmation screen in an on-line session, b) A national network of merchant terminals, at which customers can use client cards and personal security codes to make purchases. Transactions are directed against client deposit accounts.

Polluter Pays Principle: An environmental policy principle which requires that the costs of pollution be borne by those who cause it. It is also known as '*Extended Polluter Responsibility (EPR)*' which seeks to shift the responsibility of dealing with waste from governments and society to the entities producing it. In effect, it internalises the cost of waste into the cost of the product, theoretically meaning that the producers will improve the waste profile of their products, thus decreasing waste and increasing the possibilities for reuse and recycling.

Primary or **Sales Packaging:** The formation of a sales unit for the user or final consumer.

Procurement: The activities associated with acquiring products or services. The range of activities can vary widely between organizations to include all of parts of the functions of procurement planning, purchasing, inventory control, traffic, receiving, incoming inspection, and salvage operations.

Producer: Anyone whose activities produce waste or who carries waste or carries out pre-processing, mixing or other operations resulting in a change in its nature or composition.

Producer Responsibility: a) A policy tool aimed at ensuring that businesses who place products on the market take the responsibility for those products once they have reached the end of their life, b) A strategy designed to promote the integration of environmental costs associated with goods throughout their life cycles into the market price of the products (OECD, 2001).

Product: Something that has been or is being produced (see also core goods).

Product Characteristics: The elements defining a product's character (e.g. size, shape, weight).

Product Life Cycle: The life of a product in a market with respect to business sales and profits over time. There are five stages to the product life cycle: product development, introduction, growth, maturity and decline.

Q

Quality: The degree to which a set of defined characteristics of a product or service fulfils known requirements, usually customer's expectations. Quality has no specific meaning unless related to a specific function and/or object. It is a perceptual, conditional and somewhat subjective attribute.

Quality Assurance: A program for the systematic monitoring and evaluation of the various aspects of a project, service, or facility to ensure that standards of quality are being met.

Quality Control (QC): A management function that attempts to ensure that the foods or services manufactured or purchased meet the product or service specifications.

Quick Response (QR): A strategy widely adopted by general merchandise and soft lines retailers and manufacturers to reduce retail out-of-stocks, forced markdowns and operating expenses. These goals are accomplished through shipping accuracy and reduced response time. QR is a partnership strategy in which suppliers and retailers work together to respond more rapidly to the consumer by sharing point-of-sale scan data, enabling both to forecast replenishment needs.

R

Radio Frequency Identification (RFID): The use of radio frequency technology to identify objects, such as equipment, pallets of stock, or even individual units of product. RFID advantages over bar code technology are: a) the ability to be read over longer distances, b) the elimination of requirement for 'line of sight' readability, c) added capacity to contain information, and d) RFID tag data can be updated/changed.

Raw Materials (RM): Crude or processed material that can be converted by manufacturing, processing, or combination into a new and useful product.

Recovery: Any waste management operation that diverts a waste material from waste stream and which results in a certain product with a potential economic or ecological benefit. It mainly refers to material recovery (e.g. recycling), energy recovery (e.g. re-use a fuel), biological recovery (e.g. composting), and re-use.

Recycling: It is the reprocessing in a production process of the waste materials for the original purpose or for other purposes including organic recycling but excluding energy recovery (*Packaging and Packaging Waste Directive [94/62/EC]*).

Re-distribution: A trend in the foodservice distribution business where a large 're-distributor' purchase truckload quantities of products from food manufacturers and warehouses. Individual smaller distributors can then purchase multiple manufacturers' products from the re-distributor and fill up an entire truck to save on shipping costs.

Refrigerated Carriers: Truckload carriers designed to keep perishables good refrigerated. The food industry typically uses this type of carrier.

Regional Distribution Centre (RDC): A collection and consolidation centre for finished goods, components and spare parts produced by its own group of companies for its own brand to be distributed to dealers, importers or its subsidiaries or other unrelated companies within or outside the region.

Regional Shopping Centre: A large shopping centre, built in a free-standing position rather than as part of an existing central area. The lower size limit to this type of centre is around 500,000ft², but limits as low as 30,000ft² have been used. Very large centres are usually built on two levels, in order to shorten the distance which shoppers have to walk within the centre. Major stores often trade from both floors.

Remanufacturing/Refurbishing: The re-work performed on returned items to make the items saleable (CSCMP, 2010).

Replenishment: The process of moving or re-supplying inventory from a reserve (or upstream) storage location to a primary (or downstream) storage/picking location, or to another mode of storage in which picking is performed.

Resellers: A company or individual that purchases goods or services with the intention of reselling them rather than consuming or using them. This includes distributors and retailers generally.

Resources: Economic elements applied or used in the performance of activities to directly support cost objects. They include people, materials, supplies, equipment, technologies and facilities.

Retailer: An individual or organisation which purchasers' products from a manufacturer or distributor and resells them to the ultimate consumer. This group includes a wide range of businesses from door to door and corner stores to global companies like *Walmart*, as well as on-line stores like *Amazon* (CSCMP, 2010).

Retail Waste: Products other than waste from an on-site restaurant. Any raw or lightly cooked meats or raw eggs and their packaging are covered.

Return to Vendor (RTV): Refers to materials that have been rejected by the customer or the buyer's inspection department and is awaiting shipment back to the supplier for repair or replacement (CSCMP, 2010).

Re-use: Any operation by which end-of-life products and equipment (e.g. electrical and electronic equipment) or its components are used for the same purpose for which they were conceived.

Reverse Logistics: A specialised segment of logistics focusing on the movement and management of products and resources after the sale and after delivery to the customer. Includes product returns for repair and/or credit.

Routing: The process of determining how shipment will move between origin and destination. Routing information includes designation of carrier(s) involved, actual route of carrier, and estimated time enroute (CSCMP, 2010).

S

Secondary or **Grouped Packaging:** A number of sales units.

Shelf Life: The recommended time that products can be stored, before they are considered unsuitable for sale or consumption.

Shipping: a) The act of conveying materials from one point to another, b) The functional area which preparers the outgoing shipment for transport.

Shopping Centre: It is in effect contained in one very large building, although some of the internal spaces may not be roofed over. Its lower size limit is often 10,000ft² of gross retail area. It includes one or more large 'anchor stores' (department or variety stores), several (often over 50) smaller retail units, and (in larger and more recent centres) a food court, and leisure uses such as cinema or ice rink.

Short-haul: A short move that is usually under 1,000 miles.

Shuttle: A public or private vehicle that travels back and forth over a particular route, especially a short route or one that provides connections between transportation systems, employment centres, etc.

Single Sourcing: When an organisation deliberately chooses to use one supplier to provide a product or service, even though there are other suppliers available.

Social Responsibility: The continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of that of the local community and society at large. It is responsible production, socially responsible labour relations, community involvement, environmental cognizance, and sustainability.

Sub-contracting: Sending work outside the enterprise to a third party. This typically involves specialised operations related to production.
Supplier: An individual or an organisation who supplies goods or services to the company. This is also sometimes referred to as a 'vendor'. In some settings, where a company provides goods through a distribution network, network members may be referred to as suppliers, even though they are the immediate company customers.

Supply Chain Management (SCM): It encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. It includes coordination and collaboration with channel partners (e.g. suppliers, intermediaries, third-party service providers, and customers). Its primary responsibility is to link major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes manufacturing operations, and drives coordination of processes and activities with and across marketing, sales, product design, finance, and information technology.

Sustainability: It refers to the efforts a company makes related to conducting business in a socially and environmentally responsible manner. It includes elements including sustainable development, corporate social responsibility (CSR), stakeholder concerns, and corporate accountability.

T

Terminal: Any location where freight and passengers either originates, terminates, or is handled in the transportation process. Terminals are central and intermediate locations in the movements of passengers and freight. They often require specific facilities to accommodate the traffic they handle.

Tertiary or **Transport Packaging:** Packaging used to group secondary packaging together to aid handling and transportation and prevent physical handling and transport damage to the units.

Third-Party Logistics (3PL): a) A person who solely receives, holds, or transports a consumer product in the ordinary course of business but who does not take title to the product, or b) A specialised company which has undertaken all or much of a company's logistics operations (outsourcing). The term "3PL" was first used in the early 1970s to identify inter-modal marketing companies (IMCs) in transportation contracts. Up to that point, contracts for transportation had featured only two parties, the shipper and the carrier. When IMCs entered the picture, as intermediaries that accepted shipments from the shippers and tendered them to the rail carriers, they became the third party to the contract. Definition has broadened to the point where these days, every company that offers some kind of logistics service for hire calls itself a 3PL. Services they provide are transportation, warehousing, cross-docking, inventory management, packaging, and freight forwarding.

Trade Waste: The commercial element of municipal waste' and covers the waste products produced by retail establishments, offices, hotels and restaurants.

Transfer Station: It is a facility which serves to bulk up waste before it is transferred to other facilities in larger vehicles (DEFRA, 2011).

Transit Time: The total time that elapses between a shipment's pickup and delivery.

Transparency: The ability to gain access to information without regard to the systems landscape or architecture.

Transport(-ation) Mode: The method of transportation: land, sea, or air shipment.

Trans-shipment: The transfer of goods from one carrier to another and/or from one mode to the other.

Treatment: It involves the chemical or biological processing of certain types of waste for the purpose of rendering them harmless, reducing volumes before land filling, or recycling certain types.

Trip Generation: In planning, the determination or prediction of the number of trips produced by and attracted to each zone.

Turnover: a) A calculation of the number of times the inventory of an item would be consumed during a period given average inventory levels and consumption, b) A calculation of the rate that the employee base of a company or department would change during a period due to hiring and termination.

Typical Week: A week not falling during the peak business periods of the year.

V

Value Added: Increased or improved value, worth, functionality or usefulness.

Vendor: The manufacturer or distributor of an item or product line.

W

Warehouse: A storage place for products. Principal warehouse activities include receipt of product, storage, shipment, and order picking.

Waste: Any substance or object which the producer or the person in possession of it discards or intends or is required to discard (under the [75/442/EEC] Directive as amended by [91/156/EEC] and [91/692/EEC] Directives)

Waste Carrier: Any person for authorised transport purposes of 'controlled waste'.

Waste Cooking Oil: Otherwise known as 'used cooking oil' or 'recovered vegetable oil' results from the cooking of food by food manufacturers and catering establishments such as restaurants and industrial kitchens.

Waste Hierarchy: It lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy.

Weight Laden: The extent to which the vehicle is loaded to its maximum capacity. (DEFRA, 2010)

Wholesaler: A merchant middleman who sells chiefly to retailers, other merchants, or industrial, institutional, and commercial users mainly for resale or business use.

APPENDICES

APPENDIX A: QUESTIONNAIRES

A1. Questionnaire used in Interviews with *WestQuay* Retailers [Centralised Distribution]

TRG Transportation Research Group | Hammerson | WestQuay Southampton | Pamper the Planet | University of Southampton School of Civil Engineering and the Environment

Date of Interview d d m m y y **Questionnaire's Code** Completed by the Interviewer

General Information

This questionnaire forms part of a PhD research study being supervised by the Transportation Research Group at the **University of Southampton** with the approval and the cooperation of **Hammerson UK Properties plc**. The aim of the project is to improve the logistics operations and minimise the ecological footprint of reverse transport movements, in regard to returned, damaged or unsold products and the waste produced by retailers in West Quay. In this context, it is very important to contact individual retailers and identify the current cross-supply chain operations adopted to meet financial, legal and social requirements; to obtain origin-destination data; and to identify possible problems, inefficiencies, areas for improvement and solutions.

We would be grateful if you could take part in this interview questionnaire which should take about 30 min to complete. *Please note that any personal information provided will remain confidential under the Data Protection Act 1998 and the results of the study will be presented to you at the end of this project.* If you have any queries, please contact Maria Triantafyllou at the University of Southampton (023) 8059 3013 during office hours or alternatively email: *mt3c06@soton.ac.uk*. Thank you for your time and cooperation.

Section A: General Information

A1) Company's Details:

a) Company's Name:

b) General Manager:

c) Contact Details:

A2) Type of Business: (Please tick all that apply)

- ☐ Non-specialised Stores with Food, Beverages or Tobacco Predominating [52.11]
- ☐ Non-specialised Stores with other Goods where Food, Beverages or Tobacco are not Predominant [52.12]
- ☐ Specialised Store selling Food, Beverages and Tobacco [52.2]
- ☐ Pharmaceutical and Medical Goods, Cosmetic and Toilet Articles [52.3]
- ☐ Fur and Leather Clothing [52.42/1]
- ☐ Children's and Infants' Clothing [52.42/2]
- ☐ Women's Clothing [52.42/3]
- ☐ Men's Clothing [52.42/4]
- ☐ Footwear [52.43/1]
- ☐ Leather Goods [52.43/2]
- ☐ Furniture, Lighting Equipment and Household Articles [52.44]
- ☐ Electrical Household Appliances and Radio and Television Goods [52.45]
- ☐ Books, Newspapers and Stationery [52.47]
- ☐ Photographic, Optical and Precision Equipment, Office Supplies and Equipment (incl. Computers etc.) [52.48/2]
- ☐ Jewellery, Clocks and Watches [52.48.4]
- ☐ Sports Goods, Games and Toys, Stamps and Coins [52.48.5]
- ☐ Second Hand Goods [52.5]
- ☐ Repair of Personal and Household Goods [52.7]

A3) Is your business obligated under the following legislation? (Please see additional notes sheet for description)

a) Producer Responsibility Obligation 2007 (Packaging Waste): ☐ Yes ☐ No ☐ Don't know

i) If yes, could you tell me which Packaging Compliance Scheme you have registered with?

Details: ______________________________

b) Waste Electrical and Electronic Equipment Regulations 2007: ☐ Yes ☐ No ☐ Don't know

i) If yes, could you tell me which WEEE Compliance Scheme you have registered with?

Details: ______________________________

A4) Are you aware of the Producer Pre-treatment Requirements? ☐ Yes ☐ No

i) If yes, could you briefly describe what changes in waste management procedures you have made/intend to make to meet these requirements? ______________________________

1

Section B: Core Goods Deliveries

I would like to start by asking you some questions about the deliveries that take place to your business. Please Note:

1. '**Core goods**' are those that are of fundamental importance to your business activity. For retail stores are those sold to final customers and for restaurants/bars are the essential supplies of food, drink, packaging, laundry etc.
2. A '**typical week**' is **not** during one of your peak business periods of the year.

B1) So, how many deliveries are made to your business during a typical week? ☐
(If you receive less than one delivery per week please state the frequency e.g. twice/month)

B2) How many vehicles deliver core goods to your business by day of the week?

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total No of Vehicles

If you have no fixed delivery times, please tick this box ☐

B3) Which would you say are your busiest trading months of the year? *(Please circle the appropriate months)*

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

B4) During the busiest trading periods you mentioned in Question B3, how many *extra* delivery vehicles would you expect on top of the total non-peak figure you gave in Question B2? *(e.g. 4 per week)* ☐

B5) Where do delivery vehicles park when unloading is taking place?

☐ On West Quay's premises (*please circle the service yard SY*): SY A2 SY A3 SY B2
☐ On a public road outside WQ premises
☐ Away from WQ premises

B6) What is the type of distribution system that supplies your business?

☐ Deliveries from single Distribution Centre
☐ Deliveries from a number of different suppliers. Can you approximately tell me how many? Main: ☐ Secondary: ☐

B7) Who deliver core goods to your business?

☐ Suppliers ☐ Logistics Providers ☐ A combination of Suppliers and Logistic Providers ☐ Other

One thing that hasn't been done in freight surveys is trying to quantify the origin-destination movements and the 'environmental footprint of the supply chain'. In this context, I would now like to ask you a few detailed questions about your single/top 2-3 suppliers and the associated vehicle movements.

Table Questions:

1st Part: Deliveries

B8) Could you tell me the name and the contact details of your 1st/2nd/3rd top supplier/logistics provider (top in terms of delivery levels)?
B9) What is the percentage of total deliveries made by this supplier/logistics provider?
B10) If deliveries are made by logistics providers, who are the suppliers they collaborate with (a) name, b) address, c) no of deliveries on behalf of those suppliers, d) percentage on all deliveries made by the specific logistic s provider)
B11) How many deliveries per week do you receive from this supplier/logistics provider?
B12) Where do the delivery vehicles originate from (address/postcode)?
B13) Could you classify the deliveries you get by consignment types (different products combinations)?
B14) How many deliveries of each type do you receive by day of the week?
B15) Whose fleet is used for the deliveries made by the specific supplier/logistics provider? (Please provide the details/address of the carrier)
B16) Could you specify the vehicle types used to deliver your stock?
B17) What type of services do carriers provide?
B18) i) What type of packaging is used for the delivered products? ii) Could you provide me with the average quantities (fill in the left part of the packaging type) and iii) the size of the used packaging (fill in the big boxes on the right side of packaging type)? iv) Is the used type of packaging re-usable? v) If yes, who owns it?
B19) What is the number of extra deliveries per week during busy periods?

2nd Part: Take-back of Product Returns

B20) Is there any back-loading of product returns? If yes, how often?
B21) In relation to the number of deliveries you get by day of the week (Question B11), how many times by day of the week do vehicles take-back products?
B22) Are take-back services scheduled or made under request?
B23) What types of products are back-loaded?
B24) i) What type of packaging is used for the back-loaded products? ii) Could you provide me with the average quantities (fill in the left part of the packaging type) and iii) the size of the used packaging (fill in the big boxes on the right side of packaging type)? iv) Is the used type of packaging re-usable? v) If yes, who owns it?
B25) Where are the back-loaded products transferred to?
B26) What is the number of extra collections of product returns per week during busy periods?

3rd Part: Take-back of Waste

B27) Is there any back-loading of waste/recyclate? If yes, how often?
B28) In relation to the number of deliveries you get by day of the week (Question B11), how many times by day of the week do vehicles take-back waste/recyclate?
B29) Are take-back services scheduled or made under request?
B30) What types of waste/recyclate are back-loaded?
B31) i) What type of packaging is used for the back-loaded waste/recyclate? ii) Could you provide me with the average quantities (on the left side) and iii) the size of the used packaging (on the right side)?
B32) Where is the back-loaded waste/recyclate transferred to?
B33) What is the number of extra collections of waste/recyclate per week during busy periods?

Supplier/Log.Provider A		Deliveries (Typical Week)								Busy Periods
(B8) Name	(B11) No	(B12) Origin	(B13) Delivered Products	Products Info	(B14) Deliveries No/Day	(B15) Fleet	(B16) Vehicle Type	(B17) Services	(B18) Packaging (No, Type, Size)	(B19) ExtraNo
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
(B9) % of total Deliveries		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	

B10) Suppliers			
a) Name	b) Address	c) Deliveries No	d) %

Take-Back of Product Returns							Busy Periods
(B20) Take Back	(B21) No/Day	(B22) Services	(B23) Collected Products	Products Info	(B24) Packaging (No, Type, Size)	(B25) Destinations	(B26) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	

Take-Back of Waste (Typical Week)							Busy Periods
(B27) Take Back	(B28) No/Day	(B29) Services	(B30) Waste Type	Waste Types Info	(B31) Packaging	(D32) Destination	(B33) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	

3

Supplier/Log.Provider B	Deliveries (Typical Week)									Busy Periods
(B8) Name	(B11) No	(B12) Origin	(B13) Delivered Products	Products Info	(B14) Deliveries No/Day	(B15) Fleet	(B16) Vehicle Type	(B17) Services	(B18) Packaging (No, Type, Size)	(B19) ExtraNo
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van or ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van or ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van or ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
(B9) % of total Deliveries		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van or ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van or ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	

B10) Suppliers			
a) Name	b) Address	c) Deliveries No	d) %

Take-Back of Product Returns							Busy Periods
(B20) Take Back	(B21) No/Day	(B22) Services	(B23) Collected Products	Products Info	(B24) Packaging (No, Type, Size)	(B25) Destinations	(B26) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	

Take-Back of Waste (Typical Week)							Busy Periods
(B27) Take Back	(B28) No/Day	(B29) Services	(B30) Waste Type	Waste Types Info	(B31) Packaging	(D32) Destination	(B33) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ____	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	

Supplier/Log.Provider C	Deliveries (Typical Week)									Busy Periods
(B8) Name	(B11) No	(B12) Origin	(B13) Delivered Products	Products Info	(B14) Deliveries No/Day	(B15) Fleet	(B16) Vehicle Type	(B17) Services	(B18) Packaging (No, Type, Size)	(B19) ExtraNo
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
(B9) % of total Deliveries		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	

B10) Suppliers			
a) Name	b) Address	c) Deliveries No	d) %

Take-Back of Product Returns							Busy Periods
(B20) Take Back	(B21) No/Day	(B22) Services	(B23) Collected Products	Products Info	(B24) Packaging (No, Type, Size)	(B25) Destinations	(B26) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	

Take-Back of Waste (Typical Week)							Busy Periods
(B27) Take Back	(B28) No/Day	(B29) Services	(B30) Waste Type	Waste Types Info	(B31) Packaging	(D32) Destination	(B33) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ___	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	

Section C: Product Returns

Possible areas where efficiency gains can be made are in waste and returns management. I would just like to ask you a few questions on these aspects of your business. First of all, I would ask you about the returns management of your Business.

C1) In addition to the 'Back-loads', how many 'dedicated vehicles' take away returns during a typical week? (*If less than 1 collection per week takes place please state the frequency e.g. twice/month*) ☐

C2) Which are your busiest months of the year in terms of product returns? (*Please circle the appropriate months*)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

C3) During the busiest 'product returns' periods, how many *extra* collection vehicles would you expect on top of the non-peak figure you gave in Question C7? (e.g. *4 per month*) ☐

C4) Where do collection vehicles park when loading is taking place?

☐ On West Quay's premises (*please circle the service yard SY*): SY A2 SY A3 SY B2
☐ On a public road outside WQ premises
☐ Away from WQ premises

C5) How does your store typically manage its returns?

☐ Store returns and then send back. If so, how frequently? ☐
☐ Procedures vary between suppliers and collectors.
☐ Collected immediately (at the earliest convenience)
☐ Other

C6) What type of facilities do you have for storing returns in-store?

☐ Designated in-store returns area.
☐ Stock holding area.
☐ Delivery area.
☐ No designated returns area. .
☐ Other (*Please specify*): ____________

C7) Is the storage/handling capacity of these facilities adequate during:

a) **Standard trading periods** ☐ Yes ☐ No
b) **Busy peak periods** ☐ Yes ☐ No

C8) What equipment do you have on-site to handle product returns?

	No of	Type	Location
☐ Check/control facilities			
☐ Storage containers			
☐ Sorting facilities			
☐ Other			

C9) In terms of unsold <u>stock returns</u>:
a) Where is stock transferred to? Please provide the address (area/postcode).
b) Who collects stock returns? Please provide the details of the collector (name, address).
c) What is the collections frequency for each type of stock?
d) What types of vehicles are used to collect those returns?
e) What types of stock are transferred to each destination you gave in (a)?

a) Destination	b) Carrier	c)Frequency	d) Vehicle Type	e) Stock Types
☐ Stock returns to RDC RDC Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other
☐ Stock returns direct to a supplier Supplier's Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other
☐ Store transfers via RDC RDC Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other
☐ Store transfers direct to another store Store Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other

C10) In terms of <u>customer returns</u>, what is the return policy of your business?

No Returns Permitted	7 Days	14 Days	28 Days	30 Days	45 Days	60 Days	90 Days	Liberal Returns	Other (*Please specify*)
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

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C11) One area that is not well understood is who makes the decision on what happens to a customer return and how this impacts on transport. In this context, I would like to ask you:

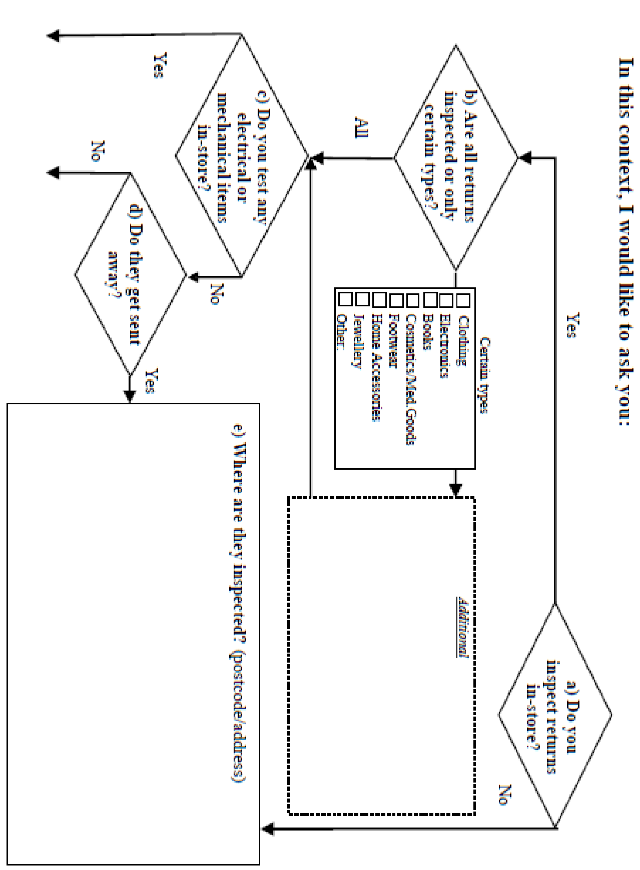

Table Questions:
C12) So, what happens to your most common types of returned products? Where are these sent to? (Please provide the address/postcode for each destination)
C13) Who transports your product returns to each destination? (Please provide the details/address of the carrier)
C14) Could you specify the vehicle types used to transport product returns to each destination?
C15) What types of services do carriers provide?
C16) How many collections take place per day of the week?
C17) What types of products are sent to the destinations you mentioned in Question C6?
C18) i) What type of packaging is used for the pre-mentioned types of returned products? (complete the product code, as mentioned in C11 in the [] area, just in the boxes next to the packaging type). **ii) Could you provide me with the average quantities** (fill in the left part of the packaging type) **and iii) the size** (fill in the big boxes on the right side of packaging type) **of the used packaging? iv) Is the used type of packaging re-usable? v) If yes, who owns it?**

(C12) Destination		(C13) Carrier		(C14) Vehicle Type	(C15) Services	(C16) No/Day	(C17) Collected Products	(C18) Packaging (No, Product, Type, Size, Re-usability)
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bag s ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ___ ☐ Fri: ___ ☐ Tue: ___ ☐ Sat: ___ ☐ Wed: ___ ☐ Sun: ___ ☐ Thu: ___ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:

C19) Do you share collection services for returned products with any other business in West Quay? ☐ Yes (*please specify the business*): ______ ☐ N
C20) If not, would you be interested in sharing collection services with other businesses in West Quay? ☐ Yes ☐ No

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Section D: Waste Management

I would now like to ask you about the collection of waste and recyclate from your business.

D1) Who is in charge of organising the waste management for your business?

- ☐ Hammerson
- ☐ Arranged through business' head office
- ☐ You/employee based on site
- ☐ Not sure
- ☐ Other

D2) Where is waste stored until its collection?

- ☐ Designated in-store waste collection area (stock room)
- ☐ West Quay's public bins/containers
- ☐ West Quay's designated collection points (*please circle the service yard SY*): SY A2 SY A3 SY B3
- ☐ Other: __________

D3) Where do collection vehicles park when loading is taking place?

- ☐ On West Quay's premises (*please circle the service yard SY*): SY A2 SY A3 SY B2
- ☐ On a public road outside WQ premises
- ☐ Away from WQ premises

D4) Which are your busiest months of the year in terms of waste production? (*Please circle the appropriate months*)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

D5) Is the storage/handling capacity of these facilities adequate during:

- **a) Standard trading periods** ☐ Yes ☐ No
- **b) Busy peak periods** ☐ Yes ☐ No

D6) What equipment do you have on-site to handle produced waste?

	No	Location	Shared with (Name of Business)
☐ Bins			
☐ Balers			
☐ Shredders			
☐ Compactors			
☐ Sorting facilities			
☐ Other			

D7) What types of hazardous waste does your business produce?

- ☐ Fluorescent Tubes
- ☐ Medical/Infectious Materials
- ☐ WEEE
- ☐ No Hazardous Waste
- ☐ Batteries
- ☐ Oil/Liquors/other Liquids
- ☐ Other

D8) Does your Business offer take-back services for end-of-life EEE? ☐ Yes ☐ No

D9) What would you describe as the key factors that currently restrict your recycling performance?

- ☐ Lack of separation/storage space (*please circle as appropriate*): In-store WQ designated areas Public
- ☐ Cost of extra collections
- ☐ Lack of awareness
- ☐ Limited quantities generated
- ☐ No suitable collections
- ☐ Other: __________

Table Questions:

D10) i) What items make up your waste output? ii) Are these items separated from general waste?
D11) Could you by any estimate give me the quantities (tons) produced in 2007 (or latest available)?
D12) In addition/Alternatively, could you provide me with the relevant percentages per total waste produced?
D13) Who collects each waste/recyclate type? (Please provide the name/address).
D14) What types of services do these waste/recyclate collectors provide?
D15) How many collections per waste/recyclate type does your business have during a typical day/week/month?
D16) Could you specify the vehicle types used to transport product returns to each destination?
D17) i) What type of packaging is used for the pre-mentioned types of waste/recyclate? ii) Could you provide me with the average quantities (fill in the left part of the packaging type) **and iii) the size of the used packaging** (fill in the big boxes on the right side of packaging type)? **iv) Is the used type of packaging re-usable? v) If yes, who owns it?**
D18) What happens to the produced waste/recyclate? Where are these sent to? (Please provide the address/postcode for each destination)

(D10) Waste Types	(D11) Quantities	(D12) %	(D13) Waste Collector (name/address)	(D14) Services	(D15) Frequency	(D16) Vehicle Types	(D17) Packaging (No/Type/Size/Reusable/Owner)	(D18) Destination
☐ General Waste			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Mixed Paper Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Plastic Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Glass Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Metals Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Cardboard Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Packaging Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Hangers Are these Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Food Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Hazardous Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ WEEE Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Other			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other: ____	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:

D19) During the busiest periods you mentioned in Question D4, how many *extra* collections would you expect on top of the total non-peak figure you gave in Question D15?

Daily ☐ Weekly ☐ Monthly ☐

If no extra collections are made, please tick this box: ☐

D20) Do you share waste collection services with any other business in West Quay?

☐ **Yes** *Waste Type:* ____ ____ ____
Business: ____ ____ ____

☐ **No**

D21) If not, would you be interested in sharing collection services with other businesses in WQ?

Yes ☐ **N** ☐

Many thanks for taking the time to take part in this survey. If you have any queries regarding this survey, please contact Maria Triantafyllou at the University of Southampton (023) 8059 3013 during office hours or alternatively email: *mt3c06@soton.ac.uk*.

A2. QUESTIONNAIRE USED IN INTERVIEWS WITH *WESTQUAY* RETAILERS [DE-CENTRALISED DISTRIBUTION]

TRG Transportation Research Group — Hammerson — WestQuay Southampton — Pamper the Planet — University of Southampton School of Civil Engineering and the Environment

Date of Interview d d m m y y **Questionnaire's Code** Completed by the Interviewer

General Information

This questionnaire forms part of a PhD research study being supervised by the Transportation Research Group at the **University of Southampton** with the approval and the cooperation of **Hammerson UK Properties plc**. The aim of the project is to improve the logistics operations and minimise the ecological footprint of reverse transport movements, in regard to returned, damaged or unsold products and the waste produced by retailers in West Quay. In this context, it is very important to contact individual retailers and identify the current cross-supply chain operations adopted to meet financial, legal and social requirements; to obtain origin-destination data; and to identify possible problems, inefficiencies, areas for improvement and solutions.

We would be grateful if you could take part in this interview questionnaire which should take about 30 min to complete. *Please note that any personal information provided will remain confidential under the Data Protection Act 1998 and the results of the study will be presented to you at the end of this project.* If you have any queries, please contact Maria Triantafyllou at the University of Southampton (023) 8059 3013 during office hours or alternatively email: *mt3c06@soton.ac.uk*. Thank you for your time and cooperation.

Section A: General Information

A1) Company's Details:

a) Company's Name: ______

b) General Manager: ______

c) Contact Details: ______

A2) Type of Business: (Please tick all that apply)

- ☐ Non-specialised Stores with Food, Beverages or Tobacco Predominating [52.11]
- ☐ Non-specialised Stores with other Goods where Food, Beverages or Tobacco are not Predominant [52.12]
- ☐ Specialised Store selling Food, Beverages and Tobacco [52.2]
- ☐ Pharmaceutical and Medical Goods, Cosmetic and Toilet Articles [52.3]
- ☐ Fur and Leather Clothing [52.42/1]
- ☐ Children's and Infants' Clothing [52.42/2]
- ☐ Women's Clothing [52.42/3]
- ☐ Men's Clothing [52.42/4]
- ☐ Footwear [52.43/1]
- ☐ Leather Goods [52.43/2]
- ☐ Furniture, Lighting Equipment and Household Articles [52.44]
- ☐ Electrical Household Appliances and Radio and Television Goods [52.45]
- ☐ Books, Newspapers and Stationery [52.47]
- ☐ Photographic, Optical and Precision Equipment, Office Supplies and Equipment (incl. Computers etc.) [52.48/2]
- ☐ Jewellery, Clocks and Watches [52.48.4]
- ☐ Sports Goods, Games and Toys, Stamps and Coins [52.48.5]
- ☐ Second Hand Goods [52.5]
- ☐ Repair of Personal and Household Goods [52.7]

A3) Is your business obligated under the following legislation? (Please see additional notes sheet for description)

a) Producer Responsibility Obligation 2007 (Packaging Waste): ☐ Yes ☐ No ☐ Don't know

i) If yes, could you tell me which Packaging Compliance Scheme you have registered with? ______

Details: ______

b) Waste Electrical and Electronic Equipment Regulations 2007: ☐ Yes ☐ No ☐ Don't know

i) If yes, could you tell me which WEEE Compliance Scheme you have registered with? ______

Details: ______

A4) Are you aware of the Producer Pre-treatment Requirements? ☐ Yes ☐ No

i) If yes, could you briefly describe what changes in waste management procedures you have made/intend to make to meet these requirements? ______

1

Section B: Core Goods Deliveries

I would like to start by asking you some questions about the deliveries that take place to your business. Please Note:

1. '**Core goods**' are those that are of fundamental importance to your business activity. For retail stores are those sold to final customers and for restaurants/bars are the essential supplies of food, drink, packaging, laundry etc.
2. A '**typical week**' is **not** during one of your peak business periods of the year.

B1) So, how many deliveries are made to your business during a typical week? ☐
(If you receive less than one delivery per week please state the frequency e.g. twice/month)

B2) How many vehicles deliver core goods to your business by day of the week?

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total No of Vehicles

If you have no fixed delivery times, please tick this box ☐

B3) Which would you say are your busiest trading months of the year? *(Please circle the appropriate months)*

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

B4) During the busiest trading periods you mentioned in Question B3, how many *extra* delivery vehicles would you expect on top of the total non-peak figure you gave in Question B2? *(e.g. 4 per week)* ☐

B5) Where do delivery vehicles park when unloading is taking place?

☐ On West Quay's premises (*please circle the service yard SY*): SY A2 SY A3 SY B2
☐ On a public road outside WQ premises
☐ Away from WQ premises

B6) What is the type of distribution system that supplies your business?

☐ Deliveries from single Distribution Centre
☐ Deliveries from a number of different suppliers. Can you approximately tell me how many? Main: ☐ Secondary: ☐

B7) Who deliver core goods to your business?

☐ Suppliers ☐ Logistics Providers ☐ A combination of Suppliers and Logistic Providers ☐ Other

One thing that hasn't been done in freight surveys is trying to quantify the origin-destination movements and the 'environmental footprint of the supply chain'. In this context, I would now like to ask you a few detailed questions about your single/top 2-3 suppliers and the associated vehicle movements.

Table Questions:

1st Part: Deliveries

B8) Could you tell me the name and the contact details of your 1st/2nd/3rd top supplier/logistics provider (top in terms of delivery levels)?
B9) What is the percentage of total deliveries made by this supplier/logistics provider?
B10) If deliveries are made by logistics providers, who are the suppliers they collaborate with (a) name, b) address, c) no of deliveries on behalf of those suppliers, d) percentage on all deliveries made by the specific logistic s provider)
B11) How many deliveries per week do you receive from this supplier/logistics provider?
B12) Where do the delivery vehicles originate from (address/postcode)?
B13) Could you classify the deliveries you get by consignment types (different products combinations)?
B14) How many deliveries of each type do you receive by day of the week?
B15) Whose fleet is used for the deliveries made by the specific supplier/logistics provider? (Please provide the details/address of the carrier)
B16) Could you specify the vehicle types used to deliver your stock?
B17) What type of services do carriers provide?
B18) i) What type of packaging is used for the delivered products? ii) Could you provide me with the average quantities (fill in the left part of the packaging type) and iii) the size of the used packaging (fill in the big boxes on the right side of packaging type)? iv) Is the used type of packaging re-usable? v) If yes, who owns it?
B19) What is the number of extra deliveries per week during busy periods?

2nd Part: Take-back of Product Returns

B20) Is there any back-loading of product returns? If yes, how often?
B21) In relation to the number of deliveries you get by day of the week (Question B11), how many times by day of the week do vehicles take-back products?
B22) Are take-back services scheduled or made under request?
B23) What types of products are back-loaded?
B24) i) What type of packaging is used for the back-loaded products? ii) Could you provide me with the average quantities (fill in the left part of the packaging type) and iii) the size of the used packaging (fill in the big boxes on the right side of packaging type)? iv) Is the used type of packaging re-usable? v) If yes, who owns it?
B25) Where are the back-loaded products transferred to?
B26) What is the number of extra collections of product returns per week during busy periods?

3rd Part: Take-back of Waste

B27) Is there any back-loading of waste/recyclate? If yes, how often?
B28) In relation to the number of deliveries you get by day of the week (Question B11), how many times by day of the week do vehicles take-back waste/recyclate?
B29) Are take-back services scheduled or made under request?
B30) What types of waste/recyclate are back-loaded?
B31) i) What type of packaging is used for the back-loaded waste/recyclate? ii) Could you provide me with the average quantities (on the left side) and iii) the size of the used packaging (on the right side)?
B32) Where is the back-loaded waste/recyclate transferred to?
B33) What is the number of extra collections of waste/recyclate per week during busy periods?

2

Supplier/Log.Provider A	Deliveries (Typical Week)									Busy Periods
(B8) Name	(B11) No	(B12) Origin	(B13) Delivered Products	Products Info	(B14) Deliveries No/Day	(B15) Fleet	(B16) Vehicle Type	(B17) Services	(B18) Packaging (No, Type, Size)	(B19) ExtraNo
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
(B9) % of total Deliveries		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	
		Address: Postcode:	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Supplier's fleet ☐ Courier: ☐ West Quay's vehicles ☐ 3PL: ☐ Business own fleet ☐ Other:	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other:	___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	

B10) Suppliers			
a) Name	b) Address	c) Deliveries No	d) %

Take-Back of Product Returns							Busy Periods
(B20) Take Back	(B21) No/Day	(B22) Services	(B23) Collected Products	Products Info	(B24) Packaging (No, Type, Size)	(B25) Destinations	(B26) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ [CM] Med.Goods ☐ Other [O]		___Sacks ___Pallets ___Plastic Boxes ___Loose Boxes ___Metal Crates ___Roll Cages ___Hanging Rails ___Other Is it Re-usable? Yes ☐ No ☐ Owner:	☐ Distribution Centre: ☐ Back to Supplier ☐ Consolidation Centre: ☐ Control/Check Facility: ☐ Other:	

Take-Back of Waste (Typical Week)							Busy Periods
(B27) Take Back	(B28) No/Day	(B29) Services	(B30) Waste Type	Waste Types Info	(B31) Packaging	(D32) Destination	(B33) ExtraNo
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	
☐ Always ☐ Often ☐ Never	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ☐ Not Fixed	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Other: ________	☐ General Waste ☐ Metals ☐ Food ☐ Mixed Paper ☐ Hangers ☐ Packaging ☐ Cardboard ☐ WEEE ☐ Hazardous ☐ Plastic ☐ Glass ☐ Other		___Sacks ___Bins ___Containers ___Skips ___Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:	

B10)	B13)	B12)	B14)	B8)	B15)	B16)	B17)	B18)	B19)		B20)	B23)	B21)	B22)	B24)	B25)	B26)		B27)	B30)	B28)	B29)	B31)	B32)	B33)	
Suppliers	Products	Origin	Deliveries No	Carrier	Fleet	Vehicle Type	Services	Packaging (Boxes No/Type)	Del No-Busy	Boxes No-Busy	Returns Take-Back	Collected Products	Frequency	Collection Services	Returns Packaging (No/Type)	Destination	Collections No Busy Periods	Collected Boxes No Busy Periods	Waste Take-Back	Collected Products	Frequency	Collection Services	Waste Packaging (No/Size)	Destination	Collections No Busy Periods	Packaging (Boxes No) Busy Periods
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				
			☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed		☐ Supplier's ☐ Courier ☐ West Quay's ☐ 3PL ☐ Own Business ☐ Other	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Scheduled ☐ Under Request ☐ Milk-runs ☐ Specialised ☐ Other						☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other					☐ Always ☐ Often ☐ Never		☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun ☐ No Fixed	☐ Dedicated (Scheduled) ☐ Occasional (Under Request) ☐ Other				

Section C: Product Returns

Possible areas where efficiency gains can be made are in waste and returns management. I would just like to ask you a few questions on these aspects of your business. First of all, I would ask you about the returns management of your Business.

C1) In addition to the 'Back-loads', how many 'dedicated vehicles' take away returns during a typical week? (*If less than 1 collection per week takes place please state the frequency e.g. twice/month*) ☐

C2) Which are your busiest months of the year in terms of product returns? (*Please circle the appropriate months*)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

C3) During the busiest 'product returns' periods, how many *extra* collection vehicles would you expect on top of the non-peak figure you gave in Question C7? (e.g. *4 per month*) ☐

C4) Where do collection vehicles park when loading is taking place?

- ☐ On West Quay's premises (*please circle the service yard SY*): SY A2 SY A3 SY B2
- ☐ On a public road outside WQ premises
- ☐ Away from WQ premises

C5) How does your store typically manage its returns?

- ☐ Store returns and then send back. If so, how frequently? ☐
- ☐ Procedures vary between suppliers and collectors.
- ☐ Collected immediately (at the earliest convenience)
- ☐ Other

C6) What type of facilities do you have for storing returns in-store?

- ☐ Designated in-store returns area.
- ☐ Stock holding area.
- ☐ Delivery area.
- ☐ No designated returns area. .
- ☐ Other (*Please specify*): ____________________

C7) Is the storage/handling capacity of these facilities adequate during:

a) Standard trading periods	☐	Yes	☐	No
b) Busy peak periods	☐	Yes	☐	No

C8) What equipment do you have on-site to handle product returns?

	No of	Type	Location
☐ Check/control facilities			
☐ Storage containers			
☐ Sorting facilities			
☐ Other			

C9) In terms of unsold stock returns:

a) Where is stock transferred to? Please provide the address (area/postcode).
b) Who collects stock returns? Please provide the details of the collector (name, address).
c) What is the collections frequency for each type of stock?
d) What types of vehicles are used to collect those returns?
e) What types of stock are transferred to each destination you gave in (a)?

a) Destination	b) Carrier	c) Frequency	d) Vehicle Type	e) Stock Types
☐ Stock returns to RDC RDC Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other
☐ Stock returns direct to a supplier Supplier's Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other
☐ Store transfers via RDC RDC Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other
☐ Store transfers direct to another store Store Address:	☐ Logistics Provider: ☐ Own Vehicle ☐ Supplier Vehicle: ☐ Courier: ☐ Other:	☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly ☐ Few times a year ☐ Once per year	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Clothing ☐ Footwear ☐ Electronics ☐ Home Accessories ☐ Books ☐ Jewellery ☐ Cosmetics/ Med.Goods ☐ Other

C10) In terms of customer returns, what is the return policy of your business?

No Returns Permitted	7 Days	14 Days	28 Days	30 Days	45 Days	60 Days	90 Days	Liberal Returns	Other (*Please specify*)
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ ________

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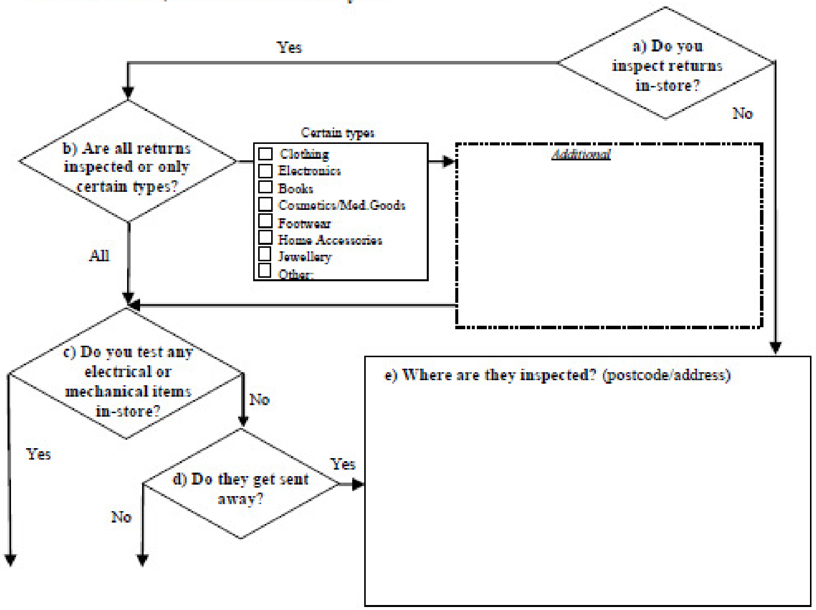
C11) One area that is not well understood is who makes the decision on what happens to a customer return and how this impacts on transport. In this context, I would like to ask you:



<u>Table Questions:</u>

C12) **So, what happens to your most common types of returned products? Where are** these sent to? (Please provide the address/postcode for each destination)

C13) **Who transports your product returns to each destination?** (Please provide the details/address of the carrier)

C14) **Could you specify the vehicle types used to transport product returns to each destination?**

C15) **What types of services do carriers provide?**

C16) **How many collections take place per day of the week?**

C17) **What types of products are sent to the destinations you mentioned in Question C6?**

C18) **i) What type of packaging is used for the pre-mentioned types of returned** products? (complete the product code, as mentioned in C11 in the [] area, just in the boxes next to the packaging type). **ii) Could you provide me with the average quantities** (fill in the left part of the packaging type) **and iii) the size** (fill in the big boxes on the right side **of packaging type) of the used packaging? iv) Is the used type of packaging re-usable? v) If yes, who owns it?**

(C12) Destination		(C13) Carrier		(C14) Vehicle Type	(C15) Services	(C16) No/Day	(C17) Collected Products	(C18) Packaging (No, Product, Type, Size, Re-usability)
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Plastic Boxes ___Metal Crates ___Hanging Rails ___Pallets ___Loose Boxes ___Roll Cages ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Plastic Boxes ___Metal Crates ___Hanging Rails ___Pallets ___Loose Boxes ___Roll Cages ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Plastic Boxes ___Metal Crates ___Hanging Rails ___Pallets ___Loose Boxes ___Roll Cages ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ ☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials)	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Plastic Boxes ___Metal Crates ___Hanging Rails ___Pallets ___Loose Boxes ___Roll Cages ___Other Is it Re-usable? Yes ☐ No ☐ Owner:
☐ Manufacturer ☐ Supplier ☐ Distribution Centre ☐ Control/Check Centre ☐ Other	Name/Address	☐ Logistics Provider ☐ Courier Company ☐ Own Vehicle ☐ Supplier ☐ Other	Name/Address	☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Other	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Specialized (eg hazardous materials) ☐ Multi-store (same business) ☐ Other: ______	☐ Mon: ____ ☐ Fri: ____ ☐ Tue: ____ ☐ Sat: ____ ☐ Wed: ____ ☐ Sun: ____ ☐ Thu: ____ ☐ Not Fixed	☐ Clothing [C] ☐ Footwear [F] ☐ Electronics [E] ☐ Home Accessories [HA] ☐ Books [B] ☐ Jewellery [J] ☐ Cosmetics/ Med.Goods [CM] ☐ Other [O]	___Bags ___Plastic Boxes ___Metal Crates ___Hanging Rails ___Pallets ___Loose Boxes ___Roll Cages ___Other Is it Re-usable? Yes ☐ No ☐ Owner:

C19) **Do you share collection services for returned products with any other business in West Quay?** ☐ Yes (*please specify the business*): ______________ ☐ No

C20) **If not, would you be interested in sharing collection services with other businesses in West Quay?** ☐ Yes ☐ No

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Section D: Waste Management

I would now like to ask you about the collection of waste and recyclate from your business.

D1) Who is in charge of organising the waste management for your business?

☐ Hammerson ☐ You/employee based on site ☐ Other
☐ Arranged through business' head office ☐ Not sure

D2) Where is waste stored until its collection?

☐ Designated in-store waste collection area (stock room)
☐ West Quay's public bins/containers
☐ West Quay's designated collection points (*please circle the service yard SY*): SY A2 SY A3 SY B3
☐ Other: ______

D3) Where do collection vehicles park when loading is taking place?

☐ On West Quay's premises (*please circle the service yard SY*): SY A2 SY A3 SY B2
☐ On a public road outside WQ premises
☐ Away from WQ premises

D4) Which are your busiest months of the year in terms of waste production? (*Please circle the appropriate months*)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

D5) Is the storage/handling capacity of these facilities adequate during:

a) **Standard trading periods** ☐ Yes ☐ No
b) **Busy peak periods** ☐ Yes ☐ No

D6) What equipment do you have on-site to handle produced waste?

	No	Location	Shared with (Name of Business)
☐ Bins			
☐ Balers			
☐ Shredders			
☐ Compactors			
☐ Sorting facilities			
☐ Other			

D7) What types of hazardous waste does your business produce?

☐ Fluorescent Tubes ☐ Medical/Infectious Materials ☐ WEEE ☐ No Hazardous Waste
☐ Batteries ☐ Oil/Liquors/other Liquids ☐ Other

D8) Does your Business offer take-back services for end-of-life EEE? ☐ Yes ☐ No

D9) What would you describe as the key factors that currently restrict your recycling performance?

☐ Lack of separation/storage space (*please circle as appropriate*): In-store WQ designated areas Public
☐ Cost of extra collections
☐ Lack of awareness
☐ Limited quantities generated
☐ No suitable collections
☐ Other: ______

Table Questions:

D10) i) What items make up your waste output? ii) Are these items separated from general waste?
D11) Could you by any estimate give me the quantities (tons) produced in 2007 (or latest available)?
D12) In addition/Alternatively, could you provide me with the relevant percentages per total waste produced?
D13) Who collects each waste/recyclate type? (Please provide the name/address).
D14) What types of services do these waste/recyclate collectors provide?
D15) How many collections per waste/recyclate type does your business have during a typical day/week/month?
D16) Could you specify the vehicle types used to transport product returns to each destination?
D17) i) What type of packaging is used for the pre-mentioned types of waste/recyclate? ii) Could you provide me with the average quantities (fill in the left part of the packaging type) and iii) the size of the used packaging (fill in the big boxes on the right side of packaging type)? iv) Is the used type of packaging re-usable? v) If yes, who owns it?
D18) What happens to the produced waste/recyclate? Where are these sent to? (Please provide the address/postcode for each destination)

(D10) Waste Types	(D11) Quantities	(D12) %	(D13) Waste Collector (name/address)	(D14) Services	(D15) Frequency	(D16) Vehicle Types	(D17) Packaging (No/Type/Size/Reusable/Owner)	(D18) Destination
☐ General Waste			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Mixed Paper Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Plastic Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Glass Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Metals Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Cardboard Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Packaging Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Hangers Are these Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Food Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Hazardous Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ WEEE Is it Separated? ☐ Yes ☐ No			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:
☐ Other			☐ 3PL: ☐ Waste Contractor: ☐ In-House Management ☐ LA: ☐ Other:	☐ Dedicated (scheduled) ☐ Occasional (under request) ☐ Multi-store (same Business) ☐ Specialized (eg. hazardous waste) ☐ Other:	Daily ☐ Weekly ☐ Monthly ☐ Other:	☐ Bulk/Skip Vehicle ☐ Front/Rear/Side Loader-Municipal ☐ Clinical Waste ☐ Van ☐ Other:	___ Sacks ___ Roll Cages ___ Bins ___ Containers ___ Skips ___ Other Re-Usable? Yes ☐ No ☐ Owner: ☐ Own Business ☐ West Quay ☐ Waste Collector ☐ Hired ☐ Other	☐ Recycling: ☐ Reuse: ☐ Landfill: ☐ Incineration: ☐ Other:

D19) During the busiest periods you mentioned in Question D4, how many *extra* collections would you expect on top of the total non-peak figure you gave in Question D15?

Daily ☐ Weekly ☐ Monthly ☐

If no extra collections are made, please tick this box: ☐

D20) Do you share waste collection services with any other business in West Quay?

☐ Yes *Waste Type*: ________ ________ ________
Business: ________ ________ ________

☐ No

D21) If not, would you be interested in sharing collection services with other businesses in WQ?

☐ **Yes** ☐ **No**

Many thanks for taking the time to take part in this survey. If you have any queries regarding this survey, please contact Maria Triantafyllou at the University of Southampton (023) 8059 3013 during office hours or alternatively email: *mt3c06@soton.ac.uk*

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A3. Questionnaire used in Interviews with Waste Contractors-Recyclers [Used Cooking Oil]

TRG Transportation Research Group | Hammerson | WestQuay Southampton | University of Southampton School of Civil Engineering and the Environment

Date of Interview ☐☐☐☐☐☐ **Questionnaire's Code** Completed by the Interviewer

General Information

This questionnaire forms part of a PhD research study linked to Module 10 of the Green Logistics Project (www.greenlogistics.org) and being supervised by the Transportation Research Group at the **University of Southampton** with the cooperation of **Hammerson UK Properties plc**. The aim of the project is to investigate the logistics operations associated with reverse transport movements, (returned, damaged or unsold products and waste/recyclate) generated by retailers in *WestQuay* shopping centre, Southampton, U.K. and recommend new strategies to minimise their environmental footprint.

Interview surveys have been undertaken with 96% (n=92) of the retailers (n=96) operating in *WestQuay* (April/May 2008) to identify current supply chain operations and their related origin-destinations, understand problems and inefficiencies associated with current 'take-back' systems and identify potential solutions. During the initial surveys with retailers, it was suggested that your company collects hazardous waste products from one or more stores operating in *WestQuay*. We would therefore like to verify some of the data collected with you regarding the waste collections taking place.

We would be grateful if you would spend 10 minutes to complete this (phone/online) questionnaire. *Please note that any personal information provided will remain confidential under the Data Protection Act 1998, and the results of the study will be presented to you at the end of the project.* If you have any queries, please contact Maria Triantafyllou at the University of Southampton (023) 8059 3013 during office hours or alternatively email: *mt3c06@soton.ac.uk*. Thank you for your time and cooperation.

Details of your Company:

a) Company's Name:

b) Interviewee (name/role):

c) Contact Details:

Section A: Procedures in *WestQuay*

A1) What types of services are offered in the stores operating in *WestQuay*?

☐ **Collection of Used Cooking Oil** ☐ **Collection of Hard Fats** ☐ **Onsite Grease Filtration**

☐ **Other** Details

A2) What type of pre-treatment has to be taken/is taking place in-store prior to collection from *WestQuay*?

☐ **None** ☐ **Separation** ☐ **Heating** ☐ **Filtration**

☐ **Other** Details

A3) What type of packaging is used for the transport of the oil/fats/other from *WestQuay*? (Please describe the type drum/barrel/container/other and its capacity)

details

A4) With regard to a typical collection from *WestQuay*, could you provide an estimate of:

A. **The number of packaging items collected and their individual volume capacity?** *(e.g. 3 plastic drums * 60 litres each)*

B. **(and/or) The total volume of the waste/recyclate collected (if known)?**

C. **(and/or) The total weight of the waste/recyclate collected (if known)?**

A5) How many collections are typically made from *WestQuay* by day of the week (or other frequency)?

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Weekly No Fixed	Few Times a Month	Few Times a Year

A6) To what extent (%) the number and/or the size of collections increase during peak business periods from WQ on a typical round? (e.g. if 6 collections are made on a busy week instead of 3 on a typical, then 200%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of Collections												
Size of Collections												

1

Section B: Collection Trip

B1) Which other locations (address/postcode) do you visit on a typical vehicle round calling at *WestQuay*? (if rounds are not fixed please provide information for the ones taking place most frequently). Please also specify the type of the waste if other than used cooking oil.

Scenario A

Location/Address	Postcode	Waste Type
Origin:		

Scenario B

Location/Address	Postcode	Waste Type
Origin:		

B2) What proportion (%) of the vehicles used to collect used cooking oil from *WestQuay* on a weekly basis (or other frequency if applicable) belong to the following categories?

☐ **Articulated Lorry** ☐ **Rigid Lorry** ☐ **Van** ☐ **Car** ☐ **Other**

B3) What is the ownership status of the fleet you use to make collections from *WestQuay*?

☐ **In-house Fleet** ☐ **Contracted 3rd Logistics Provider** ☐ **Courier** ☐ **Other**

Name of Provider/Courier/Other

B4) Are there any minimum and/or maximum limits on the quantities of used cooking oil/fats/grease/other collected as a result of operational and/or legislative restrictions in place?

From WQ	**Min**		**Max**	
In a Load	**Min**		**Max**	

B5) What other items are in the collection vehicle when collecting from *WestQuay*?

☐ **Drums/barrels/containers/other containing used cooking oil/fats/grease/other collected from other stores in the round trip**

☐ **Empty drums/barrels/containers/other to be delivered in other stores in the round trip**

☐ **Equipment used for the onsite treatment of used cooking oil/fats/grease/other in WestQuay or stores in the round trip**

☐ **Other** Details

B6) Please describe any compatibility issues limiting the range of wastes/products collected during a typical round calling at WestQuay:

B7) Could you provide an estimate of the typical spare capacity in the vehicle after collecting from *WestQuay*?

A. By number of packaging items (e.g. roll cage equivalent space):

B. (and/or) by volume capacity (litres):

Section C: Facilities (Distribution Centre/Process Facility/Disposal Facility/Other)

C1) Where is used cooking oil/fats/grease/other transported to? (please describe the waste type, the facility type and its address)

☐ Waste/recyclate is sent back to Distribution centres (waste type/facility type/postcode)

☐ Waste/recyclate is transported to the following process facilities (waste type/facility type/postcode):

A.

B.

☐ Waste/recyclate is transported directly to the following disposal facilities (waste type/facility type/postcode):

A.

B.

☐ Other (please describe the type of the facility/waste type/address/postcode)

C2) Could you describe the activities taking place in the destination where waste is transported to (e.g. the distribution centre/process facility/disposal facility/other described in C1)?

☐ Separation by commodity type:

☐ Process on site (heated/cleaned/filtrated etc):

☐ Storage (duration/conditions):

C3) Is there any extra storage/process capacity at the distribution centre/process facility/disposal facility/other?

☐ No extra storage and process capacity

☐ Storage capacity available: (how much):

☐ Process capacity available: (how much):

C4) Would you be interested in collecting used cooking oil/fats/grease/other hazardous wastes from other retail outlets/catering units operating in *WestQuay*?

☐ Yes ☐ No

If yes, are there any requirements on:

☐ The Quantities collected? (how much)

☐ Cost Issues (charge):

☐ Frequency of Collections:

Section D: Other Process/Treatment Sites and Final Disposal Sites

If waste/recyclate is transferred from the distribution centre/process facility/disposal facility/other to any other process/treatment facilities, prior to disposal (e.g. in order to turn waste oil into bio-diesel), please complete Questions D1-D4 otherwise go directly to Questions D5-D8.

D1) Where is waste/recyclate transferred to prior to being disposed of? (Waste type/facility type/postcode)

Type of Facility: ☐

Location of Facility: ☐

D2) What is the ownership status of the fleet used for transfers made from the transhipment plant to any other process/treatment site? (if more than 1 waste type is collected please provide information for all wastes, specifying the waste type each time)

- ☐ **Own (In-house) Fleet**
- ☐ **Contracted 3rd Logistics Provider:** ☐
- ☐ **Other Waste Contractor:** ☐
- ☐ **City Council:** ☐
- ☐ **Other:** ☐

D3) What proportion (%) of the vehicles typically used for the transfers from the distribution centre/process facility/disposal facility/other to any other process/treatment sites belong to the following categories?

☐ **Articulated Lorry** ☐ **Rigid Lorry** ☐ **Van** ☐ **Car** ☐ **Other**

D4) How many collections are made from the transhipment plant destined for other process/treatment sites (e.g. plants turning waste oil into bio-diesel) during a typical week? (if known)

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Weekly No Fixed	Few Times a Month	Few Times a Year

D5) Where is waste/recyclate finally disposed of? (Waste type/facility type/postcode)

Type of Facility: ☐

Location of Facility: ☐

D6) What is the ownership status of the fleet used for the collections made to the final disposal sites? (Waste type/facility type/postcode) (if more than 1 waste type is collected please provide information for all wastes, specifying the waste type each time)

- ☐ **Own (In-house) Fleet**
- ☐ **Contracted 3rd Logistics Provider:** ☐
- ☐ **Other Waste Contractor:** ☐
- ☐ **City Council:** ☐
- ☐ **Other:** ☐

D7) What proportion (%) of the vehicles typically used for the collections made to the final disposal sites belong to the following categories?

☐ **Articulated Lorry** ☐ **Rigid Lorry** ☐ **Van** ☐ **Car** ☐ **Other**

D8) How often are vehicles loads are typically made to the final disposal sites per week?

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Weekly No Fixed	Few Times a Month	Few Times a Year

A4. Questionnaire used in Interviews with Waste Contractors-Recyclers [Clinical Waste]

TRG Transportation Research Group | Hammerson | WestQuay Southampton | University of Southampton School of Civil Engineering and the Environment

Date of Interview ☐☐☐☐☐☐ **Questionnaire's Code** Completed by the Interviewer

General Information

This questionnaire forms part of a PhD research study linked to Module 10 of the Green Logistics Project (www.greenlogistics.org) and being supervised by the Transportation Research Group at the **University of Southampton** with the cooperation of **Hammerson UK Properties plc**. The aim of the project is to investigate the logistics operations associated with reverse transport movements, (returned, damaged or unsold products and waste/recyclate) generated by retailers in *WestQuay* shopping centre, Southampton, U.K. and recommend new strategies to minimise their environmental footprint.

Interview surveys have been undertaken with 96% (n=92) of the retailers (n=96) operating in *WestQuay* (April/May 2008) to identify current supply chain operations and their related origin-destinations, understand problems and inefficiencies associated with current 'take-back' systems and identify potential solutions. During the initial surveys with retailers, it was suggested that your company collects hazardous waste products from one or more stores operating in *WestQuay*. We would therefore like to verify some of the data collected with you regarding the waste collections taking place.

We would be grateful if you would spend 10 minutes to complete this (phone/online) questionnaire. *Please note that any personal information provided will remain confidential under the Data Protection Act 1998, and the results of the study will be presented to you at the end of the project.* If you have any queries, please contact Maria Triantafyllou at the University of Southampton (023) 8059 3013 during office hours or alternatively email: mt3c06@soton.ac.uk. Thank you for your time and cooperation.

Details of your Company:

a) Company's Name: ____________

b) Interviewee (name/role): ____________

c) Contact Details: ____________

Section A: Procedures in *WestQuay*

A1) What types of waste produced in stores operating in *WestQuay* is collected from your business?

- ☐ Building Materials
- ☐ Catering stuff
- ☐ Cleaning stuff
- ☐ Cytotoxic/Cytostatic Waste (incineration)
- ☐ Clinical Waste (incineration)
- ☐ Clinical Waste (to be treated)
- ☐ Offensive/Hygiene Waste
- ☐ Amalgam Waste (recovery)
- ☐ Other

A2) What type of pre-treatment has to be taken/is taking place in-store prior to collection from *WestQuay*?

- ☐ None
- ☐ Separation
- ☐ Bailing
- ☐ Compaction
- ☐ Strapping
- ☐ Groupage with other similar wastes from other retailers
- ☐ Other

A3) What type of packaging is used for the transport of the waste/recyclate from *WestQuay*?

- ☐ Tiger Striped Bags
- ☐ Yellow Clinical Bags
- ☐ Orange Clinical Bags
- ☐ Sharp Boxes
- ☐ Theatre Bins 30lt
- ☐ Theatre Bins 60lt
- ☐ Other ____ details

A4) With regard to a typical collection from *WestQuay*, could you provide an estimate of:

A. **The number of packaging items collected and their individual volume capacity?** *(e.g. 3 plastic totes * 60 litres each)*

____

B. **(and/or) The total volume of the waste/recyclate collected (if known)?**

____

C. **(and/or) The total weight of the waste/recyclate collected (if known)?**

____

A5) How many collections are typically made from *WestQuay* by day of the week (or other frequency)?

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Weekly No Fixed	Few Times a Month	Few Times a Year

A6) To what extent (%) the number and/or the size of collections increase during peak business periods from WQ on a typical round? (e.g. if 6 collections are made on a busy week instead of 3 on a typical, then 200%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of Collections												
Size of Collections												

1

Section B: Collection Trip

B1) Which other locations (address/postcode) do you visit on a typical vehicle round calling at *WestQuay*? (if rounds are not fixed please provide information for the ones taking place most frequently). Please also specify the type of the waste if other than clinical waste.

Scenario A

Location/Address	Postcode	Waste Type
Origin:		

Scenario B

Location/Address	Postcode	Waste Type
Origin:		

B2) What proportion (%) of the vehicles used to collect hazardous wastes from *WestQuay* on a weekly basis (or other frequency if applicable) belong to the following categories?

☐ Articulated Lorry ☐ Rigid Lorry ☐ Van ☐ Car ☐ Other

B3) What is the ownership status of the fleet you use to make collections from WestQuay?

☐ In-house Fleet ☐ Contracted 3rd Logistics Provider ☐ Courier ☐ Other

Name of Provider/Courier/Other

B4) Are there any minimum and/or maximum limits on the quantities of waste collected as a result of operational and/or legislative restrictions in place?

From WQ	Min		Max	
In a Load	Min		Max	

B5) What other items are in the collection vehicle when collecting from *WestQuay*?

☐ Waste/Recyclate collected from other stores in the round trip
☐ Stock/faulty/customer returns from other stores in the round trip
☐ Stock to be delivered in following stores in the round trip
☐ Other Details

B6) Please describe any compatibility issues limiting the range of wastes/products collected during a typical round calling at WestQuay:

B7) Could you provide an estimate of the typical spare capacity in the vehicle after collecting from *WestQuay*?

A. By number of packaging items (e.g. roll cage equivalent space):

B. (and/or) by volume capacity (litres):

C. (and/or) by weight capacity (kgr):

Section C: Facilities (Distribution Centre/Process Facility/Disposal Facility/Other)

C1) Where is the waste/recyclate transported to? (please describe the waste type, the facility type and its address)

☐ **Waste/recyclate is sent back to Distribution centres (Waste type/facility type/postcode)**

☐ **Waste/recyclate is transported to the following process facilities (waste type/facility type/postcode):**

☐ **Waste/recyclate is transported directly to the following disposal facilities (waste type/facility type/postcode):**

☐ **Other (please describe the type of the facility/waste type/address/postcode)**

C2) Could you describe the activities taking place in the destination where waste is transported to (e.g. the distribution centre/process facility/disposal facility/other described in C1)?

☐ **Separation by commodity type:**

☐ **Process on site (bailed/compacted etc):**

☐ **Storage (duration/conditions):**

C3) Is there any extra storage/process capacity at the distribution centre/process facility/disposal facility/other?

☐ **No extra storage and process capacity**

☐ **Storage capacity available:** (how much):

☐ **Process capacity available:** (how much):

C4) Would you be interested in collecting more hazardous waste from other retail outlets/catering units operating in *WestQuay*? ☐ **Yes** ☐ **No**

If yes, are there any requirements on:

☐ **The Quantities collected?** (how much)

☐ **Cost Issues** (charge):

☐ **Frequency of Collections:**

Section D: Other Process/Treatment Sites and Final Disposal Sites

If waste/recyclate is transferred from the distribution centre/process facility/disposal facility/other to any other process/treatment facilities, prior to disposal, please complete Questions D1-D4 otherwise go directly to Questions D5-D8.

D1) Where is waste/recyclate transferred to prior to being disposed of? (Waste type/facility type/postcode)

Type of Facility:

Location of Facility:

D2) What is the ownership status of the fleet used for transfers made from the transhipment plant to any other process/treatment site? (if more than 1 waste type is collected please provide information for all wastes, specifying the waste type each time)

- ☐ **Own (In-house) Fleet**
- ☐ **Contracted 3rd Logistics Provider:**
- ☐ **Other Waste Contractor:**
- ☐ **City Council:**
- ☐ **Other:**

D3) What proportion (%) of the vehicles typically used for the transfers from the distribution centre/process facility/disposal facility/other to any other process/treatment sites belong to the following categories?

☐ **Articulated Lorry** ☐ **Rigid Lorry** ☐ **Van** ☐ **Car** ☐ **Other**

D4) How many collections are made from the transhipment plant destined for other process/treatment sites during a typical week? (if known)

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Weekly No Fixed	Few Times a Month	Few Times a Year

D5) Where is waste/recyclate finally disposed of? (Waste type/facility type/postcode)

Type of Facility:

Location of Facility:

D6) What is the ownership status of the fleet used for the collections made to the final disposal sites? (Waste type/facility type/postcode) (if more than 1 waste type is collected please provide information for all wastes, specifying the waste type each time)

- ☐ **Own (In-house) Fleet**
- ☐ **Contracted 3rd Logistics Provider:**
- ☐ **Other Waste Contractor:**
- ☐ **City Council:**
- ☐ **Other:**

D7) What proportion (%) of the vehicles typically used for the collections made to the final disposal sites belong to the following categories?

☐ **Articulated Lorry** ☐ **Rigid Lorry** ☐ **Van** ☐ **Car** ☐ **Other**

D8) How often are vehicles loads are typically made to the final disposal sites per week?

Mon	Tue	Wed	Thu	Fri	Sat	Sun	Weekly No Fixed	Few Times a Month	Few Times a Year

APPENDIX B: GREENHOUSE GAS ANALYSIS TECHNIQUES

B1. Greenhouse Gas Analysis Techniques for American Transport Projects

B1. Greenhouse Gas Analysis Techniques for American Transportation Projects (source: TRB, 2006)								
Technique		**Model**	**Methodology**	**Geographic Level**	**Modes Addressed**	**Gases Analysed**	**Strengths**	**Weaknesses**
A. TRANSPORTATION GHG CALCULATION TOOLS	A1.Multi-Sector Inventory Tools	**SIT** State Inventory Tool	The calculations are based on the same methodologies used in EPA's Inventory of *U.S. Greenhouse Gas Emissions and Sinks*, which are based on internationally accepted emission reporting guidelines. CO_2 emissions are calculated based on fuel consumption. CH_4 and N_2O emissions are calculated based on VMT, distributed among different control technology types.	Any State within U.S.	Light Duty Vehicles Heavy Duty Vehicles Buses Rail Aircraft Maritime Vessels Other Non-road	CO_2 N_2O CH_4 HFCs	• If state-specific data are not available, the SIT can calculate emissions using default data derived from national values. • Emission estimates can be created quickly once activity data have been obtained. • Methodology mirrors that of the national GHG inventory.	• Does not output $CO_2$by mode or vehicle type, only fuel type for the entire transportation sector. Results must be post-processed to develop a more detailed inventory for transportation sources. • Default data are sometimes extrapolated from national data based on broad assumptions, and may not accurately depict state-level trends.
		SIPT State Inventory Projection Tool	Projections are based in part on projected fuel consumption reported in the Energy Information Administration's *Annual Energy Outlook with Projections to 2020*. Other characteristics – such as fleet composition, the state's proportion of national transportation fuel use, and control technology distribution – are the same used in the *Inventory of Greenhouse Gas Emissions and Sinks*, and are assumed to remain constant in the future.	Any State within U.S.	Light Duty Vehicles Heavy Duty Vehicles Buses Rail Aircraft Maritime Vessels Other Non-road	CO_2 N_2O CH_4 HFCs	• Tool is very easy to use and can develop comprehensive GHG inventory projections for CO_2, CH_4, and NO_2 with little user experience. All calculations are automated. • Tool can retrieve results directly from SIT. • If state-specific data are not available, the SIPT can calculate emissions using default data derived from national estimates.	• Projections based on historical data and emission estimates. Projection methodology is generally based on linear trends; tool is not capable of predicting impacts of future policy changes on projected emissions. • Does not output $CO_2$by vehicle type, only fuel type. • Tool not publicly available on the web. Must contact EPA.
	A2.Direct GHG Emission Calculation Tools	**NONROAD**	It multiplies equipment population, average load factor expressed as an average fraction of available power, available power in horsepower, and in hours of use per year, and emission factor with deterioration and/or new standards. Emissions are then temporally and geographically allocated using appropriate allocation factors.	Any (from county to national) within U.S., from 1970 to 2050.	Other Non-road (exempted commercial marine vessels, locomotives and aircrafts)	CO_2 Criteria Pollutants Air Toxics	• Produces CO_2estimates for many non-road sources used in highway construction and maintenance and provides detail on specific construction equipment types. Consequently, can be used to develop CO_2emissions factors for analyses of transportation agency activities at the project or program-level. • Includes other transportation-related support equipment, such as airport ground support equipment and railroad equipment. • Calculates emissions inventories within the US fromthe county to the national level, from 1970 to 2050. Allows for side-by-side comparison of different model runs.	• Does not include aircraft, commercial marine vessels, or rail, which are the primary non-road transportation sources contributing to GHG emissions. Includes a wide range of other non-road sources, but most of the equipment types and vehicle types are not relevant to transportation agencies (e.g., commercial/industrial equipment, agricultural equipment). • Background calculations not especially transparent. • Activity data for transportation construction and maintenance may not be available; defaults in model are not specific to transportation-related activities.

Technique		Model	Methodology	Geographic Level	Modes Addressed	Gases Analysed	Strengths	Weaknesses
A. TRANSPORTATION GHG CALCULATION TOOLS	A2.Direct GHG Emission Calculation Tools	**NYSDOT** Draft New York State DOT Guidance on Transportation GHG Analysis	Two methods are provided to calculate direct energy consumption from motor vehicles: 1) An urban fuel consumption method accounts for the effects of vehicle speeds on fuel consumption. Look-up tables are used to estimate a base year fuel consumption rate, which is then multiplied by VMT to approximate total fuel consumption. A corrections factor is applied to adjust the estimate for the analysis year, based on historical information on vehicle fuel economy by model year from Oak Ridge National Laboratory's "Transportation Energy Data Book", and future projections from DOE's 'Annual Energy Outlook'. 2) A VMT fuel consumption method is used when no other information than total VMT is known. Roadway maintenance energy is calculated based on a lookup table with values of energy consumption per lane mile by pavement type and urban/rural location. Roadway construction energy is also calculated based on Caltrans' methods.	Any (county, individual state, national) within US.	Light Duty Vehicles Heavy Duty Vehicles Buses	CO_2	• Geared toward the needs of transportation practitioners it includes methodology for analysing both 'direct' emissions from vehicles and 'indirect' from construction equipment. • Methodology is transparent and based on available data. Provides two different methods for each type of analysis, depending on whether or not speed data are available.	• Effects of vehicle speeds are based on data from the early 1980s and may not be applicable for recent model year vehicles. • Methodology for calculating direct emissions is somewhat cumbersome and confusing. • Calculation methodology for indirect emissions also is based on a methodology and emission factors developed by Caltrans in the early 1980s, and may be applicable for current construction equipment.
		MOBILE6	This model is based on emissions testing data and accounts for the impacts of factors such as vehicle emission standards, vehicle type, vehicle operating characteristics, and local conditions (e.g. temperature, humidity and fuel quality on criteria pollutant emission factors). Its output is in grams of pollutant per vehicle mile, which when combined with vehicle miles travelled (VMT) data produces emissions estimates. It uses average fuel economy for the entire national fleet for each vehicle category and model year, and assumes future fuel economy stays constant for model years after 2001. Consequently, projections of CO_2 in future years do not account for future changes in fuel economy, and the model cannot be used to account for the impacts of changes in vehicle operating conditions on CO_2.	Any within U.S.	Light Duty Vehicles Heavy Duty Vehicles Buses	CO_2 CH_4 Criteria Pollutants Air Toxics	• Inputs and assumptions are generally available to transportation agencies. • Standard emissions model used by transportation agencies for criteria pollutant analysis; as a result, GHG analysis assumptions would be consistent with criteria pollutant analysis assumptions.	• Does not account for impacts of vehicles speeds or operating conditions on CO_2; thus, not able to adequately address the impacts of traffic flow improvements. • Significant limitations in fuel economy data for developing projections. Much of the fuel economy data stops in 1996 and assumes fuel economy stays constant as model years progress for heavy-duty trucks; for passenger cars and light trucks, fuel economy data ends around 2001.
		CLIP Climate Leadership In Parks	The calculations are based on the same methodologies used in EPA's Inventory of *U.S. Greenhouse Gas Emissions and Sinks*, which are based on internationally accepted emission reporting guidelines. Emissions can be calculated based on fuel consumption or VMT.	Local (U.S.)	Light Duty Vehicles Heavy Duty Vehicles Buses Maritime Vessels Other Non-road	CO_2 N_2O CH_4 Criteria Pollutants	• Model is easy to use, requires inputs which should be available to practitioners. • Inventory methods are based on the national GHG inventory. • Specifically designed for use at national parks, but could be adapted for other local areas. • Provides users ability to model impacts of mitigation actions on GHG and CAP emissions.	• Very little default data available in the tool. • Tool not publicly available on the web.

Technique	Model	Methodology	Geographic Level	Modes Addressed	Gases Analysed	Strengths	Weaknesses
A. TRANSPORTATION GHG CALCULATION TOOLS — A2.Direct GHG Emission Calculation Tools	**EMFAC**	It includes 2 basic modules: emission factors and vehicle activity. Emission factors vary by vehicle characteristics and ambient and driving conditions, and were developed based on emissions tests on new and used vehicles from the California fleet. Within the EMFAC model, these factors are combined with vehicle activity, or estimates of travel and vehicle demographics, for each county, local air district, and air basin in California, relying on data provided by regional transportation agencies, as well as Department of Motor Vehicles (DMV) vehicle registration data. These data are incorporated into EMFAC2002 as defaults and can be updated by the model user. The CO_2base emission rates for gasoline passenger cars, light duty trucks, and medium duty trucks are based on emissions data collected through March 1999, while the diesel emissions data are based on more limited emissions tests comprised of model years through 1985; given limited data, the same emission factors are applied for diesel passenger cars, light duty trucks, and medium duty trucks.	Any within U.S. (Approved for use in State of California)	Light Duty Vehicles Heavy Duty Vehicles Buses	CO_2 Criteria Pollutants	• It includes methodology for analyzing both 'direct' emissions from vehicles and 'indirect' from construction equipment. • Methodology is transparent and based on available data. Provides two different methods for each type of analysis, depending on whether or not speed data are available.	• Effects of vehicle speeds are based on data from the early 1980s and may not be applicable for recent model year vehicles. • Methodology for calculating direct emissions is somewhat cumbersome and confusing. • Calculation methodology for indirect emissions also is based on a methodology and emission factors developed by Caltrans in the early 1980s, and may be applicable for current construction equipment.
	NIMN National Mobile Inventory Model	The NMIM user specifies a set of years and months, a geographic region (national, any combination of whole states or particular counties), a set of pollutants, and categories of on-road vehicles and non-road equipment. Based on these specifications and information in the NMIM county database (NCD), NMIM writes input files for the MOBILE6 and NONROAD models, then runs these models, reads their output files, performs additional processing if necessary, and puts the inventories into an output database. Additional processing includes multiplying MOBILE6 emission factors by vehicle miles travelled (VMT) and estimating emissions of some other pollutants. The model's post-processing capabilities include aggregation over months, roadway, vehicle and equipment types. It extends MOBILE6's capabilities by producing inventories rather than just emissions factors, and provides consistency across both models and all pollutants by using a single input database for MOBILE6 and NONROAD and for criteria pollutants and HAPS.	Any (county, individual state, national) within U.S.	Light Duty Vehicles Heavy Duty Vehicles Buses Other Non-road	CO_2 Criteria Pollutants Air Toxics	• Includes county-level travel and activity data for the entire nation while post-processing allows quick aggregation of emissions over months, roadway types, vehicle types, and equipment types. • Distributed processing capability achieves faster run times over the two models individually.	• Constrained by the same limitations as the NONROAD and MOBILE6 models in terms of CO estimates and forecasts (especially[2] lack of responsiveness to vehicle operating characteristics and limitations in fuel economy projections). • No capability to conduct project-level analysis or generate hourly and by-model-year output tables.
A3.Lifecycle..	**LEM** Lifecycle Emissions Model	The user specifies any year between 1970 and 2050 and the mode looks up or calculates energy-use intensities, emissions factors, or other data for that specific year. Projections in the model come from US DOE projections, constant percentage changes each year, and logistic functions. With these inputs the LEM produces results such as total life-cycle emissions by transportation source. (continued …)		Light Duty Vehicles Heavy Duty Vehicles Buses … (continued …)	CO_2 N_2O … (continued..)	• Provides estimates and projections of emissions of all GHGs for any year 1970 to 2050 for the full life-cycle of transport, including fuels (from feedstock production through fuel production through... (continued …)	• Proprietary model is not publicly available. • Emissions factor estimation is akin to a highly simplified version of EPA's MOBILE model, and does not account for as many factors. .. (continued …)

Technique	Model	Methodology	Geographic Level	Modes Addressed	Gases Analysed	Strengths	Weaknesses
A. TRANSPORTATION GHG CALCULATION TOOLS A3. Lifecycle GHG Emission Calculation Tools	(continued…) **LEM** Lifecycle Emissions Model	(continued…) …..and by component of the life-cycle, and emissions per mile (from motor vehicles). It distinguishes emissions that are in-country vs. out-of-country in the lifecycle emissions analysis, and can be used for various transportation scenarios.		(continued…) …… Rail Maritime Vessels Other Non-road	(continued..) .... CH_4 HFCs Criteria Pollutants Air Toxics	(continued…) ...end use) materials associated with vehicle manufacture, vehicles (including assembly, operation & maintenance), and infrastructure construction. • Includes not only on-road vehicles, but also heavy-rail transit, light-rail transit, diesel trains, freight tankers, cargo ships, and barges, and pipelines. • Provides results in emissions per mile from motor vehicles and energy-use intensities for other modes, and can provide other types of outputs (% change).	(continued…) • Does not include vehicle disposal in the lifecycle estimates.
	GREET Greenhouse gases Regulated Emissions and Energy Use in Transportation	GREET is designed primarily for analyses of advanced technology and alternative fuel vehicles. It allows researchers and analysts to analyse and compare various vehicle and fuel combinations on a full fuel-cycle basis. Vehicular emissions of baseline gasoline and diesel vehicles are lifted from MOBILE, and PART5. SOxemissions are calculated from the sulphur contents of fuels, CO_2emissions from carbon balance, and N_2O emissions are assumed with emissions testing results and technology potentials.	Any within U.S.	Light Duty Vehicles	CO_2 N_2O CH_4 Criteria Pollutants	• To address technology improvements over time, fuels and vehicle technologies are separated into near- and long-term options over 30 fuel-cycle pathway groups. • Developed to model advanced vehicle technologies and new transportation fuels. Analyses energy consumption from material recovery to vehicle disposal. • In additional to total emissions, the 3 GHG are reported as global warming potential used to calculate CO_2equivalents and urban emissions.	• Does not have the capability to estimate energy consumption and emission totals over multiple calendar years and multiple advanced vehicle market penetration scenarios.
	MOVES MOtor Vehicle Emissions Simulator	Estimates on-road "pump-to-wheel" energy consumption and emissions by the processes of running, start, and extended idle, and also includes fuel cycle "well-to-pump" energy and emissions via the GREET model. The model generates quantities of energy consumption (total, petroleum-based and fossil-based), emissions of nitrous oxide (N_2O) and methane (CH_4), and distance (e.g. vehicle miles travelled) for the geographic region and time period being modelled. It uses a physical emissions rate estimator (PERE) model to calculate energy consumption which allows for different energy consumptions for different speeds and facility types or duty cycles. MOVES can be used for project-level analyses, regional emissions analysis, or state or national inventory development.	Any (county, individual state, national) within US.	Light Duty Vehicles Heavy Duty Vehicles Buses	CO_2 N_2O CH_4	• Calculation of energy consumption uses a physical emissions rate estimator (PERE), for all travel modes, accounting for the effects of vehicle speed, operating mode, and vehicle type. • Combines GREET well-to-pump estimates for numerous fuel production and distribution pathways with capability to estimate energy consumption and emission totals over multiple calendar years and multiple advanced vehicle market penetration scenarios.	• The MOVES2004 version does not directly calculate CO_2 emissions. It develops estimates of energy consumption, which must be converted into CO_2 off-model. In MOVES2006, the tool calculates CO_2. • Despite the user-friendly interface and default values, the vast amount of data in the model make it somewhat complex to use for certain types of simple project analyses and if the user wants to replace default values. There is currently limited documentation on how to use the tool to generate emission factors for project-level analyses.

Technique	Model	Methodology	Geographic Level	Modes Addressed	Gases Analysed	Strengths	Weaknesses
B. TRANSPORTATION / EMISSIONS STRATEGY ANALYSIS TOOLS	**COMMUTER**	It is designed to analyse the impacts of transportation control measures (TCMs), such as regional and employer-based transportation demand management strategies and incentives (e.g. transit fare price reductions) on VMT, criteria pollutant emissions & CO_2. It contains 2 components: analysis of travel impacts and analysis of emissions. The first uses a logit mode-choice model ('pivot point' approach), which calculates the impacts of programs on mode share changes, based on starting mode shares; the approach allows analysis of the impacts of multiple strategies in combination. The changes in mode shares are then translated into changes in trips and VMT. The second applies emission factors based on EPA's MOBILE5b model; the factors reflect several different location conditions. The model offers 2 levels of analysis: 1) regional analyses can be done on programs covering an urban area, a central business district or a highly-travelled corridor; 2) site-specific analyses enable impacts to be projected for programs at individual worksites. The CO_2 estimation is very simple, relying on an average emissions factor per vehicle mile.	Any (county, individual state, and potentially national) within US.	Light Duty Vehicles	CO_2 Criteria Pollutants	• Relatively easy to use and requires few inputs. • The tool analyses the impacts of TDM and TCM strategies on VMT, criteria pollutant emissions, and CO_2 all in one package. It can also analyse packages of strategies.	• Default CO_2 emissions factor does not account for important local factors, like vehicle fleet mix, vehicle age, or speeds, although the tool allows the user to link to emissions factor outputs from MOBILE. • In addition to limitations in the CO_2 emissions factors, there is a relatively high level of uncertainty in the estimates of travel impacts.
	IDAS Intelligent Transport Systems Deployment Analysis System	IDAS operates as a post-processor to travel demand forecasting models. It utilises the modal split and traffic assignment results from the traditional planning model to estimate changes in modal, route, and temporal decisions of travellers, as well as induced/foregone demand resulting from ITS technologies. It then estimates the travel benefits of these traveller behaviour changes.	Any (county, individual state, and potentially national) within US.	Light Duty Vehicles Heavy Duty Vehicles Buses	CO_2 Criteria Pollutants	• Designed to specifically address the impact of ITS on emissions through resulting travel behaviour changes including changes in user mobility, travel time/speed, travel time reliability (non-recurring congestion duration), fuel costs, operating costs, accident costs, emissions and noise. • Operates as a post-processor to traditional 4-step travel demand forecasting models and relies upon modal split and traffic assignment results from the traditional planning models.	• Application and policy sensitivity is largely limited to ITS. • Effects of vehicle characteristics, speeds, etc. on fuel consumption and CO_2 emissions are limited.
C. ENERGY / ECONOMIC…	**SAGE** Systems for the Analysis of Global Energy Markets	For each region, reference case estimates of end-use energy service demands (e.g., car, commercial truck, and heavy truck road travel; residential lighting; steam heat requirements in the paper industry) are developed on the basis of economic and demographic projections. Projections of energy consumption to meet energy demands are estimated on the basis of each region's existing energy use patterns, the existing stock of energy-using equipment, the characteristics of available new technologies and new sources of primary energy supply.	Project within U.S. (e.g. signal improvement project and new transit service)	Light Duty Vehicles Heavy Duty Vehicle	CO_2 N_2O CH_4	• Transportation sub-model incorporates both qualitative and quantitative components including 'expert judgment'.	• Designed to replace the WEPS model, SAGE also models energy markets at the country and regional (multi-country) level, which limits the tool's usefulness at the local and state level.

Technique	Model	Methodology	Geographic Level	Modes Addressed	Gases Analysed	Strengths	Weaknesses
C. ENERGY / ECONOMIC FORECASTING ANALYSIS TOOLS	**NEMS** National Energy Modeling System	It represents the behaviour of energy markets (e.g. market economics, industry structure, and existing energy policies and regulations) and their interactions with the US economy. A series of sub-modules in TRAN build off of one another. For example, the Light Duty Vehicle (LDV) Module generates driving, fuel economy and fuel consumption estimates for light duty vehicles. This information is then passed to the Miscellaneous Energy Use Module, which uses additional inputs to calculate regional fuel consumption by mass transit vehicles and recreational boating. VMT per capita estimates are based on the fuel cost of driving per mile, per capita disposable personal income, and an adjustment for female-to-male driving ratios. Total VMT is calculated by multiplying VMT per capita by the driving age population.	Any State within U.S. (not designed for, but can be used)	Light Duty Vehicles Heavy Duty Vehicles Buses Rail Aircraft Maritime Vessels Other Non-road	CO_2	• Travel demand and energy consumption estimates are based on inputs of demographic, geographic, and economic factors. • Provides comprehensive database of vehicle types, including advanced and alternative fuel vehicles not yet on market, with model feedback influencing uptake/penetration rates. • Provides a comprehensive well to pump energy consumption analysis, in addition to vehicle emissions estimates.	• Complex to run for simple transportation analyses. • All data are provided in the model at the national and/or multi-state level; it is not available at state or lower level without simplifying assumptions or extensive local data needs. • Limited availability - proprietary portions such as the macroeconomic model and the optimization modelling libraries can be ordered but at high cost, and thus the tool is only used at a handful of places outside the DOE.
	VISION	The model consists of 2 Excel workbooks: a base case of US highway fuel use and carbon emissions to 2050 and a copy of the base case that can be modified to reflect alternative assumptions about advanced vehicle and alternative fuel market penetration. It uses vehicle survival and age dependent usage characteristics to project total light- and heavy-vehicle stock, total VMT, and total energy use by technology and fuel type by year, given market penetration and vehicle energy efficiency assumptions developed exogenously. The model also estimates total carbon equivalent emissions, based on carbon coefficients representing full fuel-cycle emissions (e.g. includes carbon emissions from petroleum production, emissions at the refinery, and delivery to and use of the fuels in vehicles), based on coefficients in the GREET model.	Any State within U.S. (not designed for, but can be used)	Light Duty Vehicles Heavy Duty Vehicles	CO_2 N_2O CH_4	• Models energy use, oil use, and carbon emissions through 2050 using a quick turnaround, easy to use format. • Allows analysis of changes to transportation or energy policies, including share of advanced technology/alternative fuel vehicles, VMT growth, and fuel prices.	• Assumptions, inputs, and most reports are calculated in 10 year intervals. • Analysis is conducted at the national level, making post-processing or edits in default energy assumptions necessary for state or regional analysis. • This tool does not take into account the impacts of economic factors on consumer vehicle choices.
	WEPS TEM World Energy Protection System Transportation Energy Model	For a given set of assumptions, the TEM component of the WEPS model forecasts energy use by transport mode. Estimates of growth in energy use for each mode are built up from estimates of growth in travel and growth in energy intensity. Energy use totals by mode and region are distributed to fuel types based on historical trends and energy market developments.	Any State within U.S. (not designed for, but can be used)	Light Duty Vehicles Heavy Duty Vehicles Buses Rail Aircraft Maritime Vessels Other Non-road	CO_2	• Takes into account world markets affecting energy supply and demand at the local and state level.	• Country level and regional (multi-country) analysis limits this tool's usefulness at the local and state level. • Places particular emphasis on the impact of developing countries' consumption patterns on future world energy and CO_2 emissions.

B2. GREENHOUSE GAS ANALYSIS TECHNIQUES FOR EUROPEAN/UK TRANSPORT PROJECTS

B2. Greenhouse Gas Analysis Techniques for European/UK Transportation Projects							
Technique	**Model**	**Methodology**	**Geographic Level**	**Modes Addressed**	**Gases Analysed**	**Strengths**	**Weaknesses**
EU/UK AIR POLLUTANT ASSESSMENT METHODS	**EMEP/ CORINAIR**	The CORINAIR methodology requires countries to collect emission estimates using a detailed source nomenclature and a detailed spatial level. The are 2 types of estimates: • *Detailed Method*: Total emissions are calculated by summing emissions from 3 different sources: the thermally stabilised engine operation (hot), the warming-up phase (cold-start) and due to evaporation. Emissions are calculated for different driving and climate conditions, fuel consumption, vehicle speeds and vehicle ages. • *Simpler Method*: It is actually the application of the detailed method using aggregated emission factors. (source: http://www.eea.europa.eu/publications/ EMEPCORINAIR5/B710vs6.0.pdf)	EU States plus Iceland, Liechtenstein Norway	Passenger Cars Light Duty Vehicles Heavy Duty Vehicles Buses Rail 2 Wheelers Aircraft Maritime Vessels Other Non-road	CO_2 N_2O CH_4 Criteria Pollutants Air Toxics Heavy Metals	• The method is periodically revised and expanded to consider advances in vehicle technologies, fuel types and modes patterns. • Emission factors are reported for many European countries separately using data from national inventories. This increases the accuracy of the method. • Dependent on the application the user may choose between the detailed and the simplified emission assessment method.	• Current emission factors must be updated for LDVs and to consider cold start tests at -7C, more capacity classes, independent estimations (e.g. at national level), statistical input to estimate the spatial allocation of vehicle emissions and trip statistics, statistical calculation of total uncertainties for the estimation of emissions (e.g. Monte Carlo analysis). • More frequent inventory updates are needed in the case of road traffic emissions due to the large and rapid changes in the sector.
	COPERT 4	Emissions estimated are distinguished in 3 sources: Emissions produced during thermally stabilised engine operation (hot emissions), emissions occurring during engine start from ambient temperature (cold-start and warming-up effects) and NMVOC emissions due to fuel evaporation. Non-exhaust PM emissions from tyre and break wear are also included. The total emissions are calculated as a product of activity data provided by the user and speed-dependent emission factors calculated by the software. The corresponding software application has been developed for the compilation of national inventories on a yearly basis. However, it can also be used with a sufficient degree of certainty at a higher resolution too. (source: http://transportpanel.jrc.ec. europa.eu/pdf/projects/TA_corinair.pdf) Copert 4 is part of the EMEP/CORINAIR Emission Inventory Guidebook. Emissions for other non-road sources can be calculated by using Copert III. Information on non-road transport activity data (maritime, rail and aviation) can be gathered by the Ex-Tremis project (http://www.ex-tremis.eu/)	27 EU States plus Croatia Norway Switzerland Turkey	Passenger Cars Light Duty Vehicles Heavy Duty Vehicles 2 Wheelers Buses	CO_2 N_2O CH_4 Air Toxics Heavy Metals	• It is available in the form of a MS Windows software program (free to use). This allows for a transparent and standardised, hence consistent and comparable data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation. • The methodology is fully consistent with the Road Transport chapter of the EMEP/CORINAIR method. • Separate databases are available for 31 countries (EU-27 plus Croatia, Norway, Switzerland and Turkey). • User friendly interface following Window's approach. Simple to import data and provision of results in lists or more aggregated reports.	• Some problems with previous versions of COPERT due to bugs, type errors and incompatibility with various MS Windows versions (eg in importing databases and exporting reports). • Uncertainties about hot emission factors due to large number {26992} individual standard deviation values. • Due to lack of robust experimental data for cold start, the standard deviation over mean of the hot emission factors were used, assuming log-normal probability functions. • Uncertainties associated with data for different countries (eg. Italy: uncertainty about allocation of HDVs to different weight categories, Poland: unknown age distribution of vehicles) (source: http://transportpanel.jrc.ec. europa.eu/pdf/projects/TA_uncertainty.pdf)
UK… (continued)	**NAEI**	This is the UKs National Atmospheric Emissions Inventory. The methodology combines traffic activity data (from DfT's national traffic census) with fleet composition data (vehicle mix by engine size, vehicle size, age, engine and exhaust treatment technology, Euro…. (continued…)	UK (continued…)	Light Duty Vehicles Heavy Duty Vehicles Buses …. (continued…)	CO_2 N_2O CH_4 ..... (continued..)	• The inventory is updated annually, to consider improved data and any advances in the methodology used to estimate the emissions. This ensures accuracy... (continued…)	• There are no emission factors available for stationary vehicles. For idling vehicles low speeds (e.g. 5km/hr) must be considered…. (continued…)

Technique	Model	Methodology	Geographic Level	Modes Addressed	Gases Analysed	Strengths	Weaknesses
UK AIR POLLUTANT ASSESSMENT METHODS	**NAEI** National Atmospheric Emissions Inventory	(continued…) …emission standards, fuel type the vehicle uses, based on licensing data from DfT) and fuel consumption/emission factors. The latter are based on published compilations of factors derived from vehicle emission test data from various UK and European sources. Representative samples of vehicles are tested over a range of drive cycles associated with different average speeds on different road conditions: there are many parameters that affect the amount of fuel a vehicle uses and average vehicle speed is one of them, so the NAEI uses functions that relate fuel consumption to average speed (source: DECC, 2007).	(continued…) UK	(continued…) …… Rail Aircraft Maritime Vessels Other Non-road	(continued.) …… HFCs PFCs SF6 Criteria Pollutants Air Toxics	(continued…) • Emissions of pollutants are available in maps presenting the pattern of their spatial disaggregation within the UK. • A large amount of information is available online to be used by public, the Government, LAs and other private organisations. • Throughout the compilation, all available data sources are considered to ensure consistency with other national statistics.	(continued…) • No road transport emission factors are available for driving vehicles up and down hills. Variations in speeds should be considered to take into account changes in gradient. • Offshore emissions are included in the inventory however it is difficult to identify an offshore total for many of the pollutants as the emissions occur from a number of different sectors.
	LAEI London Atmospheric Emissions Inventory	Currently it includes emissions data for the Greater London area (2,466 km^2) for the base year 2006 and projection for years 2010 and 2015. The emission estimates are predominantly based on emission factors and activity data estimated or measured for the base year.Using various socio-economic activity data, emission factors and a set of assumptions and simplifications of the future situation, emission estimates for future years are projected. (source: http://static.london.gov.uk/mayor/environment/air_quality/docs/laei-2004-full-report-dec08.pdf)	Greater London Area	Light Duty Vehicles Heavy Duty Vehicles Buses Rail 2 Wheelers Aircraft Maritime Vessels Other Non-road	CO_2 N_2O CH_4 NOx SO_2 CO NMVOC PM_{10}	• It allows users to compare 2003 and 2004 NOX and PM10 emission estimates. • The GLA provides the LAEI to London boroughs free of charge, as part of assisting London boroughs to implement their air quality work. • It includes data from large industrial sources outside London, which may impact upon London's air quality.	• A charge of £15 is levied to users other than London boroughs (in line with the GLA publications scheme). • Parameter uncertainty is the principal type and source of uncertainty associated with the LAEI emission estimates. Itarises due to a lack of precise and/or accurate emission factors and activity data. • Emissions are only expressed as annual average values. • Meteorological data used in the model is confined to a single location, the Heathrow Airport meteorological station.

APPENDIX C: STATISTICAL TESTS

C1. PEARSON’S CORRELATION

Test Description

The correlation between two variables reflects the degree to which the variables are related. The most common measure of correlation is the Pearson Product Moment Correlation ‘r’. Pearson's correlation reflects the degree of linear relationship between two variables. It ranges from +1 to -1. Positive correlation indicates that both variables increase or decrease together, whereas negative correlation indicates that as one variable increases, so the other decreases, and vice versa. Therefore a correlation of +1 means that there is a perfect positive linear relationship between variables and it is a positive relationship because high scores on the X-axis are associated with high scores on the Y-axis. A correlation of -1 means that there is a perfect negative linear relationship between variables and it is a negative relationship because high scores on the x-axis are associated with low scores on the y-axis. A correlation of 0 means there is no linear relationship between the two variables.

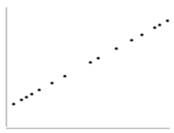
r = -1

data lie on a perfect straight line with a negative slope

r = 0

no linear relationship between the variables

r = +1



data lie on a perfect straight line with a positive slope

The formula for Pearson's correlation takes on many forms. The most commonly used formula is:

$$\textit{Pearson's Correlation:} \qquad r = \frac{\sum xy - \frac{\sum x \sum y}{N}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{N}\right)\left(\sum y^2 - \frac{(\sum y)^2}{N}\right)}} \quad \text{(Formula C1)}$$

, where Σx represents the sum of the x-axis values, Σy the sym of the y-axis values, Σx^2 the sum of the squares of the x-axis values, Σy^2 the sum of the squares of the y-axis values, $(\Sigma x)^2$ the square of the sum of the x-axis values, $(\Sigma y)^2$ the square of the sum of the y-axis values, Σxy the sum of the of the product of the x-axis and y-axis values, N the number of the variables examined and r the correlation. For interpretation purposes, the following typical classification of correlation is widely applied: $0<r<0.2$ negligible, $0.2<r<0.4$ weak, $0.4<r<0.7$ moderate, $0.7<r<0.9$ strong, $0.9<r<1$ very strong.

Sources: http://davidmlane.com/hyperstat/A34739.html
http://hsc.uwe.ac.uk/dataanalysis/quantinfasspear.asp

Pearson's Correlation Test Results

C1-1: EXAMINATION OF THE LINEAR DEPENDENCE BETWEEN THE NUMBER OF STORES WITH FLOOR SIZE A<200M², 200M²<A<500M², A>500M² AND THE NUMBER OF WEEKLY MCG DELIVERIES RECEIVED.

Table C1-1: Number of weekly MCGs deliveries made to *WestQuay* businesses (classification by business type and floor size).

Number of Business Type	A<200m²		A<200m²		A<200m²	
	Businesses (x)	Deliveries (y)	Businesses (x)	Deliveries (y)	Businesses (x)	Deliveries (y)
Clothing	7	20	17	59	9	39
Catering Units	16	99	2	5	2	22
Bookstores	1	7	1	3	2	56
Footwear	2	5	6	26	0	0
Opticians	1	3	2	15	0	0
Electronics	4	21	2	10	1	26
Jewellery	4	8	4	9	0	0
Cosmetics	4	4	0	0	0	0
Games	1	2	2	7	0	0
Other	1	1	1	1	0	0
Σx or Σy	**41**	**170**	**37**	**135**	**14**	**143**
Σx² or Σy²	**361**	**10,810**	**359**	**4,647**	**90**	**5,817**
(Σx)² or (Σy)²	**1,681**	**28,900**	**1,369**	**18,225**	**196**	**20,449**
Σxy	**1,879**	**1,879**	**1,273**	**1,273**	**533**	**533**

Applying the data from Table C1-1 to 'Formula C1' the following calculations were made:

$A < 200m^2$: $$r = \frac{1{,}879 - \frac{41*170}{10}}{\sqrt{(361 - \frac{1{,}681}{10})(10{,}810 - \frac{28{,}900}{10})}} = 0.96 \quad \textit{very strong} \quad (r^2 = 0.92)$$

$200m^2 < A < 500m^2$: $$r = \frac{1{,}273 - \frac{37*135}{10}}{\sqrt{(359 - \frac{1{,}369}{10})(4{,}647 - \frac{18{,}225}{10})}} = 0.98 \quad \textit{very strong} \quad (r^2 = 0.95)$$

$A > 500m^2$: $$r = \frac{533 - \frac{14*143}{10}}{\sqrt{(90 - \frac{196}{10})(5{,}817 - \frac{20{,}449}{10})}} = 0.65 \quad \textit{moderate} \quad (r^2 = 0.42)$$

The following scatterplot summarizes the above results:

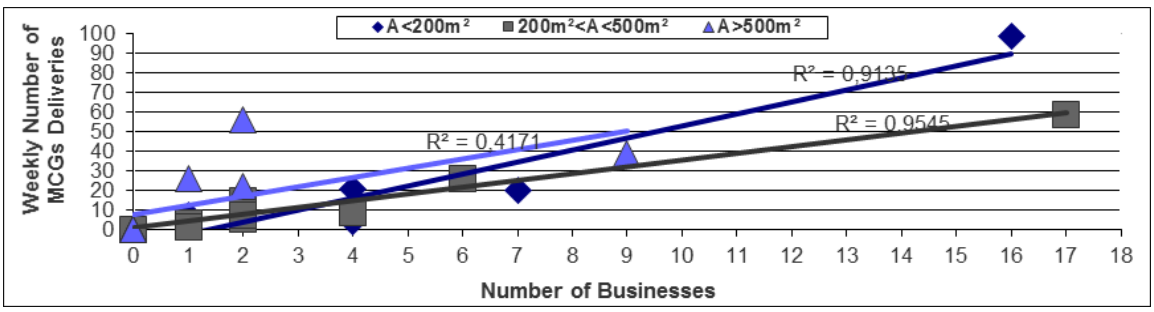


Figure C1-1: Linear regression of the number of weekly MCGs deliveries made on the number of *WestQuay* businesses receiving them (classification by floor size).

C1-2: EXAMINATION OF THE LINEAR DEPENDENCE BETWEEN THE NUMBER OF STORES WITH FLOOR SIZE A<200M², 200M²<A<500M², A>500M² AND THE WEEKLY DISTANCE TRAVELLED (KM) TO DELIVER MCGS.

Table C1-2: Weekly distance travelled (km) to deliver MCGs to *WestQuay* businesses (classification by business type and floor size).

Number of Business / Type	A<200m²		A<200m²		A<200m²	
	Businesses (x)	Distance(km) (y)	Businesses (x)	Distance(km) (y)	Businesses (x)	Distance(km) (y)
Clothing	7	3,005	17	12,320	9	12,281
Catering Units	16	17,901	2	38	2	2,280
Bookstores	1	1,985	1	819	2	13,231
Footwear	2	1,265	6	10,425	0	0
Opticians	1	366	2	8,280	0	0
Electronics	4	4,711	2	2,826	1	684
Jewellery	4	1,394	4	2,458	0	0
Cosmetics	4	621	0	0	0	0
Games	1	98	2	450	0	0
Other	1	217	1	412	0	0
Σx or Σy	41	31,563	37	38,028	14	28,476
Σx² or Σy²	361	359,729,323	359	344,093,914	90	331,548,578
(Σx)² or (Σy)²	1,681	996,222,969	1,369	1,446,128,784	196	810,882,576
Σxy	339,551	339,551	306,241	306,241	142235	142,235

Applying the data from Table C1-2 to 'Formula C1' the following calculations were made:

$$A < 200m^2: \quad r = \frac{339{,}551 - \frac{41 * 31{,}563}{10}}{\sqrt{(361 - \frac{1{,}681}{10})(359{,}729{,}323 - \frac{996{,}222{,}969}{10})}} = 0.94 \quad \textit{very strong} \quad (r^2 = 0.88)$$

$$200m^2 < A < 500m^2: \quad r = \frac{306{,}241 - \frac{37 * 38{,}028}{10}}{\sqrt{(359 - \frac{1{,}369}{10})(344{,}093{,}914 - \frac{1{,}446{,}128{,}784}{10})}} = 0.79 \quad \textit{strong} \quad (r^2 = 0.62)$$

$$A > 500m^2: \quad r = \frac{142{,}235 - \frac{14 * 28{,}476}{10}}{\sqrt{(90 - \frac{196}{10})(331{,}548{,}578 - \frac{810{,}882{,}576}{10})}} = 0.77 \quad \textit{strong} \quad (r^2 = 0.59)$$

The following scatterplot summarizes the above results:

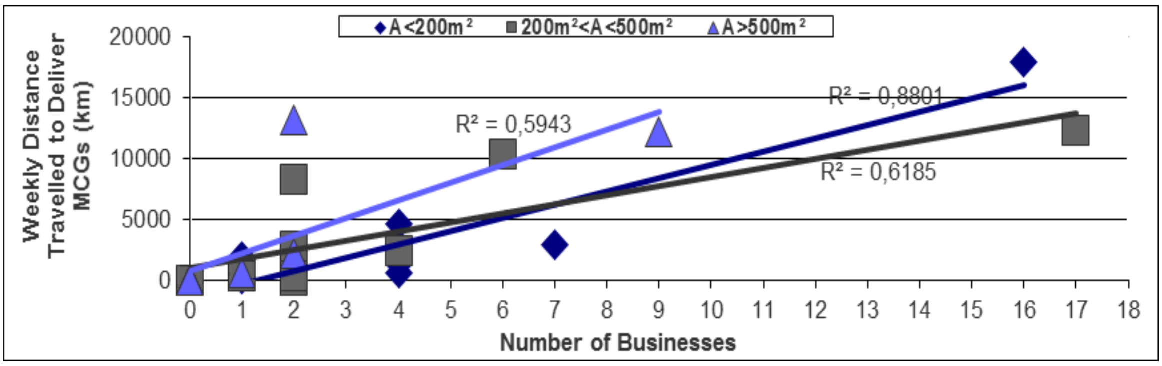


Figure C1-2: Linear regression of the weekly distance travelled (km) to deliver MCGs on the number of *WestQuay* businesses receiving them (classification by floor size).

C1-3: EXAMINATION OF THE LINEAR DEPENDENCE BETWEEN THE NUMBER OF MCGS DELIVERIES MADE TO STORES WITH FLOOR SIZE A<200M², 200M²<A<500M², A>500M² AND THE WEEKLY DISTANCE TRAVELLED (KM) TO DELIVER MCGS.

Table C1-3: Weekly distance travelled (km) to deliver a weekly number of MCGs to *WestQuay* businesses (classification by business type and floor size).

Number of Business Type	A<200m²		A<200m²		A<200m²	
	Deliveries (x)	Distance(km) (y)	Deliveries (x)	Distance(km) (y)	Deliveries (x)	Distance(km) (y)
Clothing	20	3,005	59	12,320	39	12,281
Catering Units	99	17,901	5	38	22	2,280
Bookstores	7	1,985	3	819	56	13,231
Footwear	5	1,265	26	10,425	0	0
Opticians	3	366	15	8,280	0	0
Electronics	21	4,711	10	2,826	26	684
Jewellery	8	1,394	9	2,458	0	0
Cosmetics	4	621	0	0	0	0
Games	2	98	7	450	0	0
Other	1	217	1	412	0	0
Σx or Σy	**170**	**31,563**	**135**	**38,028**	**143**	**28,476**
Σx² or Σy²	**10,810**	**359,729,323**	**4,647**	**344,093,914**	**5,817**	**331,548,578**
(Σx)² or (Σy)²	**28,900**	**996,222,969**	**18,225**	**1,446,128,784**	**20,449**	**810,882,576**
Σxy	**1,961,601**	**1,961,601**	**1,178,911**	**1,178,911**	**1,287,839**	**1,287,839**

Applying the data from Table C1-3 to 'Formula C1' the following calculations were made:

$$A < 200m^2: \quad r = \frac{1{,}961{,}601 - \frac{170*31{,}563}{10}}{\sqrt{(10{,}810 - \frac{28{,}900}{10})(359{,}729{,}323 - \frac{996{,}222{,}969}{10})}} = 1 \quad \textit{very strong} \quad (r^2 = 0.99)$$

$$200m^2 < A < 500m^2: \quad r = \frac{1{,}178{,}911 - \frac{135*38{,}028}{10}}{\sqrt{(4{,}647 - \frac{18{,}225}{10})(344{,}093{,}914 - \frac{1{,}446{,}128{,}784}{10})}} = 0.89 \quad \textit{strong} \quad (r^2 = 0.79)$$

$$A > 500m^2: \quad r = \frac{1{,}287{,}839 - \frac{143*28{,}476}{10}}{\sqrt{(5{,}817 - \frac{20{,}449}{10})(331{,}548{,}578 - \frac{810{,}882{,}576}{10})}} = 0.91 \quad \textit{very strong} \quad (r^2 = 0.82)$$

The following scatterplot summarizes the above results:

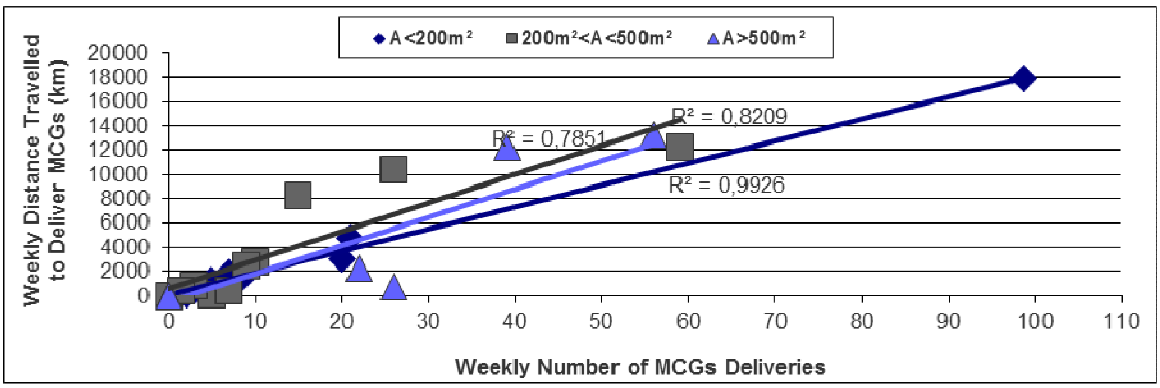


Figure C1-3: Linear regression of the weekly distance travelled (km) to deliver MCGs to *WestQuay* businesses on the number of MCGs delivered (classification by floor size).

C1-4: EXAMINATION OF THE LINEAR DEPENDENCE BETWEEN THE NUMBER OF STORES WITH FLOOR SIZE A<200M², 200M²<A<500M², A>500M² AND THE WEEKLY NUMBER OF MCGS PACKAGING UNITS DELIVERED.

Table C1-4: Weekly number of MCGs packaging units delivered to *WestQuay* businesses (classification by business type and floor size).

Number of Business Type	A<200m²		A<200m²		A<200m²	
	Businesses (x)	MCGs Units (y)	Businesses (x)	MCGs Units (y)	Businesses (x)	MCGs Units (y)
Clothing	7	217	17	873	9	1,681
Catering Units	16	2,112	2	21	2	84
Bookstores	1	19	1	102	2	481
Footwear	2	136	6	763	0	0
Opticians	1	3	2	65	0	0
Electronics	4	100	2	33	1	62
Jewellery	4	35	4	59	0	0
Cosmetics	4	57	0	0	0	0
Games	1	14	2	74	0	0
Other	1	25	1	22	0	0
Σx or Σy	41	2,718	37	2,012	14	2,308
Σx² or Σy²	361	4,541,794	359	1,369,898	90	3,068,022
(Σx)² or (Σy)²	1,681	7,387,524	1,369	4,048,144	196	5,326,864
Σxy	36,412	36,412	20,165	20,165	16,321	16,321

Applying the data from Table C1-4 to 'Formula C1' the following calculations were made:

$$A < 200m^2: \quad r = \frac{36{,}412 - \frac{41 * 2{,}718}{10}}{\sqrt{(361 - \frac{1{,}681}{10})(4{,}541{,}794 - \frac{7{,}387{,}524}{10})}} = 0.93 \quad \textit{very strong} \quad (r^2 = 0.87)$$

$$200m^2 < A < 500m^2: \quad r = \frac{20{,}165 - \frac{37 * 2{,}012}{10}}{\sqrt{(359 - \frac{1{,}369}{10})(1{,}369{,}898 - \frac{4{,}048{,}144}{10})}} = 0.87 \quad \textit{very strong} \quad (r^2 = 0.75)$$

$$A > 500m^2: \quad r = \frac{16{,}321 - \frac{14 * 2{,}308}{10}}{\sqrt{(90 - \frac{196}{10})(3{,}068{,}022 - \frac{5{,}326{,}864}{10})}} = 0.98 \quad \textit{very strong} \quad (r^2 = 0.96)$$

The following scatterplot summarizes the above results:

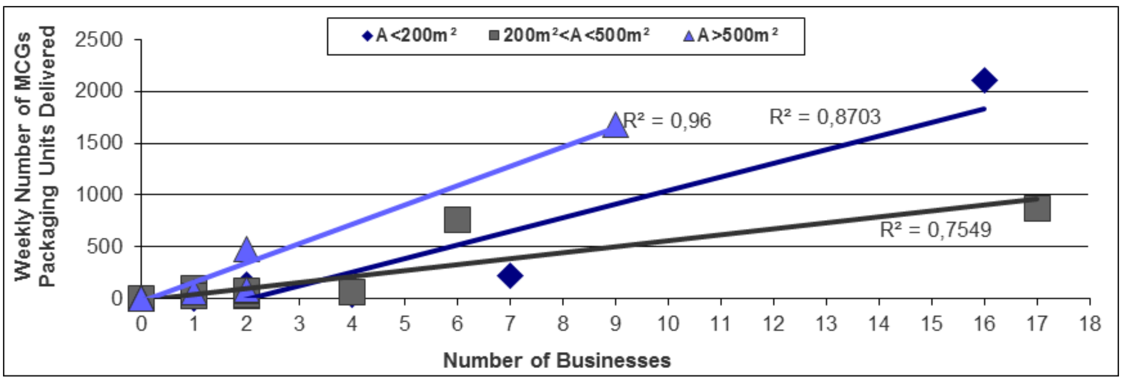


Figure C1-4: Linear regression of the weekly number of MCGs packaging units delivered to *WestQuay* businesses on the number of businesses receiving them (classification by floor size).

C1-5: EXAMINATION OF THE LINEAR DEPENDENCE BETWEEN THE NUMBER OF MCGS DELIVERIES MADE TO STORES WITH FLOOR SIZE A<200M², 200M²<A<500M², A>500M² AND THE WEEKLY NUMBER OF MCGS PACKAGING UNITS DELIVERED.

Table C1-5: Weekly number of MCGs packaging units delivered to *WestQuay* businesses through a weekly number of MCGs deliveries (classification by business type and floor size).

Number of Business Type	A<200m²		A<200m²		A<200m²	
	Deliveries (x)	MCGs Units (y)	Deliveries (x)	MCGs Units (y)	Deliveries (x)	MCGs Units (y)
Clothing	20	217	59	873	39	1,681
Catering Units	99	2,112	5	21	22	84
Bookstores	7	19	3	102	56	481
Footwear	5	136	26	763	0	0
Opticians	3	3	15	65	0	0
Electronics	21	100	10	33	26	62
Jewellery	8	35	9	59	0	0
Cosmetics	4	57	0	0	0	0
Games	2	14	7	74	0	0
Other	1	25	1	22	0	0
Σx or Σy	**170**	**2,718**	**135**	**2,012**	**143**	**2,308**
Σx² or Σy²	**10,810**	**4,541,794**	**4,647**	**1,369,898**	**5,817**	**3,068,022**
(Σx)² or (Σy)²	**28,900**	**7,387,524**	**18,225**	**4,048,144**	**20,449**	**5,326,864**
Σxy	**216,270**	**216,270**	**74,142**	**74,142**	**95,955**	**95,955**

Applying the data from Table C1-5 to 'Formula C1' the following calculations were made:

$$A < 200m^2: \quad r = \frac{216{,}270 - \frac{170*2{,}718}{10}}{\sqrt{(10{,}810 - \frac{28{,}900}{10})(4{,}541{,}794 - \frac{7{,}387{,}524}{10})}} = 0.98 \quad \textit{very strong} \quad (r^2 = 0.97)$$

$$200m^2 < A < 500m^2: \quad r = \frac{74{,}142 - \frac{135*2{,}012}{10}}{\sqrt{(4{,}647 - \frac{18{,}225}{10})(1{,}369{,}898 - \frac{4{,}048{,}144}{10})}} = 0.90 \quad \textit{very strong} \quad (r^2 = 0.81)$$

$$A > 500m^2: \quad r = \frac{95{,}955 - \frac{143*2{,}308}{10}}{\sqrt{(5{,}817 - \frac{20{,}449}{10})(3{,}068{,}022 - \frac{5{,}326{,}864}{10})}} = 0.64 \quad \textit{moderate} \quad (r^2 = 0.41)$$

The following scatterplot summarizes the above results:

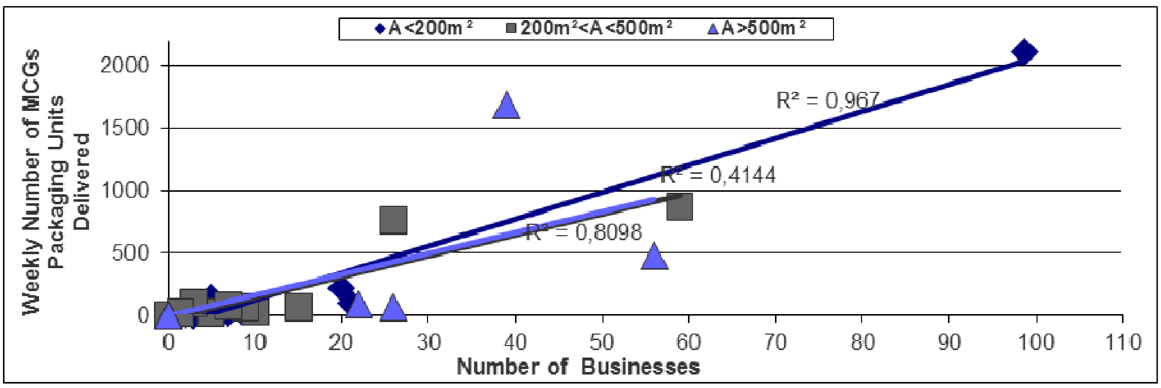


Figure C1-5: Linear regression of the weekly number of MCGs packaging units delivered to *WestQuay* businesses on the number of businesses receiving them (classification by floor size).

C1-6: EXAMINATION OF THE LINEAR DEPENDENCE BETWEEN THE NUMBER OF STORES WITH FLOOR SIZE A<200M², 200M²<A<500M², A>500M² AND THE VOLUME OF WEEKLY MCG DELIVERIES RECEIVED.

Table C1-6: Weekly volume (m3) of MCGs delivered to WestQuay businesses (classification by business type and floor size).

Number of Business Type	A<200m²		A<200m²		A<200m²	
	Businesses (x)	Volume(m^3) (y)	Businesses (x)	Volume(m^3) (y)	Businesses (x)	Volume(m^3) (y)
Clothing	7	112.6	17	69.4	9	308.1
Catering Units	16	146.8	2	13.6	2	36.2
Bookstores	1	3.6	1	12	2	36.4
Footwear	2	8.2	6	62.6	0	0
Opticians	1	0.4	2	2.5	0	0
Electronics	4	21.3	2	8.5	1	12.2
Jewellery	4	2	4	7.2	0	0
Cosmetics	4	19.8	0	0	0	0
Games	1	1	2	12	0	0
Other	1	2.7	1	2.2	0	0
Σx or Σy	**41**	**318.4**	**37**	**189.9**	**14**	**392.8**
Σx² or Σy²	**361**	**35,167**	**359**	**9,343**	**90**	**97,710**
(Σx)² or (Σy)²	**1,681**	**101,379**	**1,369**	**36,062**	**196**	**154,222**
Σxy	**3,334**	**3,334**	**1,672**	**1,672**	**2,930**	**2,939**

Applying the data from Table C1-6 to 'Formula C1' the following calculations were made:

$$A < 200m^2: \quad r = \frac{3{,}334 - \frac{41*318.4}{10}}{\sqrt{(361 - \frac{1{,}681}{10})(35{,}167 - \frac{101{,}379}{10})}} = 0.92 \quad \textit{very strong} \quad (r^2 = 0.85)$$

$$200m^2 < A < 500m^2: \quad r = \frac{1{,}672 - \frac{37*189.9}{10}}{\sqrt{(359 - \frac{1{,}369}{10})(9{,}343 - \frac{36{,}062}{10})}} = 0.86 \quad \textit{strong} \quad (r^2 = 0.74)$$

$$A > 500m^2: \quad r = \frac{2{,}930 - \frac{14*392.8}{10}}{\sqrt{(90 - \frac{196}{10})(97{,}710 - \frac{154{,}222}{10})}} = 0.99 \quad \textit{very strong} \quad (r^2 = 0.98)$$

The following scatterplot summarizes the above results:

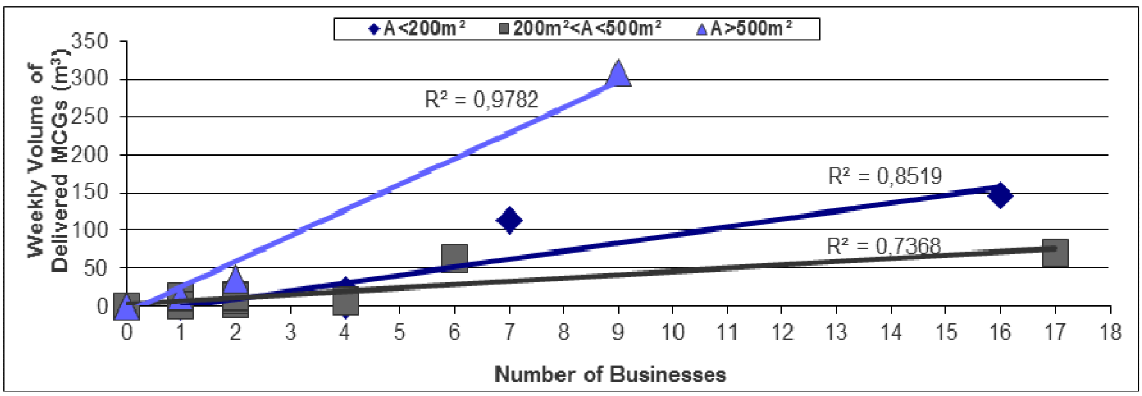


Figure C1-6: Linear regression of the weekly volume (m3) of MCGs delivered on the number of *WestQuay* businesses receiving them (classification by floor size).

C1-7: Examination of the linear dependence between the number of MCGs deliveries made to stores with floor size A<200m², 200m²<A<500m², A>500m² and the volume of weekly MCG deliveries received.

Table C1-7: Weekly volume (m³) of MCGs delivered to *WestQuay* businesses (classification by business type and floor size).

Number of Business Type	A<200m²		A<200m²		A<200m²	
	Deliveries (x)	Volume(m³) (y)	Deliveries (x)	Volume(m³) (y)	Deliveries (x)	Volume(m³) (y)
Clothing	20	112.6	59	69.4	39	308.1
Catering Units	99	146.8	5	13.6	22	36.2
Bookstores	7	3.6	3	12	56	36.4
Footwear	5	8.2	26	62.6	0	0
Opticians	3	0.4	15	2.5	0	0
Electronics	21	21.3	10	8.5	26	12.2
Jewellery	8	2	9	7.2	0	0
Cosmetics	4	19.8	0	0	0	0
Games	2	1	7	12	0	0
Other	1	2.7	1	2.2	0	0
Σx or Σy	**170**	**318.4**	**135**	**189.9**	**143**	**392.8**
Σx² or Σy²	**10,810**	**35,167**	**4,647**	**9,343**	**5,817**	**97,710**
(Σx)² or (Σy)²	**28,900**	**101,379**	**18,225**	**36,062**	**20,449**	**154,222**
Σxy	**17,355**	**17,355**	**6,101**	**6,101**	**15167.9**	**15167.9**

Applying the data from Table C1-7 to 'Formula C1' the following calculations were made:

$A < 200m^2$: $$r = \frac{17,355 - \frac{170*318.4}{10}}{\sqrt{(10,810 - \frac{28,900}{10})(35,167 - \frac{101,379}{10})}} = 0.85 \quad \textit{very strong} \quad (r^2 = 72)$$

$200m^2 < A < 500m^2$: $$r = \frac{6,101 - \frac{135*189.9}{10}}{\sqrt{(4,647 - \frac{18,225}{10})(9,343 - \frac{36,062}{10})}} = 0.88 \quad \textit{strong} \quad (r^2 = 0.77)$$

$A > 500m^2$: $$r = \frac{15,167.9 - \frac{143*392.8}{10}}{\sqrt{(5,817 - \frac{20,449}{10})(97,710 - \frac{154,222}{10})}} = 0.54 \quad \textit{very strong} \quad (r^2 = 0.29)$$

The following scatterplot summarizes the above results:

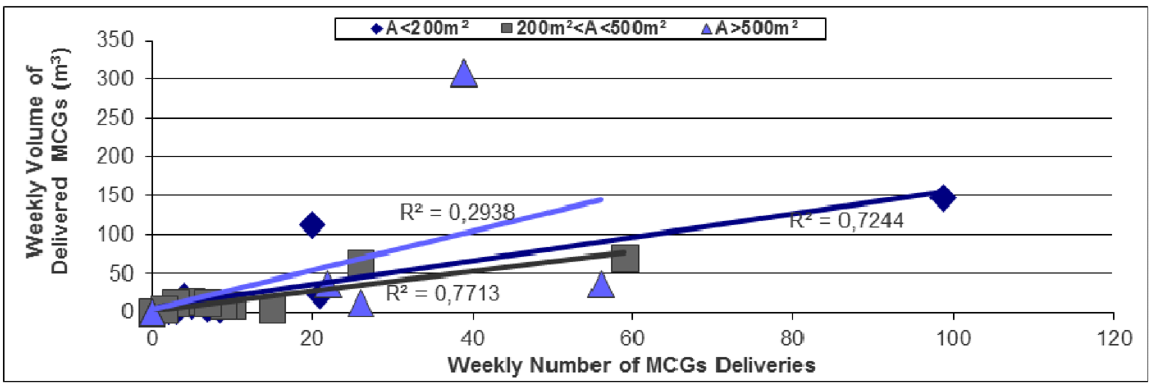


Figure C1-7: Linear regression of the weekly volume (m³) of MCGs delivered to *WestQuay* businesses on the number of weekly MCGs deliveries them (classification by floor size).

C2. STUDENT'S T-TEST

Test Description

The T-test assesses whether the means of two groups are statistically different from each other (in simple words to 'judge' the difference between two group means relative to the spread or variability of their scores). In order to test whether the difference between the two groups is significant the following values must be determined: the t-value, the degrees of freedom (df) and the level of significance.

The formula for the t-test is a ratio. The top part of the ratio is the difference between the two means or averages ($\overline{x}_1$ and $\overline{x}_2$). The bottom part is a measure of the variability or dispersion of the scores and is called 'standard error of the difference'. It is calculated by taking the variance (square of standard deviation) for each group (S_1^2 and S_2^2) and dividing it by the number of the people in that group (n_1 and n_2), then adding these two values and taking their square root.

$$t = \frac{\overline{x1} - \overline{x2}}{\sqrt{\frac{\int 1^2}{n1} + \frac{\int 2^2}{n2}}} \qquad \text{(Formula C2)}$$

The 'Degrees of Freedom (df)' is the sum of the data items in both groups minus 2.

The 'Level of Significance' is the risk level (or alpha level) set to say whether the difference between the two groups is not likely to have been a chance finding. Usually it is set at 0.05 (95%) or sometimes at 0.01 (99%) which means that five times out of a hundred there would be found a statistically significant difference between the examined means even if there was actually none but it was due to chance.

In order to test whether the t-value ratio is large enough to be significant one has to use a table of significance given the t-value, the significance level and the degrees of freedom. If the t-value ratio is found to be significant then it can be concluded that the difference between the means for the two groups is different.

Sources:
http://www.socialresearchmethods.net/kb/stat_t.php/
http://www.utdallas.edu/~banuri/ttest.jpg

alpha one-tailed	.05	.025	.01	.005
alpha two-tailed	.10	.05	.02	.01
df				
1	6.314	12.706	31.821	63.657
2	2.920	4.303	6.965	9.925
3	2.353	3.182	4.541	5.841
4	2.132	2.776	3.743	4.604
5	2.015	2.571	3.365	4.032
6	1.943	2.447	3.143	3.707
7	1.895	2.365	2.998	3.499
8	1.869	2.306	2.896	3.355
9	1.833	2.262	2.821	3.250
10	1.812	2.228	2.764	3.169
11	1.796	2.201	2.718	3.106
12	1.782	2.179	2.681	3.055
13	1.771	2.160	2.650	3.012
14	1.761	2.145	2.624	2.977
15	1.753	2.131	2.602	2.947
16	1.746	2.120	2.583	2.921
17	1.740	2.110	2.567	2.898
18	1.734	2.101	2.552	2.878
19	1.729	2.093	2.539	2.861
20	1.725	2.086	2.528	2.845
21	1.721	2.080	2.518	2.831
22	1.717	2.074	2.508	2.819
23	1.714	2.069	2.500	2.807
24	1.711	2.064	2.492	2.797
25	1.708	2.060	2.485	2.787
30	1.697	2.042	2.457	2.750
40	1.684	2.021	2.423	2.704
60	1.671	2.000	2.390	2.660
120	1.658	1.980	2.358	2.617
inf	1.645	1.96	2.326	2.576

Table C2-1: Example of table of significance for T-test.

C3. One-Way ANOVA and Tukey's Post-Hoc Test

Tests Description

One-Way ANOVA: This technique is used to examine if the means of a population are the same (null hypothesis) or if they differ between populations (research hypothesis) by looking at the variances (sums of squares between groups ($\iint A$), within a group or 'error sum of squares' ($\iint A/S$), and total sum of squares ($\iint T$)). It is preferred against T-test analysis when there is a categorical independent variable and a continuous dependent variable and there are more than two levels of the independent variable and/or there is more than one independent variable. One of its principal advantages is that the number of observations does not need to be the same in each group.

The 'Between Groups' row represents the 'explained or systematic variance' which is the difference among the examined groups due to the independent variable. It examines the differences among the group means by calculating the variation of each mean ($\overline{xi}$) around the grand mean ($\bar{x}$) and is equal to the 'sum of squares $\iint A$ between the groups', where *n* is the number of observations in each group, *a* the number of groups and *N* the total number of observations in the study.

$$\textit{Between Groups Sum of Squares:} \quad \iint A = n\sum(\overline{xi} - \bar{x})^2 \qquad \text{(Formula C3)}$$

The degrees of freedom (df) for the 'Between Groups' variance are equal to:

$$dfA = a - 1 \qquad \text{(Formula C4)}$$

The 'Within Groups' variance represents the 'error variance' which is the difference within the examined groups not due to the independent variable. It examines the variation of individual scores (xij) around each group mean ($\overline{xj}$) and is equal to the 'sum of their squares $\iint A/S$'.

$$\textit{Within Groups Sum of Squares:} \quad \iint A/S = n\sum(xij - \overline{xj})^2 \qquad \text{(Formula C5)}$$

The degrees of freedom (df) for the '*Within Groups*' variance are equal to:

$$dfA/S = a(n-1) = N - a \qquad \text{(Formula C6)}$$

The '*Total Sum of Squares*' is the sum of the '*Between Groups*' variance ($\iint A$) and the 'Within Groups' variance ($\iint A/S$) which represent the variation due to the independent variable and the variation due to individual differences in the score, respectively.

$$\textit{Total Sum of Squares:} \quad \iint T = \iint A + \iint A/S \qquad \text{(Formula C7)}$$

The degrees of freedom (df) for the '*Total*' variance are equal to:

$$dfT = an - 1 = N - 1 \qquad \text{(Formula C8)}$$

The '*Mean Squares* MS are calculated by dividing the '*Between Groups*' and the '*Within Groups*' sums of squares by the corresponding degrees of freedom.

$$Mean\ Square\ of\ Between Groups: \quad M\int A = \frac{n\sum(\bar{x}_i - \bar{x})^2}{a-1} \qquad \text{(Formula C9)}$$

$$Mean\ Square\ of\ Within\ Groups: \quad M\int S/A = \frac{n\sum(x_{ij} - \bar{x}_j)^2}{N-a} \qquad \text{(Formula C10)}$$

The '*F score*' is a ratio of the 'Between Groups or Explained' variance' versus the 'Within Groups or Error' variance.

$$F\ score: \quad F = \frac{M\int A}{M\int S/A} = \frac{\frac{n\sum(\bar{x}_i-\bar{x})^2}{a-1}}{\frac{n\sum(x_{ij}-\bar{x}_j)^2}{N-a}} \qquad \text{(Formula C11)}$$

The output of the ANOVA analysis is reported in the following form: [F(2, 27)=5.77, P=0.008], where the degrees of freedom of the between groups come before the degrees of freedom of the within groups 'error'. The calculated value of '*F ratio*' follows and is compared to the F-values table for regression (P value in the above equation) for the given degrees of freedom and level of significance (95% and/or 99%). The following table includes the F-values for dfA =1-9 and $dfA/S = 1 - 120$.

Table C3-1: Example of F-values table used in conjunction with the one-way ANOVA test.

F - Distribution (α = 0.05 in the Right Tail)

df_2 \ df_1 (Denominator Degrees of Freedom \ Numerator Degrees of Freedom)	1	2	3	4	5	6	7	8	9
1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54
2	18.513	19.000	19.164	19.247	19.296	19.330	19.353	19.371	19.385
3	10.128	9.5521	9.2766	9.1172	9.0135	8.9406	8.8867	8.8452	8.8123
4	7.7086	9.9443	6.5914	6.3882	6.2561	6.1631	6.0942	6.0410	6.9988
5	6.6079	5.7861	5.4095	5.1922	5.0503	4.9503	4.8759	4.8183	4.7725
6	5.9874	5.1433	4.7571	4.5337	4.3874	4.2839	4.2067	4.1468	4.0990
7	5.5914	4.7374	4.3468	4.1203	3.9715	3.8660	3.7870	3.7257	3.6767
8	5.3177	4.4590	4.0662	3.8379	3.6875	3.5806	3.5005	3.4381	3.3881
9	5.1174	4.2565	3.8625	3.6331	3.4817	3.3738	3.2927	3.2296	3.1789
10	4.9646	4.1028	3.7083	3.4780	3.3258	3.2172	3.1355	3.0717	3.0204
11	4.8443	3.9823	3.5874	3.3567	3.2039	3.0946	3.0123	2.9480	2.8962
12	4.7472	3.8853	3.4903	3.2592	3.1059	2.9961	2.9134	2.8486	2.7964
13	4.6672	3.8056	3.4105	3.1791	3.0254	2.9153	2.8321	2.7669	2.7144
14	4.6001	3.7389	3.3439	3.1122	2.9582	2.8477	2.7642	2.6987	2.6458
15	4.5431	3.6823	3.2874	3.0556	2.9013	2.7905	2.7066	2.6408	2.5876
16	4.4940	3.6337	3.2389	3.0069	2.8524	2.7413	2.6572	2.5911	2.5377
17	4.4513	3.5915	3.1968	2.9647	2.8100	2.6987	2.6143	2.5480	2.4943
18	4.4139	3.5546	3.1599	2.9277	2.7729	2.6613	2.5767	2.5102	2.4563
19	4.3807	3.5219	3.1274	2.8951	2.7401	2.6283	2.5435	2.4768	2.4227
20	4.3512	3.4928	3.0984	2.8661	2.7109	2.5990	2.5140	2.4471	2.3928
21	4.3248	3.4668	3.0725	2.8401	2.6848	2.5727	2.4876	2.4205	2.3660
22	4.3009	3.4434	3.0491	2.8167	2.6613	2.5491	2.4638	2.3965	2.3419
23	4.2793	3.4221	3.0280	2.7955	2.6400	2.5277	2.4422	2.3748	2.3201
24	4.2597	3.4028	3.0088	2.7763	2.6207	2.5082	2.4226	2.3551	2.3002
25	4.2417	3.3852	2.9912	2.7587	2.6030	2.4904	2.4047	2.3371	2.2821
26	4.2252	3.3690	2.9752	2.7426	2.5868	2.4741	2.3883	2.3205	2.2655
27	4.2100	3.3541	2.9604	2.7278	2.5719	2.4591	2.3732	2.3053	2.2501
28	4.1960	3.3404	2.9467	2.7141	2.5581	2.4453	2.3593	2.2913	2.2360
29	4.1830	3.3277	2.9340	2.7014	2.5454	2.4324	2.3463	2.2783	2.2229
30	4.1709	3.3158	2.9223	2.6896	2.5336	2.4205	2.3343	2.2662	2.2107
40	4.0847	3.2317	2.8387	2.6060	2.4495	2.3359	2.2490	2.1802	2.1240
60	4.0012	3.1504	2.7581	2.5252	2.3683	2.2541	2.1665	2.0970	2.0401
120	3.9201	3.0718	2.6802	2.4472	2.2899	2.1750	2.0868	2.0164	1.9588
∞	3.8415	2.9957	2.6049	2.3719	2.2141	2.0986	2.0096	1.9384	1.8799

The results of the ANOVA analysis test are usually summarised in a table of the following form:

Table C3-2: Example table containing the output of One-Way ANOVA statistical analysis.

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	F	P
Between	5.043	2	2.521	5.770	0.008
Error	11.799	27	0.437		
Total	16.842	29			

If the probability (P) of an '*F* score' is below the .05 or the 0.01 cut off (95% or 99% significance level), then the groups are statistically significantly different from one another and a post-hoc test is required to identify which group(s) is/are significantly different from the rest.

Post-Hoc Tests: For one-way ANOVA analysis four post-hoc tests should be considered: Tukey's, Scheffe, the Games Howell and the Dunnett's C post-hoc test. The former two are used when the data meet the assumption of homogeneity of variances. Tukey's test is recommended by statisticians as it is more likely to detect potential differences between the samples and is a single-step multiple comparison procedure contrary to the Scheffe's test which is customarily used with unequal sample sizes and is harder to compute as it requires pair-wise comparisons. The latter two post-hoc tests are used when data do not meet the homogeneity of variances assumption with statisticians generally recommending the Games Howell test.

Tukey's Post-Hoc Test: It is a single-step multiple comparison statistical procedure used in conjunction with ANOVA test when the examined groups are found statistically different with the aim to find which group(s) differ(s) significantly from each other. This test compares all possible pairs of means based on a studentised range distribution (similar to a series of t-tests). The differences between the means of all the groups are calculated to be compared to a critical value to see if the difference is significant. The critical value is called '*Honestly Significant Difference (HSD)*' and is computed using the following formula:

$$Honestly\ Significant\ Difference: \quad HSD = q\sqrt{\frac{MS_{S/A}}{n}} \qquad \text{(Formula C12)}$$

, where q is the relevant critical value of the studentised range statistic as obtained by the studentised statistic table looking up for a specific significance level (e.g. 0.05 or 0.01), the degrees of freedom and the number (k) of means or levels of the factor being tested. Thus, the differences of the means of all groups that exceed the HSD critical value are significant at the specific level of significance (e.g. $P<0.05$ or $P<0.01$).

Sources: http://web.mst.edu/~psyworld/anovadescribe.htm
http://www.upa.pdx.edu/IOA/newsom/da1/ho_ANOVA.pdf
https://statistics.laerd.com/statistical-guides/one-way-anova-statistical-guide.php
http://pages.uoregon.edu/stevensj/posthoc.pdf

ANOVA calculations were made using the online calculator of the 'College of Saint Benedict and Saint John's University' available at:
www.physics.csbsju.edu/stats/anova.html while Tukey's calculations (whenever required) were made using the online StatTools calculator available at:
http://www.stattools.net/LSDTukey_Pgm.php

ANOVA and Tukey's Post-Hoc Test Results

C3.1: SEASONAL VARIATION OF THE MONTHLY NUMBERS OF MCG DELIVERIES RECEIVED BY THE 10 DIFFERENT *WESTQUAY* BUSINESS GROUPS.

The monthly numbers of MCGs deliveries made to the ten different *WestQuay* business group are summarised in the following table:

Table C3.3: Average monthly MCG deliveries made to the 10 different *WestQuay* business groups.

SIC Business Groups	n: Monthly number of MCG deliveries made to *WestQuay* (A: floor area in m^2)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	n_{tot}	n_{aver}
Clothing	536	492	523	510	523	519	545	527	506	523	544	611	6357	530
Catering Units	557	503	565	547	557	539	557	557	539	557	552	570	6597	1015
Bookstores	292	264	292	283	292	283	292	292	287	310	300	297	3485	290
Footwear	137	124	137	133	137	141	137	137	133	137	133	151	1638	252
Opticians	80	72	80	77	80	77	80	80	77	80	77	80	939	78
Electronics	261	228	252	244	252	244	252	252	274	283	287	266	3098	477
Jewellery	77	82	77	75	77	75	77	77	75	77	109	112	989	82
Cosmetics	18	16	18	17	18	17	18	18	17	18	21	22	217	33
Games	40	36	40	39	40	39	40	40	47	49	51	53	513	79
Other	11	10	11	11	11	11	11	11	11	11	11	11	128	20
Total	2009	1826	1995	1935	1986	1944	2009	1991	1965	2044	2085	2172	23962	1997

Using the online ANOVA calculator (www.physics.csbsju.edu/stats/anova.html the following estimations were made:

Table C3.4: ANOVA test results for the examination of the difference between the mean monthly numbers of MCG deliveries received by the 10 different *WestQuay* business groups.

Source of Variation	Sum of Squares	Degrees of Freedom (df)	Mean Squares	F	P
Between	4.4283E+06	9	4.9204E+05	2651	0.001
Error	2.0419E+04	110	185.6		
Total	4.4488E+06	119			

Findings: Analysis of variance (one-way ANOVA) showed that the mean number of MCG deliveries made to *WestQuay* businesses across calendar months differed significantly (F{9,110}=2,651, P<0.001). Therefore a Tukey's post-hoc test was run to identify which group(s) was/were significantly different from the rest.

Using the online Tukey's Post-Hoc calculator www.stattools.net/LSDTukey_Pgm.php and considering the Error Variance ($M \int S/A = 2.0419E+04$), the degrees of freedom for the Within Groups ($dfA/S = 110$) and the number of groups (n=10) it was estimated that the Least Significant Difference was equal to LSD=217.2 at the 95% significance level and LSD=252.4 at the 99% significance level. Comparison with the differences of the mean values of all possible pairs (Table C3.5) showed that the number of MCG deliveries was significantly different between a group of three business types (catering units, stores selling clothing and stores selling electronics) and the rest 7 business categories at both the 0.05 and the 0.01 level of significance (pink areas), as well as between bookstores and stores selling clothing, and between stores selling footwear and stores selling electronics, cosmetics and other at the 0.01 level of significance (yellow areas). All other comparisons were not significant.

Table C3.5: ANOVA test results for the examination of the difference between the mean monthly numbers of MCG deliveries received by the 10 *WestQuay* business groups.

SIC Business Groups	Clothing	Catering	Bookstores	Footwear	Opticians	Electronics	Jewellery	Cosmetics	Games	Other
Clothing	0	485	239	278	452	53	447	496	451	510
Catering Units	485	0	725	763	937	538	933	982	936	995
Bookstores	239	725	0	38	212	186	208	257	212	271
Footwear	278	763	38	0	174	225	170	219	173	232
Opticians	452	937	212	174	0	398	4	45	1	58
Electronics	53	538	186	225	398	0	394	443	398	457
Jewellery	447	933	208	170	4	394	0	49	4	63
Cosmetics	496	982	257	219	45	443	49	0	45	14
Games	451	936	212	173	1	398	4	45	0	59
Other	510	995	271	232	58	457	63	14	59	0

C3.2: SEASONAL VARIATION OF THE MONTHLY NUMBERS OF MCG DELIVERIES RECEIVED BY THE 3 DIFFERENT FLOOR AREA GROUPS OF *WESTQUAY* BUSINESSES.

Table C3.6: Monthly MCG deliveries made to the 3 different floor area groups of *WestQuay* businesses.

Store Size Business Groups	n: Monthly number of MCG deliveries made to *WestQuay* (A: floor area in m^2)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	n_{tot}	n_{aver}
$A<200m^2$	762	680	762	738	753	742	753	753	729	753	772	806	9004	750
$200m^2<A<500m^2$	609	574	600	585	600	589	622	604	593	613	645	693	7327	1127
$A>500m^2$	638	572	633	613	633	613	633	633	643	678	669	673	7631	636
Total	2009	1826	1995	1935	1986	1944	2009	1991	1965	2044	2085	2172	23962	1997

Using the online ANOVA calculator the following estimations were made:

Table C3.7: ANOVA test results for the examination of the difference between the mean monthly numbers of MCG deliveries received by the 3 different floor area groups of *WestQuay* businesses.

Source of Variation	Sum of Squares	Degrees of Freedom (df)	Mean Squares	F	P
Between	1.3288E+05	2	6.6441E+04	72.82	0.001
Error	3.0108E+04	33	912.4		
Total	1.6299E+05	35			

Findings: Analysis of variance (one-way ANOVA) showed that the mean number of MCG deliveries made to *WestQuay* businesses across calendar months differed significantly (F{9,110}=, P<0.001). Therefore a Tukey's post-hoc test was run to identify which group(s) was/were significantly different from the rest. Using the online Tukey's Post-Hoc calculator and considering the Error Variance ($M\int S/A = 3.0108E+04$), the degrees of freedom for the Within Groups ($dfA/S = 33$) and the number of groups (n=3) it was estimated that LSD=425.8 at the 95% significance level and LSD=542.7 at the 99% significance level. Comparison with the differences of the mean values of all possible pairs (Table C3.8) showed that the number of MCG deliveries received was significantly different between medium-sized and the largest businesses in *WestQuay* (yellow areas) at the 0.05 significance level.

Table C3.8: ANOVA test results for the examination of the difference between the mean monthly numbers of MCG deliveries received by the 3 different floor area groups of *WestQuay* businesses.

Store Size Business Groups	Differences of Monthly Means		
	$A<200m^2$	$200m^2<A<500m^2$	$A>500m^2$
$A<200m^2$	0	377	114
$200m^2<A<500m^2$	377	0	491
$A>500m^2$	114	491	0

C3.3: Seasonal variation of the monthly numbers of 8 different types of packaging units delivered to *WestQuay* businesses.

Table C3.9: Average monthly numbers of the 8 different types of packaging delivered to *WestQuay*.

Packaging Units	n: Monthly number of packaging units delivered to *WestQuay* (A: floor area in m^2)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	n_{tot}	n_{aver}
Cardboard Boxes	24699	23041	47077	45083	21171	32288	35113	26573	24544	32173	67238	75919	**454919**	**37910**
Plastic Totes	7535	5504	5305	5151	5403	7200	7216	5365	5349	6545	11247	26132	**97953**	**8163**
Pallets	934	364	403	390	403	390	403	934	3304	2883	2897	686	**13992**	**1166**
Hanging Rails	1014	724	802	827	855	904	934	802	776	899	1974	2403	**12913**	**1076**
Roll Cages	618	558	618	1025	618	598	618	618	1379	983	1726	1465	**10823**	**902**
Sacks	771	588	651	1155	651	1166	1298	1287	630	651	1181	2053	**12080**	**1007**
Packs of Drinks	968	874	968	936	968	936	968	968	936	1465	1935	1791	**13712**	**1143**
Trays	1187	1072	1187	1149	1187	1149	1187	1187	1149	1187	1234	2484	**15358**	**1280**
Total	**37725**	**32725**	**57011**	**55717**	**31255**	**44631**	**47737**	**37733**	**38066**	**46786**	**89432**	**11293**	**631750**	**52646**

Using the online ANOVA calculator (www.physics.csbsju.edu/stats/anova.html) the following estimations were made:

Table C3.10: ANOVA test results for the examination of the difference between the average monthly numbers of the 8 different types of packaging units delivered to *WestQuay*.

Source of Variation	Sum of Squares	Degrees of Freedom (df)	Mean Squares	F	P
Between	1.3976E+10	7	1.9965E+09	45	0.001
Error	3.905E+09	88	4.4377E+07		
Total	1.7881E+10	95		`	

Findings: Analysis of variance (one-way ANOVA) showed that the mean values of the 8 different types of packaging units delivered to *WestQuay* businesses across calendar months differed significantly (F{7,88}=45, P<0.001).

Therefore a Tukey's post-hoc test was run to identify which group(s) was/were significantly different from the rest. Using the online Tukey's Post-Hoc calculator (www.stattools.net/LSDTukey_Pgm.php) and considering the Mean Square of Within Groups (Error Variance: $M\int S/A = 4.4377E + 07$), the degrees of freedom for the Within Groups ($df A/S = 88$) and the number of groups (n=8) it was estimated that the Least Significant Difference was equal to LSD=10,985 at the 95% significance level and LSD=12,886 at the 99% significance level. Comparison with the differences of the mean values of all possible pairs (Table C3.11) showed that the number of 'Cardboard Boxes' delivered to *WestQuay* businesses across the year was significantly higher than that of the other seven packaging groups at both the 0.01 and the 0.05 level of significance (pink areas). All other comparisons were not significant.

Table C3.11: ANOVA test results for the examination of the difference between the average monthly numbers of the 8 different types of packaging units delivered to *WestQuay*.

Packaging Units	Differences of Monthly Means							
	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays
Cardboard Boxes	0	31382	36054	36994	37155	37059	34153	35499
Plastic Totes	31382	0	4672	5612	5773	5677	2771	4117
Pallets	36054	4672	0	940	1101	1005	1901	555
Hanging Rails	36994	5612	940	0	161	65	2841	1495
Roll Cages	37155	5773	1101	161	0	96	3002	1656
Sacks	37059	5677	1005	65	96	0	2906	1560
Packs of Drinks	34153	2771	1901	2841	3002	2906	0	1346
Trays	35499	4117	555	1495	1656	1560	1346	0

APPENDIX D: STATISTICAL DATA TABLES & GRAPHS

D1: Statistical Data Tables and Graphs for Main Core Goods (MCGs) Deliveries

D1-1: Number of MCGs deliveries by day of the week – Classification by type and size of business

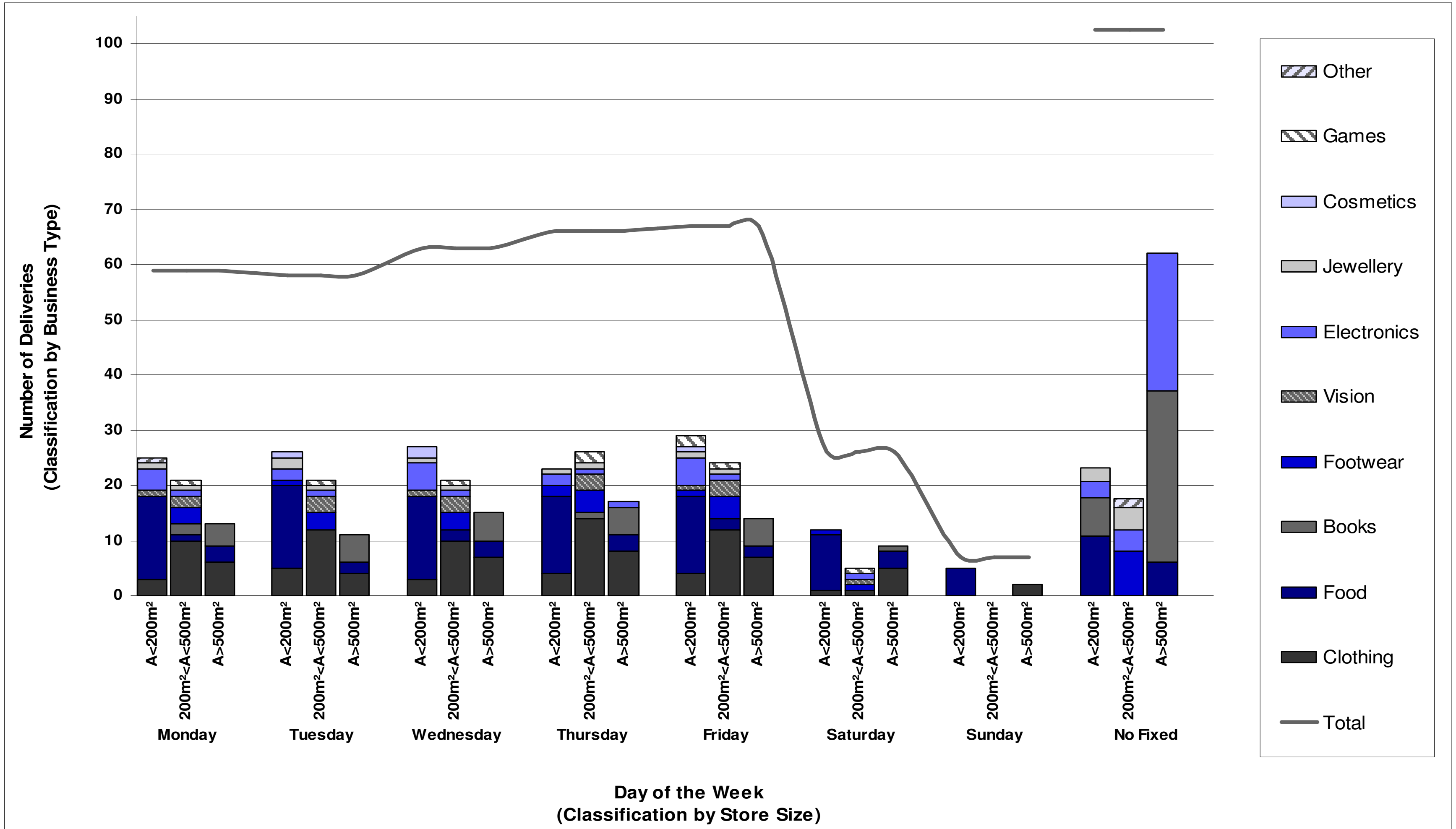


Figure D1-1: Variation in the number of MCGs deliveries made to *WestQuay* businesses by day of a standard week.
(classification by type of economic activity and store size)

Table D1-1: Variation in the number of MCGs deliveries made to *WestQuay* businesses by day of the week.
(classification by type of economic activity and store size)

	Monday				Tuesday				Wednesday				Thursday				Friday				Saturday				Sunday			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	3	10	6	**19**	5	12	4	**21**	3	10	7	**20**	4	14	8	**26**	4	12	7	**23**	1	1	5	**7**	0	0	2	**2**
Food	0	3	0	**3**	1	3	0	**4**	0	3	0	**3**	2	4	0	**6**	1	4	0	**5**	1	1	0	**2**	0	0	0	**0**
Books	0	2	4	**6**	0	0	5	**5**	0	0	5	**5**	0	1	5	**6**	0	0	5	**5**	0	0	1	**1**	0	0	0	**0**
Footwear	15	1	3	**19**	15	0	2	**17**	15	2	3	**20**	14	0	3	**17**	14	2	2	**18**	10	0	3	**13**	5	0	0	**5**
Vision	1	2	0	**3**	0	3	0	**3**	1	3	0	**4**	0	3	0	**3**	1	3	0	**4**	0	1	0	**1**	0	0	0	**0**
Electronic	4	1	0	**5**	2	1	0	**3**	5	1	0	**6**	2	1	1	**4**	5	1	0	**6**	0	1	0	**1**	0	0	0	**0**
Jewellery	1	1	0	**2**	2	1	0	**3**	1	1	0	**2**	1	1	0	**2**	1	1	0	**2**	0	0	0	**0**	0	0	0	**0**
Cosmetics	0	0	0	**0**	1	0	0	**1**	2	0	0	**2**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**
Games	0	1	0	**1**	0	1	0	**1**	0	1	0	**1**	0	2	0	**2**	2	1	0	**3**	0	1	0	**1**	0	0	0	**0**
Other	1	0	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
TOTAL	**25**	**21**	**13**	**59**	**26**	**21**	**11**	**58**	**27**	**21**	**15**	**63**	**23**	**26**	**17**	**66**	**29**	**24**	**14**	**67**	**12**	**5**	**9**	**26**	**5**	**0**	**2**	**7**

	Not Fixed				Total Deliveries Standard Week				Extra Deliveries Busy Week				Total Deliveries Busy Week			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	0	0	0	**0**	**20**	**59**	**39**	**118**	1	13	9	**23**	**21**	**72**	**48**	**141**
Food	0	8	0	**8**	**5**	**26**	**0**	**31**	3	0	0	**3**	**8**	**26**	**0**	**34**
Books	7	0	31	**38**	**7**	**3**	**56**	**66**	0	1	3	**4**	**7**	**4**	**59**	**70**
Footwear	11	0	6	**17**	**99**	**5**	**22**	**126**	2	1	0	**3**	**101**	**6**	**22**	**129**
Vision	0	0	0	**0**	**3**	**15**	**0**	**18**	0	0	0	**0**	**3**	**15**	**0**	**18**
Electronic	3	4	25	**32**	**21**	**10**	**26**	**57**	3	0	7	**10**	**24**	**10**	**33**	**67**
Jewellery	2	4	0	**6**	**8**	**9**	**0**	**17**	1	7	0	**8**	**9**	**16**	**0**	**25**
Cosmetics	0	0	0	**0**	**4**	**0**	**0**	**4**	1	0	0	**1**	**5**	**0**	**0**	**5**
Games	0	0	0	**0**	**2**	**7**	**0**	**9**	1	2	0	**3**	**3**	**9**	**0**	**12**
Other	0	1.5	0	**1.5**	**1**	**1**	**0**	**2**	0	0	0	**0**	**1**	**1**	**0**	**2**
TOTAL	**23**	**17.5**	**62**	**102.56**	**170**	**135**	**143**	**449**	**12**	**24**	**19**	**55**	**182**	**159**	**162**	**504**

D1-2: NUMBER OF BUSINESSES RECEIVING INCREASED MCGS DELIVERIES (BUSY PERIODS) – CLASSIFICATION BY TYPE AND SIZE OF BUSINESSES

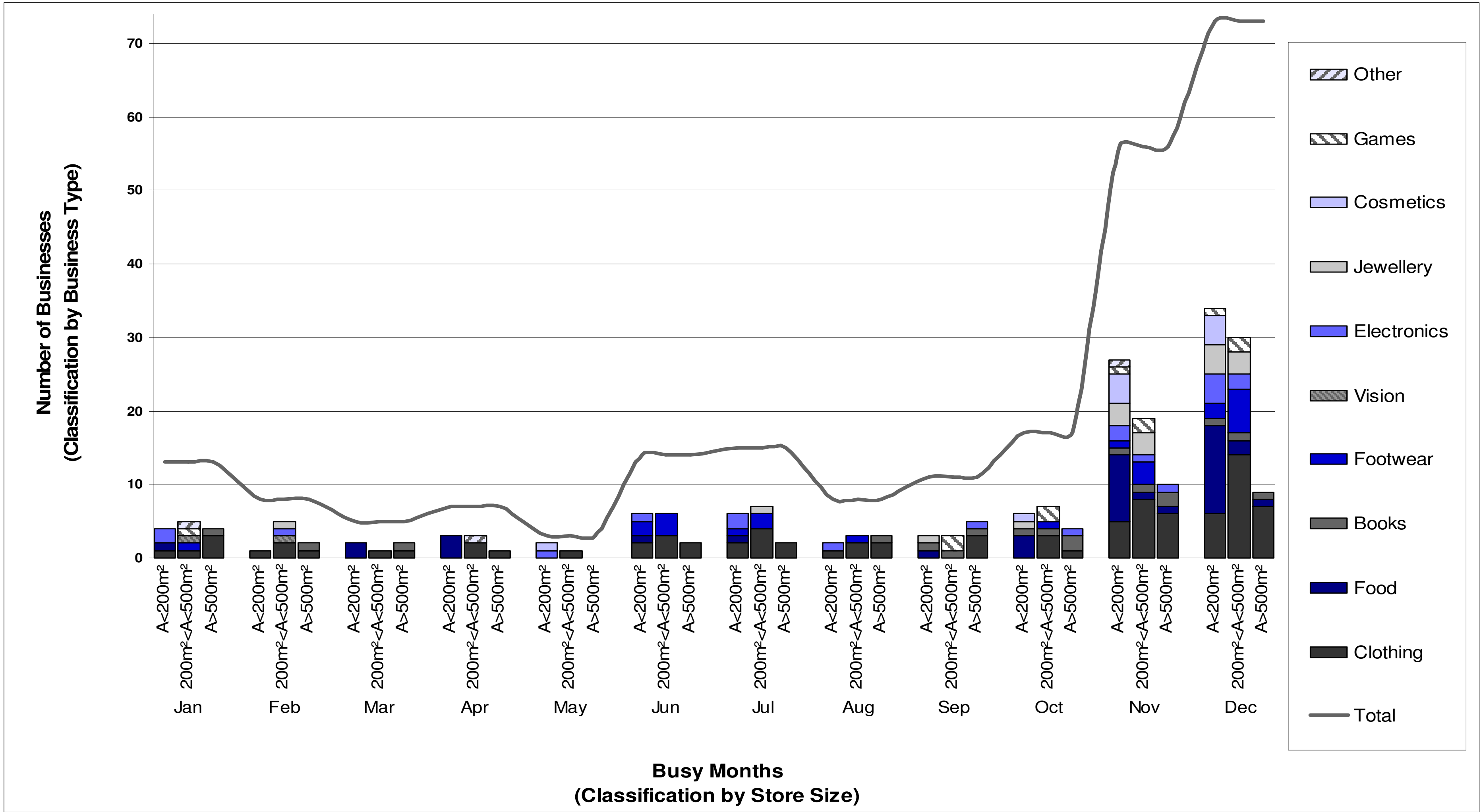


Figure D1-2: Seasonal variation in the number of *WestQuay* businesses claiming busy periods in terms of commercial activity.
(classification by type of economic activity and store size)

Table D1-2: Seasonal variation in the number of *WestQuay* businesses claiming busy periods in terms of commercial activity. (classification by type of economic activity and store size)

	Jan				Feb				Mar				Apr				May				Jun			
A: Surface (m^2)	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**
Clothing	1	1	3	**5**	1	2	1	**4**	0	1	1	**2**	0	2	1	**3**	0	1	0	**1**	2	3	2	**7**
Food	1	0	0	**1**	0	0	0	**0**	2	0	0	**2**	3	0	0	**3**	0	0	0	**0**	1	0	0	**1**
Books	0	0	1	**1**	0	0	1	**1**	0	0	1	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Footwear	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	2	3	0	**5**
Vision	0	1	0	**1**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Electronics	2	0	0	**2**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	1	0	0	**1**
Jewellery	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Cosmetics	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
Games	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Other	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**	0	0	0	**0**	0	0	0	**0**
TOTAL	**4**	**5**	**4**	**13**	**1**	**5**	**2**	**8**	**2**	**1**	**2**	**5**	**3**	**3**	**1**	**7**	**2**	**1**	**0**	**3**	**6**	**6**	**2**	**14**

	Jul				Aug				Sep				Oct				Nov				Dec			
A: Surface (m^2)	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**	**<200**	**200< <500**	**>500**	**Total**
Clothing	2	4	2	**8**	1	2	2	**5**	0	0	3	**3**	0	3	1	**4**	5	8	6	**19**	6	14	7	**27**
Food	1	0	0	**1**	0	0	0	**0**	1	0	0	**1**	3	0	0	**3**	9	1	1	**11**	12	2	1	**15**
Books	0	0	0	**0**	0	0	1	**1**	1	1	1	**3**	1	1	2	**4**	1	1	2	**4**	1	1	1	**3**
Footwea	1	2	0	**3**	0	1	0	**1**	0	0	0	**0**	0	1	0	**1**	1	3	0	**4**	2	6	0	**8**
Vision	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Electron	2	0	0	**2**	1	0	0	**1**	0	0	1	**1**	0	0	1	**1**	2	1	1	**4**	4	2	0	**6**
Jeweller	0	1	0	**1**	0	0	0	**0**	1	0	0	**1**	1	0	0	**1**	3	3	0	**6**	4	3	0	**7**
Cosmeti	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	4	0	0	**4**	4	0	0	**4**
Games	0	0	0	**0**	0	0	0	**0**	0	2	0	**2**	0	2	0	**2**	1	2	0	**3**	1	2	0	**3**
Other	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**
TOTAL	**6**	**7**	**2**	**15**	**2**	**3**	**3**	**8**	**3**	**3**	**5**	**11**	**6**	**7**	**4**	**17**	**27**	**19**	**10**	**56**	**34**	**30**	**9**	**73**

D1-3: SEASONAL VARIATION IN THE NUMBER OF MCGS DELIVERIES – CLASSIFICATION BY TYPE AND SIZE OF BUSINESS

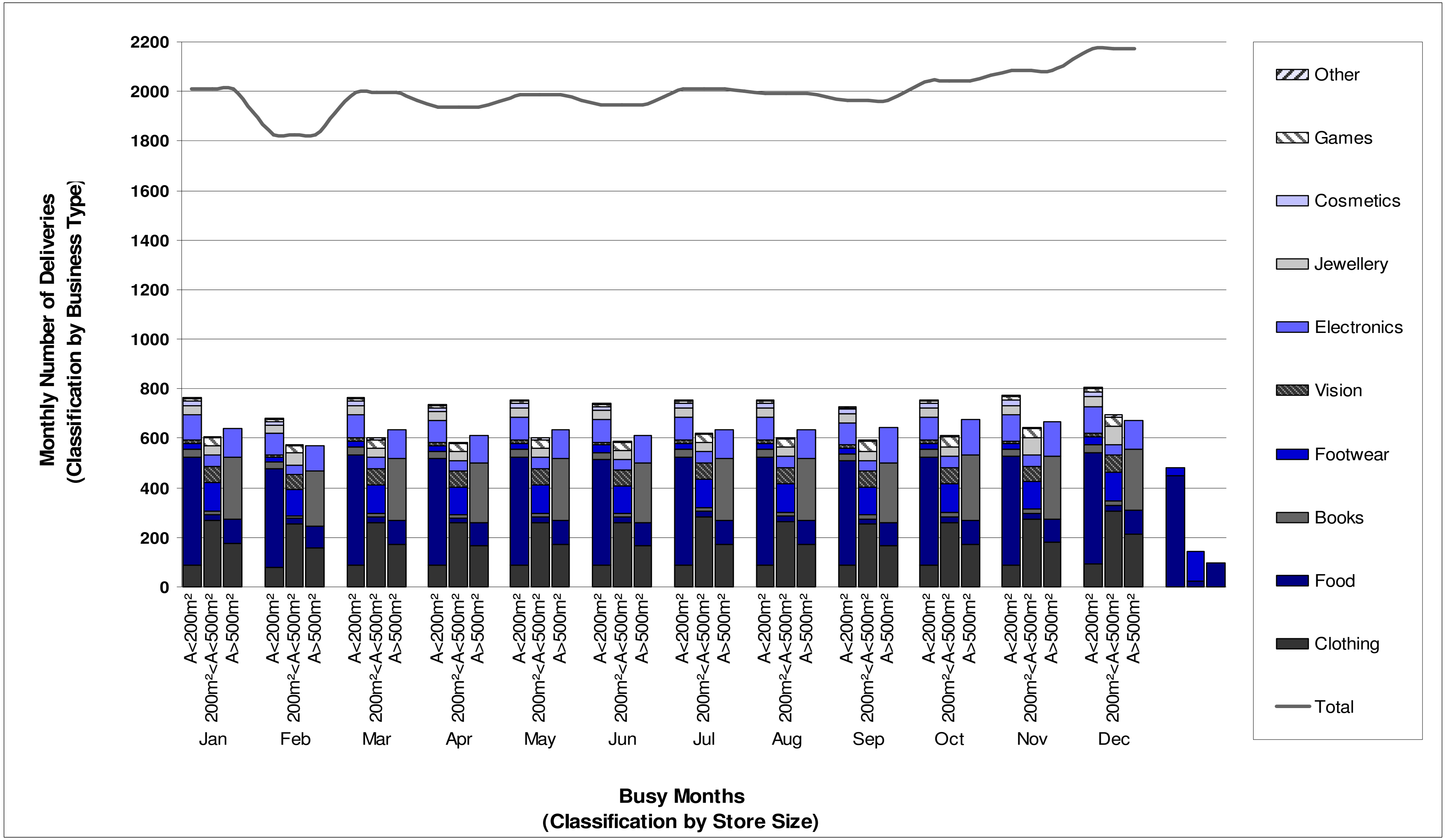


Figure D1-3: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses.
(classification by type of economic activity and store size).

Table D1-3: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses.
(classification by type of economic activity and store size)

A: Surface (m^2)	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	88.6	270.1	177.1	535.9	80	256	156	492.0	89	261	173	522.6	86	257	167	510.0	89	261	173	522.6	90	261	167	518.6	89	283	173	544.7	89	266	173	527.0	86	253	167	505.7	89	261	173	522.6	90	274	180	544.3	93	306	213	611.1
Food	437.1	22.1	97.4	556.6	395	20	88	502.8	446	22	97	565.5	432	21	94	547.2	437	22	97	556.6	423	21	94	538.7	437	22	97	556.6	437	22	97	556.6	423	21	94	538.7	437	22	97	556.6	436	21	94	551.5	450	22	97	569.9
Books	31.0	13.3	248.0	292.3	28	12	224	264.0	31	13	248	292.3	30	13	240	282.9	31	13	248	292.3	30	13	240	282.9	31	13	248	292.3	31	13	248	292.3	30	17	240	287.1	31	18	261	310.0	30	17	253	300.0	31	18	248	296.7
Footwear	22.1	115.1	0.0	137.3	20	104	0	124.0	22	115	0	137.3	21	111	0	132.9	22	115	0	137.3	30	111	0	141.4	22	115	0	137.3	22	115	0	137.3	21	111	0	132.9	22	115	0	137.3	21	111	0	132.9	31	120	0	150.6
Vision	13.3	66.4	0.0	79.7	12	60	0	72.0	13	66	0	79.7	13	64	0	77.1	13	66	0	79.7	13	64	0	77.1	13	66	0	79.7	13	66	0	79.7	13	64	0	77.1	13	66	0	79.7	13	64	0	77.1	13	66	0	79.7
Electronics	101.9	44.3	115.1	261.3	84	40	104	228.0	93	44	115	252.4	90	43	111	244.3	93	44	115	252.4	90	43	111	244.3	93	44	115	252.4	93	44	115	252.4	90	43	141	274.3	93	44	146	283.4	103	43	141	287.1	106	44	115	265.7
Jewellery	37.2	39.9	0.0	77.0	34	48	0	81.6	37	40	0	77.0	36	39	0	74.6	37	40	0	77.0	36	39	0	74.6	37	40	0	77.0	37	40	0	77.0	36	39	0	74.6	37	40	0	77.0	40	69	0	108.8	42	71	0	112.5
Cosmetics	17.7	0.0	0.0	17.7	16	0	0	16.0	18	0	0	17.7	17	0	0	17.1	18	0	0	17.7	17	0	0	17.1	18	0	0	17.7	18	0	0	17.7	17	0	0	17.1	18	0	0	17.7	21	0	0	21.4	22	0	0	22.1
Games	8.9	31.0	0.0	39.9	8	28	0	36.0	9	31	0	39.9	9	30	0	38.6	9	31	0	39.9	9	30	0	38.6	9	31	0	39.9	9	31	0	39.9	9	39	0	47.1	9	40	0	48.7	13	39	0	51.4	13	40	0	53.1
Other	4.4	6.5	0.0	10.9	4	5.84	0	9.8	4	6	0	10.9	4	6	0	10.5	4	6	0	10.9	4	6	0	10.5	4	6	0	10.9	4	6	0	10.9	4	6	0	10.5	4	6	0	10.9	4	6	0	10.5	4	6	0	10.9
TOTAL	762.1	608.8	637.7	2008.6	680	573.84	572	1826.2	762	600	633	1995.3	738	585	613	1935.2	753	600	633	1986.4	742	589	613	1943.8	753	622	633	2008.6	753	604	633	1990.9	729	593	643	1965.2	753	613	678	2044.0	772	645	669	2085.2	806	693	673	2172.4

D1-4: SEASONAL VARIATION IN THE DISTANCE TRAVELLED FOR MCGS DELIVERIES – CLASSIFICATION BY TYPE AND SIZE OF BUSINESS

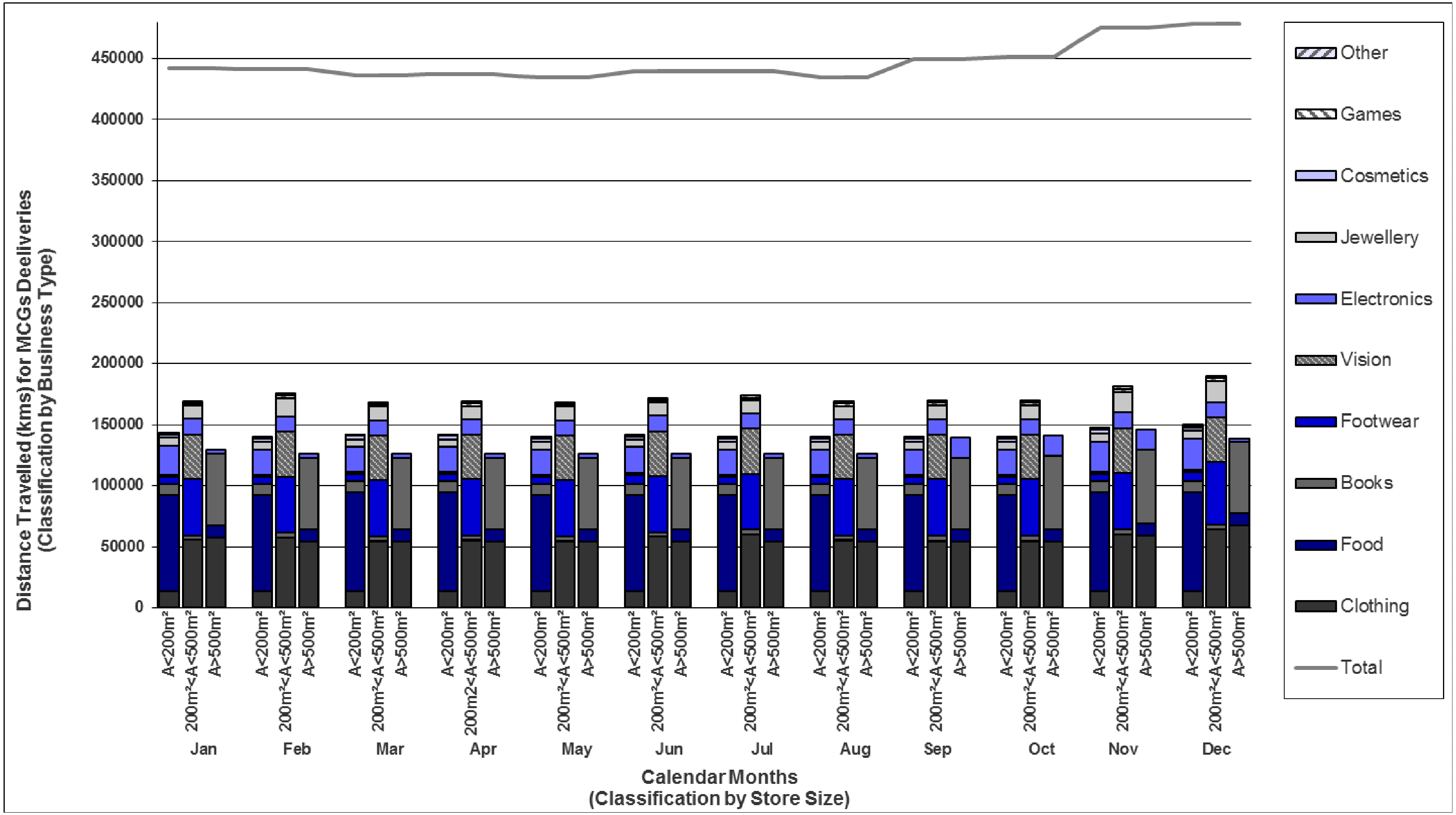


Figure D1-4: Seasonal variation in the distance travelled (kms) to deliver MCGs to *WestQuay* businesses.
(classification by type of economic activity and store size)

Table D1-4: Seasonal variation in the distance travelled (kms) to deliver MCGs to *WestQuay* businesses.
(classification by type of economic activity and store size).

	Jan				Feb				Mar				Apr				May				Jun			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	13306	55525	57483	**126314**	13306	57422	54389	**125117**	13306	54560	54389	**122256**	13306	55226	54389	**122922**	13306	54560	54389	**122256**	13316	57995	54389	**125701**
Food	79278	168	10098	**89543**	79278	168	10098	**89543**	81587	168	10098	**91853**	81587	168	10098	**91853**	79278	168	10098	**89543**	79278	168	10098	**89543**
Books	8791	3628	58593	**71012**	8791	3628	58593	**71012**	8791	3628	58593	**71012**	8791	3628	58593	**71012**	8791	3628	58593	**71012**	8791	3628	58593	**71012**
Footwear	5602	46166	0	**51768**	5602	46166	0	**51768**	5602	46166	0	**51768**	5602	46166	0	**51768**	5602	46166	0	**51768**	7754	46166	0	**53920**
Vision	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**
Electronics	24229	12515	3029	**39773**	20865	12515	3029	**36409**	20865	12515	3029	**36409**	20865	12515	3029	**36409**	20865	12515	3029	**36409**	20865	12515	3029	**36409**
Jewellery	6172	10885	0	**17058**	6172	15119	0	**21291**	6172	10885	0	**17058**	6172	10885	0	**17058**	6172	10885	0	**17058**	6172	10885	0	**17058**
Cosmetics	2751	0	0	**2751**	2751	0	0	**2751**	2751	0	0	**2751**	2751	0	0	**2751**	2751	0	0	**2751**	2751	0	0	**2751**
Games	433	1993	0	**2426**	433	1993	0	**2426**	433	1993	0	**2426**	433	1993	0	**2426**	433	1993	0	**2426**	433	1993	0	**2426**
Other	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**
TOTAL	**143144**	**169374**	**129203**	**441721**	**139780**	**175504**	**126109**	**441394**	**142089**	**168409**	**126109**	**436608**	**142089**	**169076**	**126109**	**437274**	**139780**	**168409**	**126109**	**434299**	**141942**	**171845**	**126109**	**439896**

	Jul				Aug				Sep				Oct				Nov				Dec			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	13306	59892	54389	**127588**	13306	55226	54389	**122922**	13306	54560	54389	**122256**	13306	54560	54389	**122256**	13316	59627	59236	**132179**	13316	63748	67147	**144211**
Food	79278	168	10098	**89543**	79278	168	10098	**89543**	79278	168	10098	**89543**	79278	168	10098	**89543**	81611	168	10098	**91877**	81611	168	10098	**91877**
Books	8791	3628	58593	**71012**	8791	3628	58593	**71012**	8791	4533	58593	**71917**	8791	4533	60314	**73638**	8791	4533	60314	**73638**	8791	4533	58593	**71917**
Footwea	5602	46166	0	**51768**	5602	46166	0	**51768**	5602	46166	0	**51768**	5602	46166	0	**51768**	5602	46166	0	**51768**	7754	50941	0	**58695**
Vision	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**	1621	36669	0	**38290**
Electron	20865	12515	3029	**36409**	20865	12515	3029	**36409**	20865	12515	16499	**49879**	20865	12515	16499	**49879**	25056	12515	16499	**54070**	25056	12515	3029	**40600**
Jeweller	6172	10885	0	**17058**	6172	10885	0	**17058**	6172	10885	0	**17058**	6172	10885	0	**17058**	6756	16838	0	**23594**	6756	16838	0	**23594**
Cosmeti	2751	0	0	**2751**	2751	0	0	**2751**	2751	0	0	**2751**	2751	0	0	**2751**	3080	0	0	**3080**	3080	0	0	**3080**
Games	433	1993	0	**2426**	433	1993	0	**2426**	433	2884	0	**3317**	433	2884	0	**3317**	865	2884	0	**3750**	865	2884	0	**3750**
Other	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**	962	1825	0	**2787**
TOTAL	**139780**	**173741**	**126109**	**439631**	**139780**	**169076**	**126109**	**434965**	**139780**	**170205**	**139580**	**449565**	**139780**	**170205**	**141301**	**451286**	**147660**	**181225**	**146147**	**475032**	**149812**	**190121**	**138867**	**478800**

D1-5: SEASONAL VARIATION IN THE NUMBER OF MCGS DELIVERIES – CLASSIFICATION BY TYPE OF BUSINESS AND CARRIER

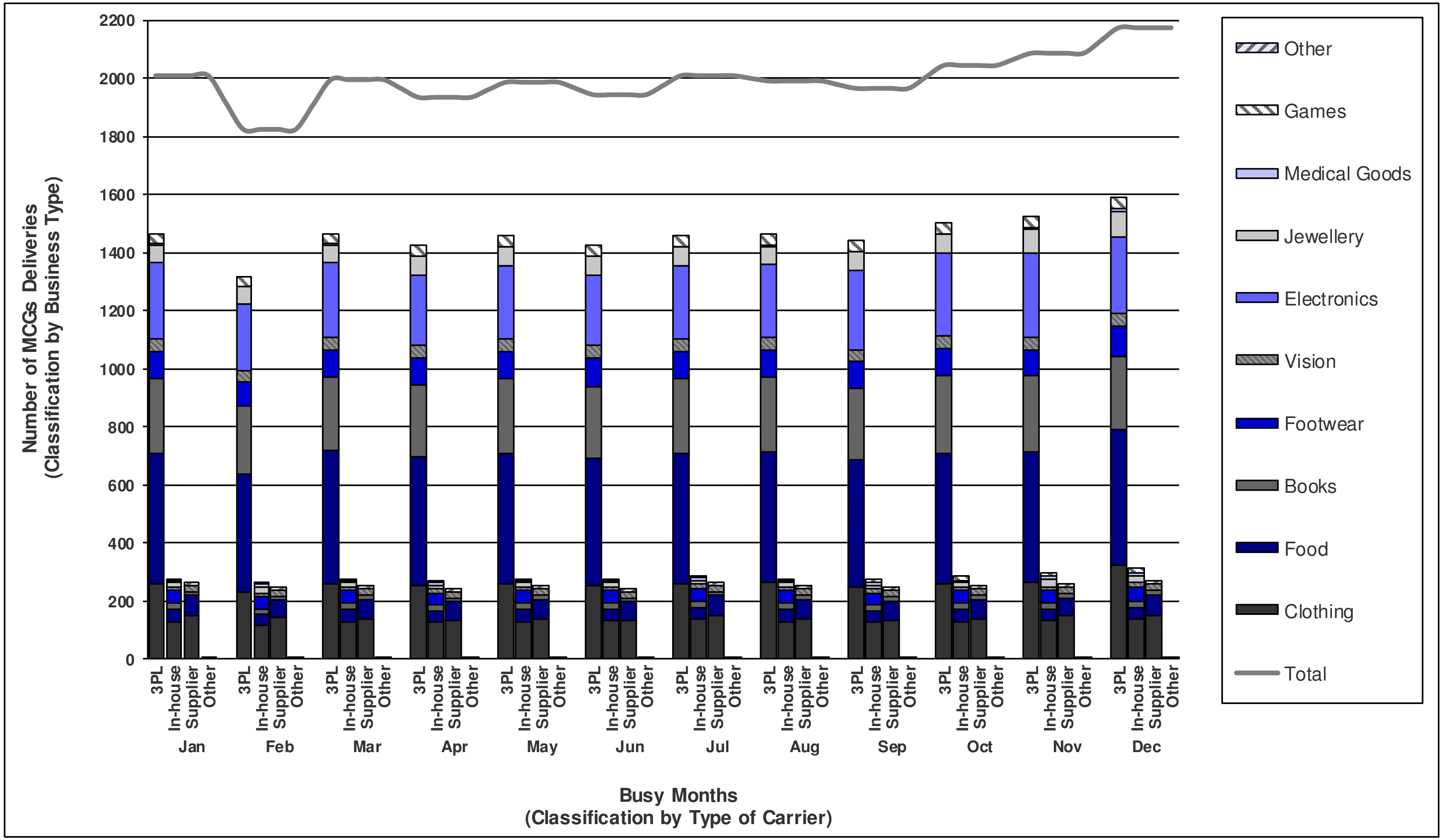


Figure D1-5: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses by different carriers.
(classification by type of economic activity and type of carrier)

Table D1-5: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses by different carriers. (classification by type of economic activity and type of carrier).

	Jan					Feb					Mar					Apr					May					Jun				
A: Surface (m^2)	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total
Clothing	256.9	128.4	150.6	0.0	**535.9**	232.0	116.0	144.0	0.0	**492.0**	256.9	128.4	137.3	0.0	**522.6**	252.9	124.3	132.9	0.0	**510.0**	256.9	128.4	137.3	0.0	**522.6**	252.9	132.9	132.9	0.0	**518.6**
Food	450.3	39.9	66.4	0.0	**556.6**	406.8	36.0	60.0	0.0	**502.8**	459.2	39.9	66.4	0.0	**565.5**	444.4	38.6	64.3	0.0	**547.2**	450.3	39.9	66.4	0.0	**556.6**	435.8	38.6	64.3	0.0	**538.7**
Books	256.9	22.1	13.3	0.0	**292.3**	232.0	20.0	12.0	0.0	**264.0**	256.9	22.1	13.3	0.0	**292.3**	248.6	21.4	12.9	0.0	**282.9**	256.9	22.1	13.3	0.0	**292.3**	248.6	21.4	12.9	0.0	**282.9**
Footwear	93.0	44.3	0.0	0.0	**137.3**	84.0	40.0	0.0	0.0	**124.0**	93.0	44.3	0.0	0.0	**137.3**	90.0	42.9	0.0	0.0	**132.9**	93.0	44.3	0.0	0.0	**137.3**	98.6	42.9	0.0	0.0	**141.4**
Vision	44.3	13.3	22.1	0.0	**79.7**	40.0	12.0	20.0	0.0	**72.0**	44.3	13.3	22.1	0.0	**79.7**	42.9	12.9	21.4	0.0	**77.1**	44.3	13.3	22.1	0.0	**79.7**	42.9	12.9	21.4	0.0	**77.1**
Electronics	261.3	0.0	0.0	0.0	**261.3**	228.0	0.0	0.0	0.0	**228.0**	252.4	0.0	0.0	0.0	**252.4**	244.3	0.0	0.0	0.0	**244.3**	252.4	0.0	0.0	0.0	**252.4**	244.3	0.0	0.0	0.0	**244.3**
Jewellery	63.8	13.3	0.0	0.0	**77.0**	57.6	24.0	0.0	0.0	**81.6**	63.8	13.3	0.0	0.0	**77.0**	61.7	12.9	0.0	0.0	**74.6**	63.8	13.3	0.0	0.0	**77.0**	61.7	12.9	0.0	0.0	**74.6**
Cosmetics	4.4	8.9	0.0	4.4	**17.7**	4.0	8.0	0.0	4.0	**16.0**	4.4	8.9	0.0	4.4	**17.7**	4.3	8.6	0.0	4.3	**17.1**	4.4	8.9	0.0	4.4	**17.7**	4.3	8.6	0.0	4.3	**17.1**
Games	35.4	4.4	0.0	0.0	**39.9**	32.0	4.0	0.0	0.0	**36.0**	35.4	4.4	0.0	0.0	**39.9**	34.3	4.3	0.0	0.0	**38.6**	35.4	4.4	0.0	0.0	**39.9**	34.3	4.3	0.0	0.0	**38.6**
Other	0.0	0.0	10.9	0.0	**10.9**	0.0	0.0	9.8	0.0	**9.8**	0.0	0.0	10.9	0.0	**10.9**	0.0	0.0	10.5	0.0	**10.5**	0.0	0.0	10.9	0.0	**10.9**	0.0	0.0	10.5	0.0	**10.5**
TOTAL	**1466.2**	**274.6**	**263.3**	**4.4**	**2008.6**	**1316.3**	**260.0**	**245.8**	**4.0**	**1826.2**	**1466.2**	**274.6**	**250.0**	**4.4**	**1995.3**	**1423.2**	**265.7**	**242.0**	**4.3**	**1935.2**	1457.4	**274.6**	**250.0**	**4.4**	**1986.4**	**1423.2**	**274.3**	**242.0**	**4.3**	**1943.8**

	Jul					Aug					Sep					Oct					Nov					Dec				
A: Surface (m^2)	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total	3PL	Own	Supplier	Other	Total
Clothing	256.9	137.3	150.6	0.0	**544.7**	261.3	128.4	137.3	0.0	**527.0**	248.6	124.3	132.9	0.0	**505.7**	256.9	128.4	137.3	0.0	**522.6**	265.7	132.9	145.7	0.0	**544.3**	323.3	137.3	150.6	0.0	**611.1**
Food	450.3	39.9	66.4	0.0	**556.6**	450.3	39.9	66.4	0.0	**556.6**	435.8	38.6	64.3	0.0	**538.7**	450.3	39.9	66.4	0.0	**556.6**	448.7	38.6	64.3	0.0	**551.5**	463.6	39.9	66.4	0.0	**569.9**
Books	256.9	22.1	13.3	0.0	**292.3**	256.9	22.1	13.3	0.0	**292.3**	248.6	21.4	17.1	0.0	**287.1**	270.1	22.1	17.7	0.0	**310.0**	261.4	21.4	17.1	0.0	**300.0**	256.9	22.1	17.7	0.0	**296.7**
Footwear	93.0	44.3	0.0	0.0	**137.3**	93.0	44.3	0.0	0.0	**137.3**	90.0	42.9	0.0	0.0	**132.9**	93.0	44.3	0.0	0.0	**137.3**	90.0	42.9	0.0	0.0	**132.9**	101.9	48.7	0.0	0.0	**150.6**
Vision	44.3	13.3	22.1	0.0	**79.7**	44.3	13.3	22.1	0.0	**79.7**	42.9	12.9	21.4	0.0	**77.1**	44.3	13.3	22.1	0.0	**79.7**	42.9	12.9	21.4	0.0	**77.1**	44.3	13.3	22.1	0.0	**79.7**
Electronics	252.4	0.0	0.0	0.0	**252.4**	252.4	0.0	0.0	0.0	**252.4**	274.3	0.0	0.0	0.0	**274.3**	283.4	0.0	0.0	0.0	**283.4**	287.1	0.0	0.0	0.0	**287.1**	265.7	0.0	0.0	0.0	**265.7**
Jewellery	63.8	13.3	0.0	0.0	**77.0**	63.8	13.3	0.0	0.0	**77.0**	61.7	12.9	0.0	0.0	**74.6**	63.8	13.3	0.0	0.0	**77.0**	83.1	25.7	0.0	0.0	**108.8**	85.9	26.6	0.0	0.0	**112.5**
Cosmetics	4.4	8.9	0.0	4.4	**17.7**	4.4	8.9	0.0	4.4	**17.7**	4.3	8.6	0.0	4.3	**17.1**	4.4	8.9	0.0	4.4	**17.7**	8.6	8.6	0.0	4.3	**21.4**	8.9	8.9	0.0	4.4	**22.1**
Games	35.4	4.4	0.0	0.0	**39.9**	35.4	4.4	0.0	0.0	**39.9**	34.3	12.9	0.0	0.0	**47.1**	35.4	13.3	0.0	0.0	**48.7**	38.6	12.9	0.0	0.0	**51.4**	39.9	13.3	0.0	0.0	**53.1**
Other	0.0	0.0	10.9	0.0	**10.9**	0.0	0.0	10.9	0.0	**10.9**	0.0	0.0	10.5	0.0	**10.5**	0.0	0.0	10.9	0.0	**10.9**	0.0	0.0	10.5	0.0	**10.5**	0.0	0.0	10.9	0.0	**10.9**
TOTAL	**1457.4**	**283.4**	**263.3**	**4.4**	**2008.6**	**1461.8**	**274.6**	**250.0**	**4.4**	**1990.9**	**1440.4**	**274.3**	**246.3**	**4.3**	**1965.2**	**1501.7**	**283.4**	**254.5**	**4.4**	**2044.0**	**1526.1**	**295.7**	**259.1**	**4.3**	**2085.2**	**1590.2**	**310.0**	**267.8**	**4.4**	**2172.4**

D1-6: SEASONAL VARIATION IN THE NUMBER OF MCGS DELIVERIES – CLASSIFICATION BY SIZE OF BUSINESS AND TYPE OF CARRIER

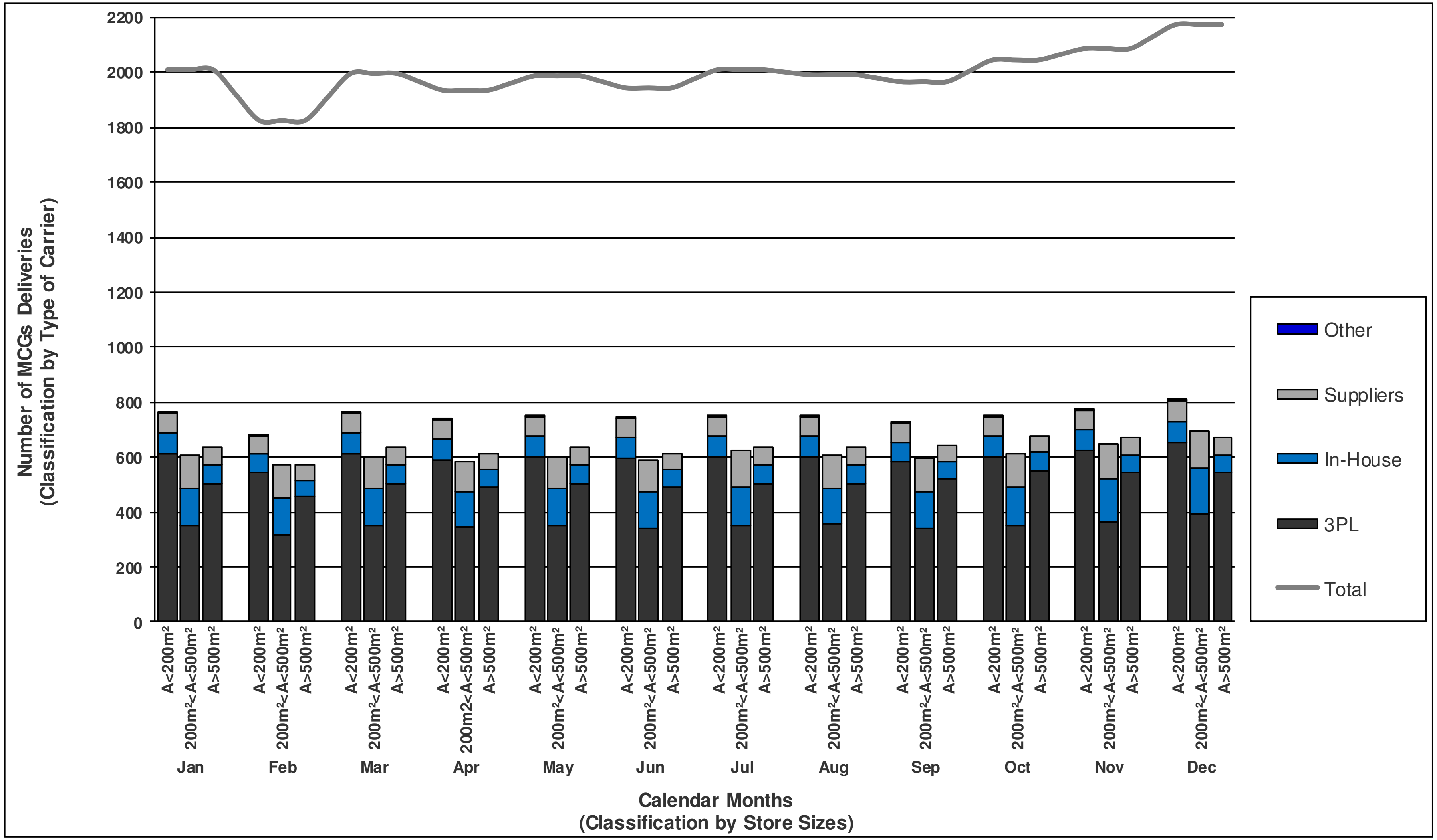


Figure D1-6: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses by different carriers.
(classification by type of carrier and store size)

Table D1-6 Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses by different carriers. (classification by type of carrier and store size)

	Jan				Feb				Mar				Apr			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
3PL Providers	612	350	505	**1466**	544	316	456	**1316**	612	350	505	**1466**	592	343	489	**1423**
In-house Fleet	75	133	66	**275**	68	132	60	**260**	75	133	66	**275**	73	129	64	**266**
Suppliers Fleet	71	126	66	**263**	64	126	56	**246**	71	117	62	**250**	69	113	60	**242**
Other	4	0	0	**4**	4	0	0	**4**	4	0	0	**4**	4	0	0	**4**
TOTAL	**762**	**609**	**638**	**2009**	**680**	**574**	**572**	**1826**	**762**	**600**	**633**	**1995**	**738**	**585**	**613**	**1935**

	May				Jun				Jul				Aug			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
3PL Providers	603	350	505	**1457**	596	339	489	**1423**	603	350	505	**1457**	603	354	505	**1462**
In-house Fleet	75	133	66	**275**	73	137	64	**274**	75	142	66	**283**	75	133	66	**275**
Suppliers Fleet	71	117	62	**250**	69	113	60	**242**	71	130	62	**263**	71	117	62	**250**
Other	4	0	0	**4**	4	0	0	**4**	4	0	0	**4**	4	0	0	**4**
TOTAL	**753**	**600**	**633**	**1986**	**742**	**589**	**613**	**1944**	**753**	**622**	**633**	**2009**	**753**	**604**	**633**	**1991**

	Sep				Oct				Nov				Dec			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
3PL Providers	583	339	519	**1440**	603	350	549	**1502**	626	360	540	**1526**	656	394	540	**1590**
In-house Fleet	73	137	64	**274**	75	142	66	**283**	73	159	64	**296**	75	168	66	**310**
Suppliers Fleet	69	118	60	**246**	71	122	62	**254**	69	126	64	**259**	71	130	66	**268**
Other	4	0	0	**4**	4	0	0	**4**	4	0	0	**4**	4	0	0	**4**
TOTAL	**729**	**593**	**643**	**1965**	**753**	**613**	**678**	**2044**	**772**	**645**	**669**	**2085**	**806**	**693**	**673**	**2172**

D1-7: SEASONAL VARIATION IN THE NUMBER OF MCGS DELIVERIES – CLASSIFICATION BY TYPE OF BUSINESS AND VEHICLE MODE

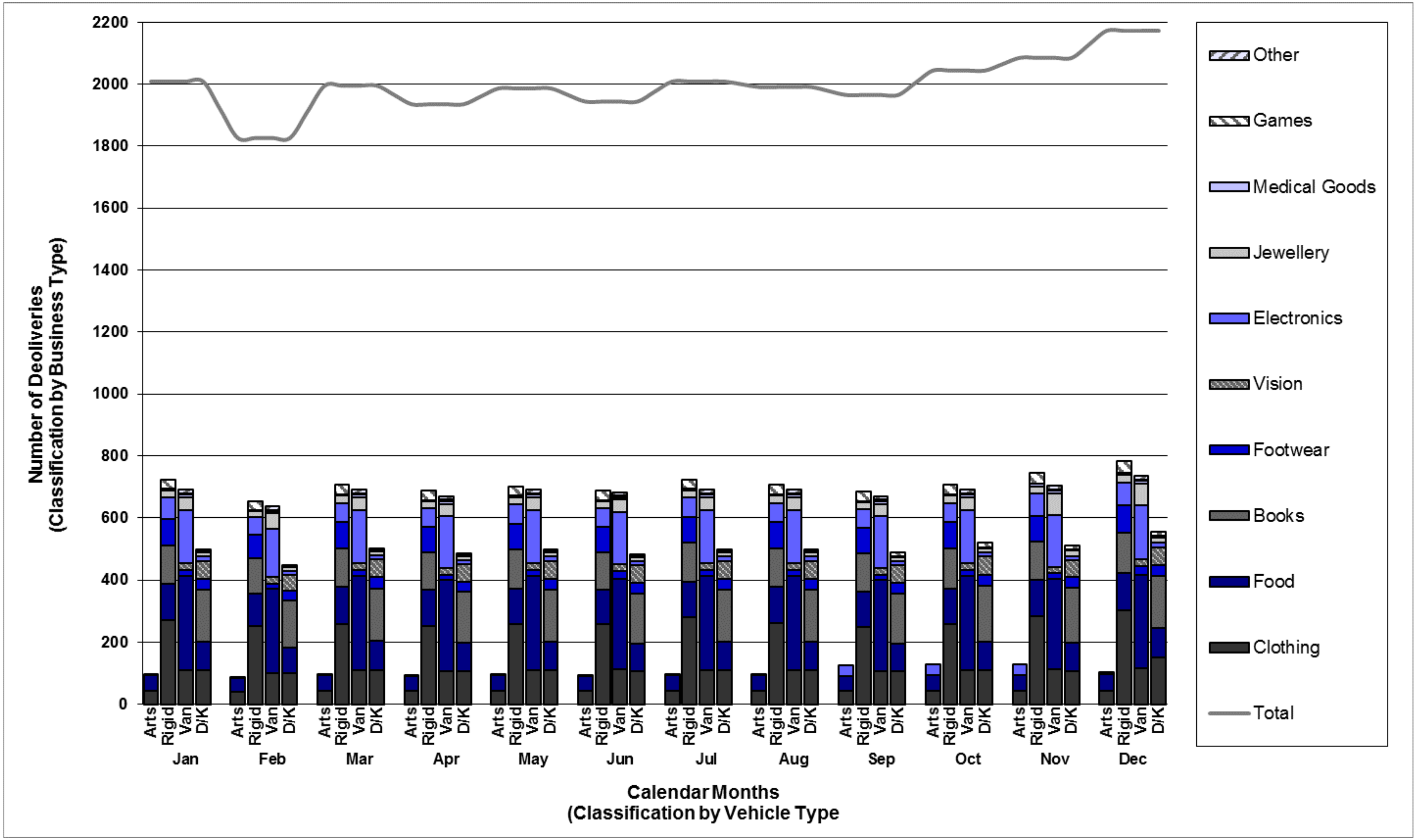


Figure D1-7 Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses.
(classification by type of economic activity and vehicle type).

Table D1-7: Seasonal variation in the number of MCGS deliveries made to *WestQuay* businesses.
(classification by type of economic activity and vehicle type).

	Jan					Feb					Mar					Apr					May					Jun				
A: Surface (m^2)	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Clothing	44	270	111	111	**536**	40	252	100	100	**492**	44	257	111	111	**523**	43	253	107	107	**510**	44	257	111	111	**523**	43	257	111	107	**519**
Food	49	116	302	90	**557**	44	105	273	81	**503**	49	121	302	94	**565**	47	117	292	91	**547**	49	116	302	90	**557**	47	112	292	87	**539**
Books	0	124	0	168	**292**	0	112	0	152	**264**	0	124	0	168	**292**	0	120	0	163	**283**	0	124	0	168	**292**	0	120	0	163	**283**
Footwear	0	84	18	35	**137**	0	76	16	32	**124**	0	84	18	35	**137**	0	81	17	34	**133**	0	84	18	35	**137**	0	81	26	34	**141**
Vision	0	0	22	58	**80**	0	0	20	52	**72**	0	0	22	58	**80**	0	0	21	56	**77**	0	0	22	58	**80**	0	0	21	56	**77**
Electronics	4	71	173	13	**261**	4	56	156	12	**228**	4	62	173	13	**252**	4	60	167	13	**244**	4	62	173	13	**252**	4	60	167	13	**244**
Jewellery	0	23	41	13	**77**	0	21	49	12	**82**	0	23	41	13	**77**	0	22	40	13	**75**	0	23	41	13	**77**	0	22	40	13	**75**
Cosmetics	0	4	9	4	**18**	0	4	8	4	**16**	0	4	9	4	**18**	0	4	9	4	**17**	0	4	9	4	**18**	0	4	9	4	**17**
Games	0	31	4	4	**40**	0	28	4	4	**36**	0	31	4	4	**40**	0	30	4	4	**39**	0	31	4	4	**40**	0	30	4	4	**39**
Other	0	0	11	0	**11**	0	0	10	0	**10**	0	0	11	0	**11**	0	0	11	0	**11**	0	0	11	0	**11**	0	0	11	0	**11**
TOTAL	**97**	**724**	**690**	**497**	**2009**	**88**	**654**	**636**	**449**	**1826**	**97**	**706**	**690**	**501**	**1995**	**94**	**687**	**668**	**485**	**1935**	**97**	**702**	**690**	**497**	**1986**	**94**	**687**	**681**	**481**	**1944**

	Jul					Aug					Sep					Oct					Nov					Dec				
A: Surface (m^2)	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Clothing	44	279	111	111	**545**	44	261	111	111	**527**	43	249	107	107	**506**	44	257	111	111	**523**	43	283	111	107	**544**	44	301	115	151	**611**
Food	49	116	302	90	**557**	49	116	302	90	**557**	47	112	292	87	**539**	49	116	302	90	**557**	51	117	292	91	**552**	53	121	302	94	**570**
Books	0	124	0	168	**292**	0	124	0	168	**292**	0	124	0	163	**287**	0	128	0	182	**310**	0	124	0	176	**300**	0	128	0	168	**297**
Footwear	0	84	18	35	**137**	0	84	18	35	**137**	0	81	17	34	**133**	0	84	18	35	**137**	0	81	17	34	**133**	0	89	27	35	**151**
Vision	0	0	22	58	**80**	0	0	22	58	**80**	0	0	21	56	**77**	0	0	22	58	**80**	0	0	21	56	**77**	0	0	22	58	**80**
Electronics	4	62	173	13	**252**	4	62	173	13	**252**	34	60	167	13	**274**	35	62	173	13	**283**	34	73	167	13	**287**	4	75	173	13	**266**
Jewellery	0	23	41	13	**77**	0	23	41	13	**77**	0	22	40	13	**75**	0	23	41	13	**77**	0	22	70	17	**109**	0	23	72	18	**112**
Cosmetics	0	4	9	4	**18**	0	4	9	4	**18**	0	4	9	4	**17**	0	4	9	4	**18**	0	9	9	4	**21**	0	9	9	4	**22**
Games	0	31	4	4	**40**	0	31	4	4	**40**	0	30	4	13	**47**	0	31	4	13	**49**	0	34	4	13	**51**	0	35	4	13	**53**
Other	0	0	11	0	**11**	0	0	11	0	**11**	0	0	11	0	**11**	0	0	11	0	**11**	0	0	11	0	**11**	0	0	11	0	**11**
TOTAL	**97**	**724**	**690**	**497**	**2009**	**97**	**706**	**690**	**497**	**1991**	**124**	**683**	**668**	**490**	**1965**	**128**	**706**	**690**	**519**	**2044**	**129**	**743**	**702**	**511**	**2085**	**102**	**781**	**735**	**555**	**2172**

D1-8: SEASONAL VARIATION IN THE NUMBER OF MCGS DELIVERIES – CLASSIFICATION BY SIZE OF BUSINESS AND VEHICLE MODE

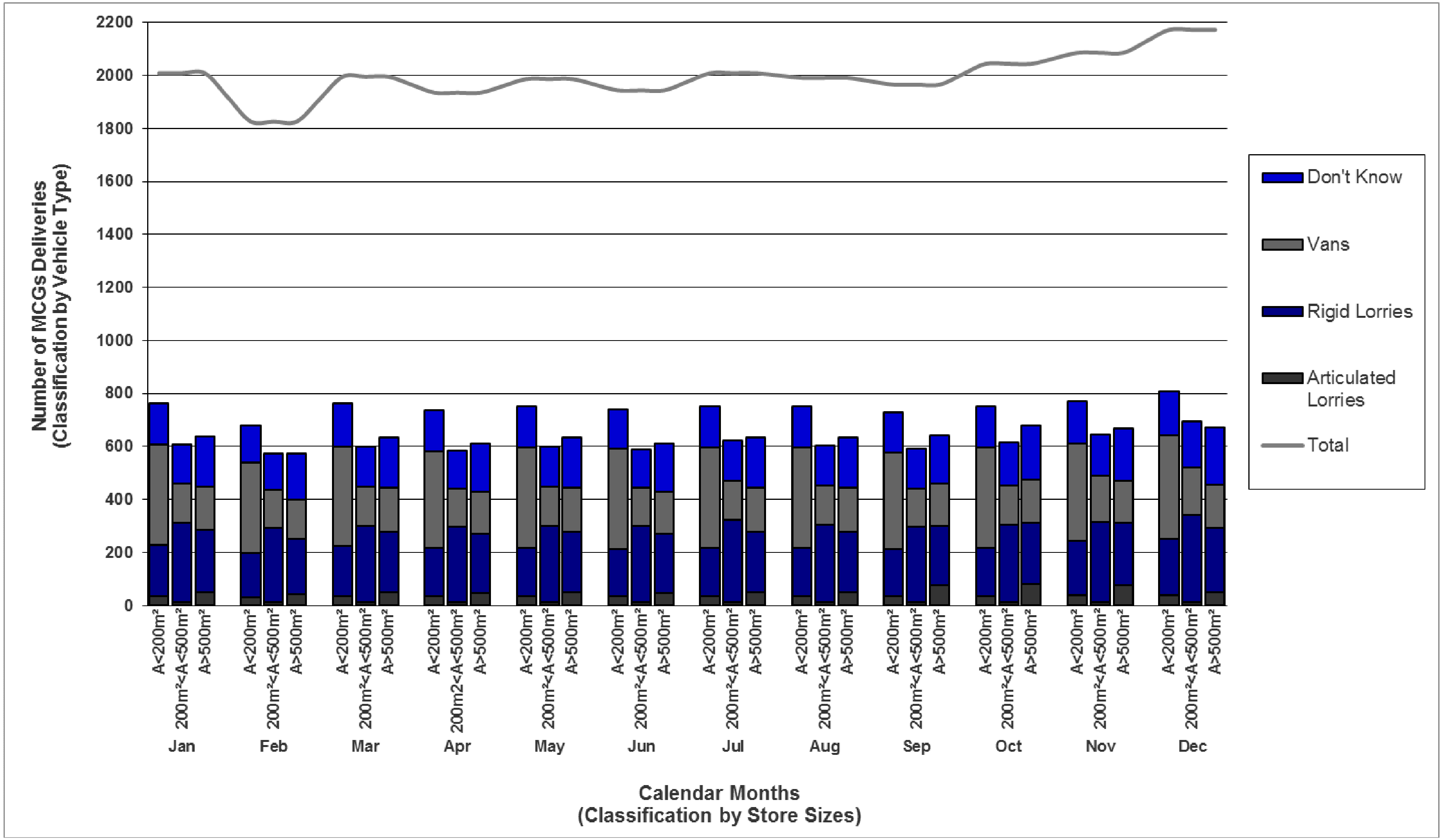


Figure D1-8: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses.
(classification by vehicle type and store size).

Table D1-8: Seasonal variation in the number of MCGs deliveries made to *WestQuay* businesses.
(classification by vehicle type and store size)

	Jan				Feb				Mar				Apr			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Articulated Lorries	8	13	49	**97**	32	12	44	**88**	35	13	49	**97**	34	13	47	**94**
Rigid Lorries	192	297	235	**724**	166	280	208	**654**	188	288	230	**706**	182	283	223	**687**
Vans	378	148	164	**690**	342	146	148	**636**	378	148	164	**690**	366	143	159	**668**
Don't Know	156	151	190	**497**	141	136	172	**449**	160	151	190	**501**	155	146	184	**485**
TOTAL	**762**	**609**	**638**	**2009**	**680**	**574**	**572**	**1826**	**762**	**600**	**633**	**1995**	**738**	**585**	**613**	**1935**

	May				Jun				Jul				Aug			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Articulated Lorries	35	13	49	97	34	13	47	**94**	35	13	49	**97**	35	13	49	**97**
Rigid Lorries	183	288	230	702	177	287	223	**687**	183	310	230	**724**	183	292	230	**706**
Vans	378	148	164	690	379	143	159	**681**	378	148	164	**690**	378	148	164	**690**
Don't Know	156	151	190	497	151	146	184	**481**	156	151	190	**497**	156	151	190	**497**
TOTAL	**753**	**600**	**633**	**1986**	**742**	**589**	**613**	**1944**	**753**	**622**	**633**	**2009**	**753**	**604**	**633**	**1991**

	Sep				Oct				Nov				Dec			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Articulated Lorries	8	13	77	**124**	35	13	80	**128**	39	13	77	**129**	40	13	49	**102**
Rigid Lorries	177	283	223	**683**	183	292	230	**706**	203	304	236	**743**	210	328	244	**781**
Vans	366	143	159	**668**	378	148	164	**690**	371	173	159	**702**	392	179	164	**735**
Don't Know	151	154	184	**490**	156	159	204	**519**	160	154	197	**511**	165	173	217	**555**
TOTAL	**729**	**593**	**643**	**1965**	**753**	**613**	**678**	**2044**	**772**	**645**	**669**	**2085**	**806**	**693**	**673**	**2172**

D1-9: SEASONAL VARIATION IN THE DISTANCE TRAVELLED FOR MCGS DELIVERIES – CLASSIFICATION BY TYPE OF BUSINESS AND VEHICLE MODE

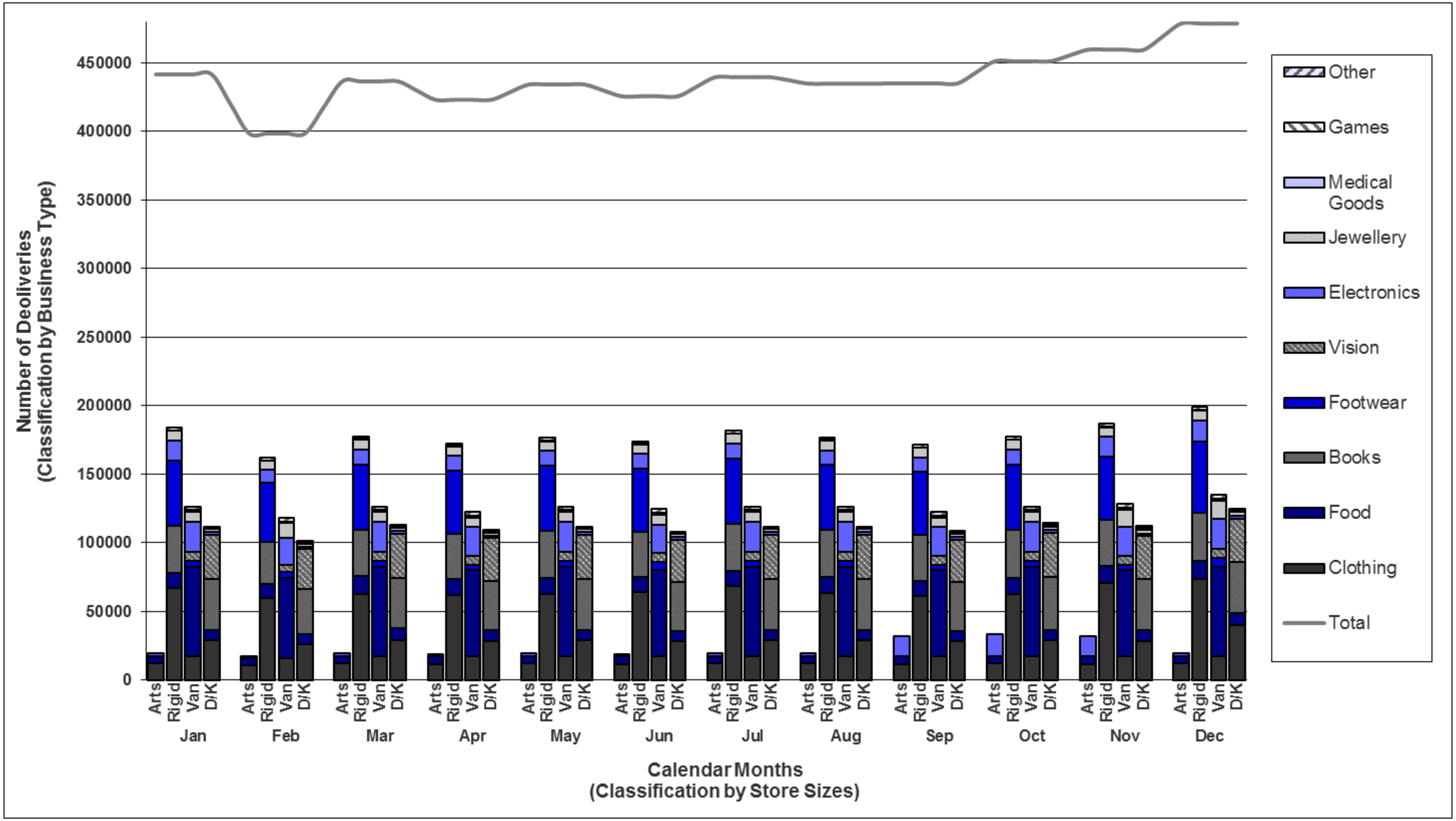


Figure D1-9: Seasonal variation in the distance travelled to deliver MCGs to *WestQuay* businesses.
(classification by type of economic activity and vehicle type).

Table D1-9: Seasonal variation in the distance travelled to deliver MCGs to *WestQuay* businesses.
(classification by type of economic activity and vehicle type).

	Jan					Feb					Mar				
A: Surface (m^2)	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Clothing	12212	67179	17787	29136	**126314**	11030	59597	16066	26316	**113009**	12212	63121	17787	29136	**122256**
Food	5605	11274	64975	7690	**89543**	5062	10183	58687	6946	**80878**	5605	12599	64975	8674	**91853**
Books	0	34068	0	36944	**71012**	0	30771	0	33369	**64139**	0	34068	0	36944	**71012**
Footwear	0	47463	4305	0	**51768**	0	42870	3888	0	**46758**	0	47463	4305	0	**51768**
Vision	0	0	6236	32053	**38290**	0	0	5633	28951	**34584**	0	0	6236	32053	**38290**
Electronics	1924	14254	21761	1833	**39773**	1738	9836	19655	1656	**32886**	1924	10890	21761	1833	**36409**
Jewellery	0	7199	7322	2537	**17058**	0	6502	10437	2291	**19231**	0	7199	7322	2537	**17058**
Cosmetics	0	329	1395	1026	**2751**	0	297	1260	927	**2485**	0	329	1395	1026	**2751**
Games	0	1981	0	445	**2426**	0	1789	0	402	**2191**	0	1981	0	445	**2426**
Other	0	0	2787	0	**2787**	0	0	2517	0	**2517**	0	0	2787	0	**2787**
TOTAL	**19741**	**183746**	**126569**	**111665**	**441721**	**17831**	**161845**	**118144**	**100859**	**398678**	**19741**	**177649**	**126569**	**112648**	**436608**

	Apr					May					Jun				
A: Surface (m^2)	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Clothing	11818	61730	17213	28196	**118957**	12212	63121	17787	29136	**122256**	11818	64409	17223	28196	**121646**
Food	5424	12193	62879	8394	**88890**	5605	11274	64975	7690	**89543**	5424	10910	62879	7442	**86655**
Books	0	32969	0	35752	**68721**	0	34068	0	36944	**71012**	0	32969	0	35752	**68721**
Footwear	0	45932	4166	0	**50098**	0	47463	4305	0	**51768**	0	45932	6249	0	**52181**
Vision	0	0	6035	31019	**37054**	0	0	6236	32053	**38290**	0	0	6035	31019	**37054**
Electronics	1862	10539	21059	1774	**35235**	1924	10890	21761	1833	**36409**	1862	10539	21059	1774	**35235**
Jewellery	0	6967	7086	2455	**16507**	0	7199	7322	2537	**17058**	0	6967	7086	2455	**16507**
Cosmetics	0	319	1350	993	**2662**	0	329	1395	1026	**2751**	0	319	1350	993	**2662**
Games	0	1917	0	431	**2348**	0	1981	0	445	**2426**	0	1917	0	431	**2348**
Other	0	0	2697	0	**2697**	0	0	2787	0	**2787**	0	0	2697	0	**2697**
TOTAL	**19105**	**172564**	**122486**	**109015**	**423169**	**19741**	**176324**	**126569**	**111665**	**434299**	**19105**	**173960**	**124579**	**108063**	**425706**

	Jul					Aug					Sep				
A: Surface (m^2)	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Clothing	12212	68453	17787	29136	**127588**	12212	63787	17787	29136	**122922**	11818	61085	17213	28196	**118312**
Food	5605	11274	64975	7690	**89543**	5605	11274	64975	7690	**89543**	5424	10910	62879	7442	**86655**
Books	0	34068	0	36944	**71012**	0	34068	0	36944	**71012**	0	33845	0	35752	**69597**
Footwear	0	47463	4305	0	**51768**	0	47463	4305	0	**51768**	0	45932	4166	0	**50098**
Vision	0	0	6236	32053	**38290**	0	0	6236	32053	**38290**	0	0	6035	31019	**37054**
Electronic	1924	10890	21761	1833	**36409**	1924	10890	21761	1833	**36409**	14898	10539	21059	1774	**48270**
Jewellery	0	7199	7322	2537	**17058**	0	7199	7322	2537	**17058**	0	6967	7086	2455	**16507**
Cosmetics	0	329	1395	1026	**2751**	0	329	1395	1026	**2751**	0	319	1350	993	**2662**
Games	0	1981	0	445	**2426**	0	1981	0	445	**2426**	0	1917	0	1293	**3210**
Other	0	0	2787	0	**2787**	0	0	2787	0	**2787**	0	0	2697	0	**2697**
TOTAL	**19741**	**181656**	**126569**	**111665**	**439631**	**19741**	**176990**	**126569**	**111665**	**434965**	**32140**	**171512**	**122486**	**108925**	**435063**

	Oct					Nov					Dec				
A: Surface (m^2)	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total	Arts	Rigid	Vans	D/K	Total
Clothing	12212	63121	17787	29136	**122256**	11818	70678	17223	28196	**127915**	12212	74054	17797	40147	**144211**
Food	5605	11274	64975	7690	**89543**	5447	12193	62879	8394	**88913**	5629	12599	64975	8674	**91877**
Books	0	34973	0	38665	**73638**	0	33845	0	37418	**71262**	0	34973	0	36944	**71917**
Footwear	0	47463	4305	0	**51768**	0	45932	4166	0	**50098**	0	52238	6457	0	**58695**
Vision	0	0	6236	32053	**38290**	0	0	6035	31019	**37054**	0	0	6236	32053	**38290**
Electronic	15395	10890	21761	1833	**49879**	14898	14594	21059	1774	**52326**	1924	15081	21761	1833	**40600**
Jewellery	0	7199	7322	2537	**17058**	0	6967	12846	3020	**22833**	0	7199	13275	3120	**23594**
Cosmetics	0	329	1395	1026	**2751**	0	637	1350	993	**2981**	0	659	1395	1026	**3080**
Games	0	1981	0	1336	**3317**	0	2335	0	1293	**3629**	0	2413	0	1336	**3750**
Other	0	0	2787	0	**2787**	0	0	2697	0	**2697**	0	0	2787	0	**2787**
TOTAL	**33212**	**177229**	**126569**	**114277**	**451286**	**32164**	**187181**	**128256**	**112107**	**459708**	**19766**	**199216**	**134684**	**125134**	**478800**

D1-10: SEASONAL VARIATION IN THE DISTANCE TRAVELLED FOR MCGS DELIVERIES – CLASSIFICATION BY SIZE OF BUSINESS AND VEHICLE MODE

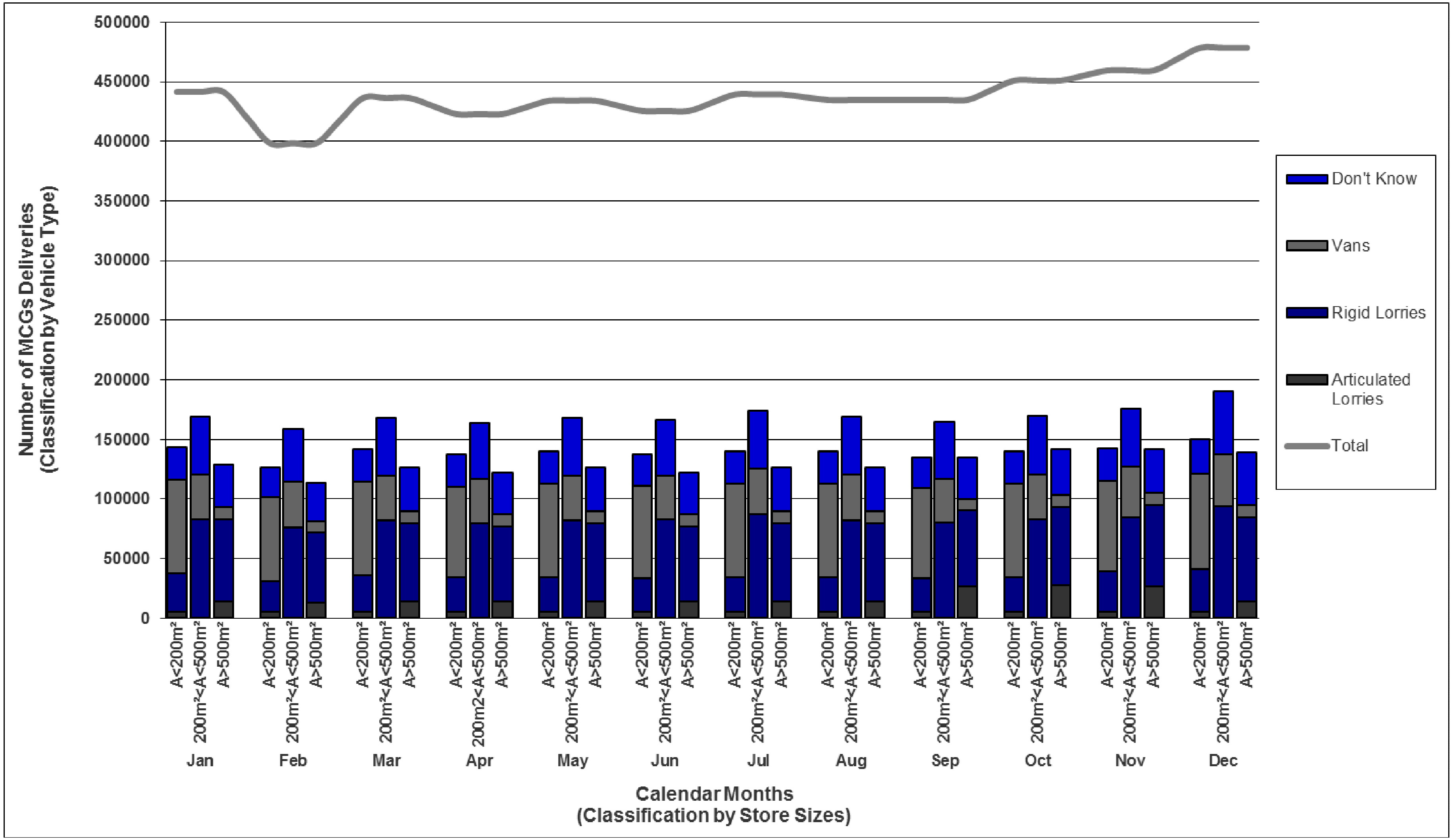


Figure D1-10: Seasonal variation in the distance (kms) travelled to deliver MCGs to *WestQuay* businesses.
(classification by vehicle type and store size)

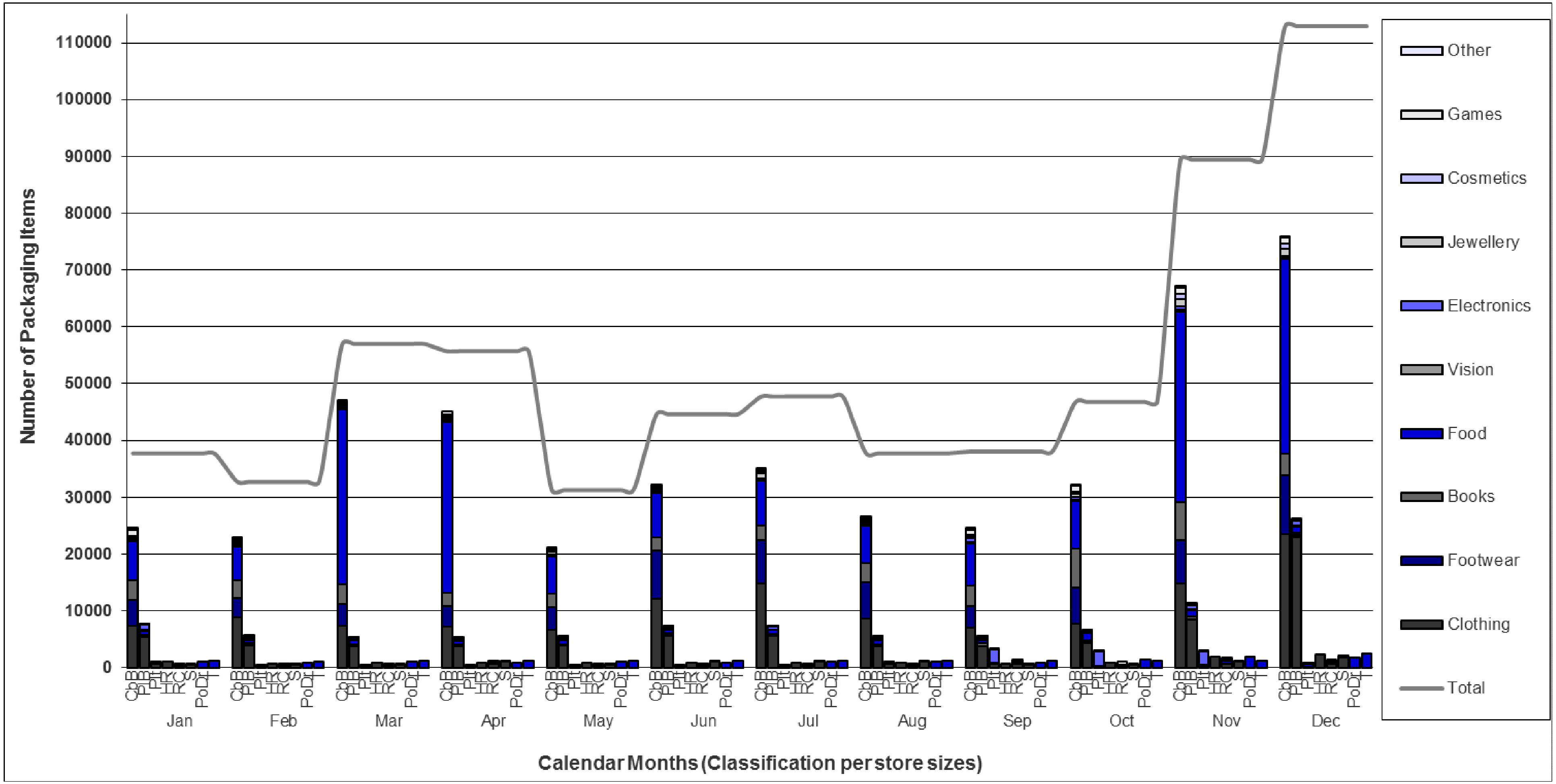
Table D1-10: Seasonal variation in the distance (kms) travelled to deliver MCGs to *WestQuay* businesses.
(classification by vehicle type and store size)

	Jan				Feb				Mar				Apr			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Articulated Lorries	5532	73	14137	**19741**	4997	66	12769	**17831**	5532	73	14137	**19741**	5354	70	13681	**19105**
Rigid Lorries	32266	82709	68771	**183746**	26105	76418	59322	**161845**	30227	81744	65678	**177649**	29252	79752	63559	**172564**
Vans	78473	38011	10085	**126569**	70879	38156	9109	**118144**	78473	38011	10085	**126569**	75942	36784	9760	**122486**
Don't Know	26873	48582	36210	**111665**	24272	43880	32706	**100859**	27857	48582	36210	**112648**	26958	47015	35042	**109015**
TOTAL	**143144**	**169374**	**129203**	**441721**	**126253**	**158520**	**113905**	**398678**	**142089**	**168409**	**126109**	**436608**	**137506**	**163622**	**122041**	**423169**

	May				Jun				Jul				Aug			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Articulated Lorries	5532	73	14137	**19741**	5354	70	13681	**19105**	5532	73	14137	**19741**	5532	73	14137	**19741**
Rigid Lorries	28902	81744	65678	**176324**	27969	82432	63559	**173960**	28902	87076	65678	**181656**	28902	82411	65678	**176990**
Vans	78473	38011	10085	**126569**	78035	36784	9760	**124579**	78473	38011	10085	**126569**	78473	38011	10085	**126569**
Don't Know	26873	48582	36210	**111665**	26006	47015	35042	**108063**	26873	48582	36210	**111665**	26873	48582	36210	**111665**
TOTAL	**139780**	**168409**	**126109**	**434299**	**137364**	**166301**	**122041**	**425706**	**139780**	**173741**	**126109**	**439631**	**139780**	**169076**	**126109**	**434965**

	Sep				Oct				Nov				Dec			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Articulated Lorries	5354	70	26716	**32140**	5532	73	27607	**33212**	5377	70	26716	**32164**	5556	73	14137	**19766**
Rigid Lorries	27969	79983	63559	**171512**	28902	82649	65678	**177229**	34045	84886	68249	**187181**	35180	93512	70524	**199216**
Vans	75942	36784	9760	**122486**	78473	38011	10085	**126569**	75952	42545	9760	**128256**	80636	43963	10085	**134684**
Don't Know	26006	47877	35042	**108925**	26873	49473	37931	**114277**	27523	47877	36708	**112107**	28440	52573	44121	**125134**
TOTAL	**135271**	**164715**	**135077**	**435063**	**139780**	**170205**	**141301**	**451286**	**142897**	**175379**	**141433**	**459708**	**149812**	**190121**	**138867**	**478800**

D1-11: SEASONAL VARIATION OF MCGS PACKAGING ITEMS DELIVERED – CLASSIFICATION BY TYPE OF BUSINESS AND TYPE OF PACKAGING



*CbB: Cardboard Boxes, PlB: Plastic Boxes, Plt: Palettes, HR: Hanging Rails, RC: Roll Cages, S: Sacks, PoDr: Packs of Drinks, T: Trays

Figure D1-11: Seasonal variation in the number of MCGs packaging items delivered to *WestQuay* businesses (classification by type of economic activity and type of packaging).

Table D1-11: Seasonal variation in the number of MCGs packaging items delivered to *WestQuay* businesses (classification by type of economic activity, store size and type of packaging).

A: Surface (m^2)	Jan									Feb									Mar									Apr								
	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total
Clothing	7338	5487	709	1014	332	531	0	0	**15411**	8836	3916	160	724	300	480	0	0	**14416**	7427	3848	177	802	332	531	0	0	**13117**	7123	3741	171	827	749	1039	0	0	**7123**
Food	4623	133	0	0	0	0	0	0	**4756**	3476	120	0	0	0	0	0	0	**3596**	3848	133	0	0	0	0	0	0	**3981**	3724	129	0	0	0	0	0	0	**3724**
Books	3392	221	9	0	0	0	0	0	**3623**	3064	200	8	0	0	0	0	0	**3272**	3392	221	9	0	0	0	0	0	**3623**	2357	214	9	0	0	0	0	0	**2357**
Footwear	6869	682	166	0	213	0	968	1187	**10084**	5964	616	150	0	192	0	874	107	**8868**	30871	682	166	0	213	0	968	11	**34087**	30133	660	161	0	206	0	936	114	**30133**
Vision	235	199	0	0	0	0	0	0	**434**	212	180	0	0	0	0	0	0	**392**	235	66	0	0	0	0	0	0	**301**	227	64	0	0	0	0	0	0	**227**
Electronic	115	779	44	0	40	239	0	0	**1218**	263	290	40	0	36	108	0	0	**737**	115	321	44	0	40	120	0	0	**640**	111	311	43	0	39	116	0	0	**111**
Jewellery	388	27	0	0	0	0	0	0	**414**	502	176	0	0	0	0	0	0	**678**	388	27	0	0	0	0	0	0	**414**	375	26	0	0	0	0	0	0	**375**
Cosmetics	237	7	7	0	0	0	0	0	**250**	214	6	6	0	0	0	0	0	**226**	237	7	7	0	0	0	0	0	**250**	229	6	6	0	0	0	0	0	**229**
Games	1027	0	0	0	33	0	0	0	**1060**	320	0	0	0	30	0	0	0	**350**	354	0	0	0	33	0	0	0	**388**	343	0	0	0	32	0	0	0	**343**
Other	475	0	0	0	0	0	0	0	**475**	189	0	0	0	0	0	0	0	**189**	209	0	0	0	0	0	0	0	**209**	460	0	0	0	0	0	0	0	**460**
TOTAL	**24699**	**7535**	**934**	**1014**	**618**	**771**	**968**	**1187**	**37725**	**23041**	**5504**	**364**	**724**	**558**	**588**	**874**	**107**	**32725**	**47077**	**5305**	**403**	**802**	**618**	**651**	**968**	**11**	**57011**	**45083**	**5151**	**390**	**827**	**1025**	**1155**	**936**	**114**	**45083**

A: Surface (m^2)	May									Jun									Jul									Aug								
	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total
Clothing	6740	3866	177	855	332	531	0	0	**12502**	12195	5559	171	904	321	1050	0	0	**20201**	14754	5620	177	934	332	1085	0	0	**22902**	8640	3848	709	802	332	1074	0	0	**15405**
Food	3848	133	0	0	0	0	0	0	**3981**	8400	283	0	0	0	0	0	0	**8683**	7746	133	0	0	0	0	0	0	**7878**	6399	133	0	0	0	0	0	0	**6532**
Books	2436	221	9	0	0	0	0	0	**2666**	2357	214	9	0	0	0	0	0	**2580**	2436	221	9	0	0	0	0	0	**2666**	3392	221	9	0	0	0	0	0	**3623**
Footwear	6603	682	166	0	213	0	968	1187	**9818**	7847	660	161	0	206	0	936	114	**10958**	8109	682	166	0	213	0	968	11	**11324**	6603	682	166	0	213	0	968	118	**9818**
Vision	235	66	0	0	0	0	0	0	**301**	227	64	0	0	0	0	0	0	**291**	235	66	0	0	0	0	0	0	**301**	235	66	0	0	0	0	0	0	**301**
Electronic	115	401	44	0	40	120	0	0	**720**	111	388	43	0	39	116	0	0	**696**	115	461	44	0	40	213	0	0	**872**	115	381	44	0	40	213	0	0	**793**
Jewellery	388	27	0	0	0	0	0	0	**414**	375	26	0	0	0	0	0	0	**401**	919	27	0	0	0	0	0	0	**946**	388	27	0	0	0	0	0	0	**414**
Cosmetics	242	7	7	0	0	0	0	0	**256**	229	6	6	0	0	0	0	0	**242**	237	7	7	0	0	0	0	0	**250**	237	7	7	0	0	0	0	0	**250**
Games	354	0	0	0	33	0	0	0	**388**	343	0	0	0	32	0	0	0	**375**	354	0	0	0	33	0	0	0	**388**	354	0	0	0	33	0	0	0	**388**
Other	209	0	0	0	0	0	0	0	**209**	203	0	0	0	0	0	0	0	**203**	209	0	0	0	0	0	0	0	**209**	209	0	0	0	0	0	0	0	**209**
TOTAL	**21171**	**5403**	**403**	**855**	**618**	**651**	**968**	**1187**	**31255**	**32288**	**7200**	**390**	**904**	**598**	**1166**	**936**	**114**	**44631**	**35113**	**7216**	**403**	**934**	**618**	**1298**	**968**	**11**	**47737**	**26573**	**5365**	**934**	**802**	**618**	**1287**	**968**	**118**	**37733**

A: Surface (m^2)	Sep									Oct									Nov									Dec								
	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total	Cardboard Boxes	Plastic Totes	Pallets	Hanging Rails	Roll Cages	Sacks	Packs of Drinks	Trays	Total
Clothing	7101	3724	686	776	749	514	0	0	**13550**	7692	4309	177	899	332	531	0	0	**13941**	14904	8434	171	1974	749	1039	0	0	**27271**	23533	23055	177	240	774	1814	0	0	**51756**
Food	3724	129	0	0	0	0	0	0	**3853**	6399	133	0	0	0	0	0	0	**6532**	7577	129	0	0	0	0	0	0	**7706**	10345	292	0	0	0	0	0	0	**10637**
Books	3660	429	51	0	0	0	0	0	**4140**	6889	443	53	0	0	0	0	0	**7385**	6666	429	51	0	0	0	0	0	**7146**	3782	443	53	0	0	0	0	0	**4278**
Footwear	7430	660	161	0	206	0	936	1149	**10542**	8322	1240	166	0	213	0	146	118	**12592**	33590	1200	236	0	514	0	1935	12	**38710**	34228	1085	372	0	213	0	179	248	**40173**
Vision	227	64	0	0	0	0	0	0	**291**	235	66	0	0	0	0	0	0	**301**	227	64	0	0	0	0	0	0	**291**	235	66	0	0	0	0	0	0	**301**
Electronic	583	311	2400	0	39	116	0	0	**3448**	602	321	2480	0	40	120	0	0	**3563**	583	774	2400	0	77	141	0	0	**3975**	292	939	44	0	80	239	0	0	**1594**
Jewellery	392	26	0	0	0	0	0	0	**418**	406	27	0	0	0	0	0	0	**432**	1294	189	0	0	0	0	0	0	**1483**	1249	221	0	0	0	0	0	0	**1470**
Cosmetics	229	6	6	0	0	0	0	0	**242**	392	7	7	0	0	0	0	0	**405**	909	29	39	0	0	0	0	0	**977**	940	30	40	0	0	0	0	0	**1009**
Games	993	0	0	0	386	0	0	0	**1379**	1027	0	0	0	399	0	0	0	**1425**	1071	0	0	0	386	0	0	0	**1456**	1106	0	0	0	399	0	0	0	**1505**
Other	203	0	0	0	0	0	0	0	**203**	209	0	0	0	0	0	0	0	**209**	417	0	0	0	0	0	0	0	**417**	209	0	0	0	0	0	0	0	**209**
TOTAL	**24544**	**5349**	**3304**	**776**	**1379**	**630**	**936**	**1149**	**38066**	**32173**	**6545**	**2883**	**899**	**983**	**651**	**146**	**118**	**46786**	**67238**	**11247**	**2897**	**1974**	**1726**	**1181**	**1935**	**12**	**89432**	**75919**	**26132**	**686**	**240**	**1465**	**2053**	**179**	**248**	**112932**

D1-12: SEASONAL VARIATION IN THE NUMBER OF MCGS PACKAGING ITEMS DELIVERED – CLASSIFICATION BY TYPE AND SIZE OF BUSINESS

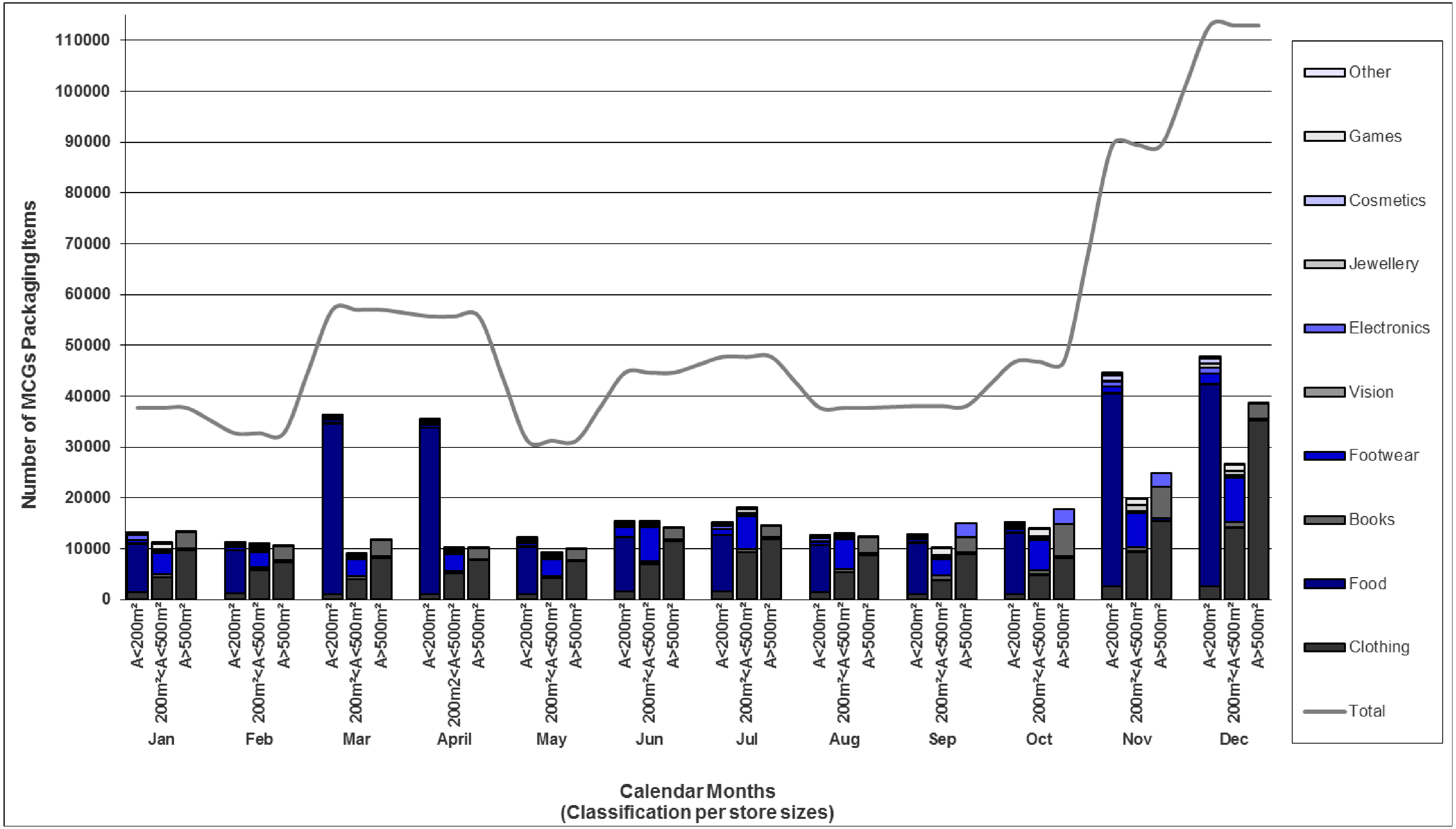


Figure D1-12: Seasonal variation in the number of MCGs packaging items delivered to *WestQuay* businesses (classification by type of economic activity and store size).

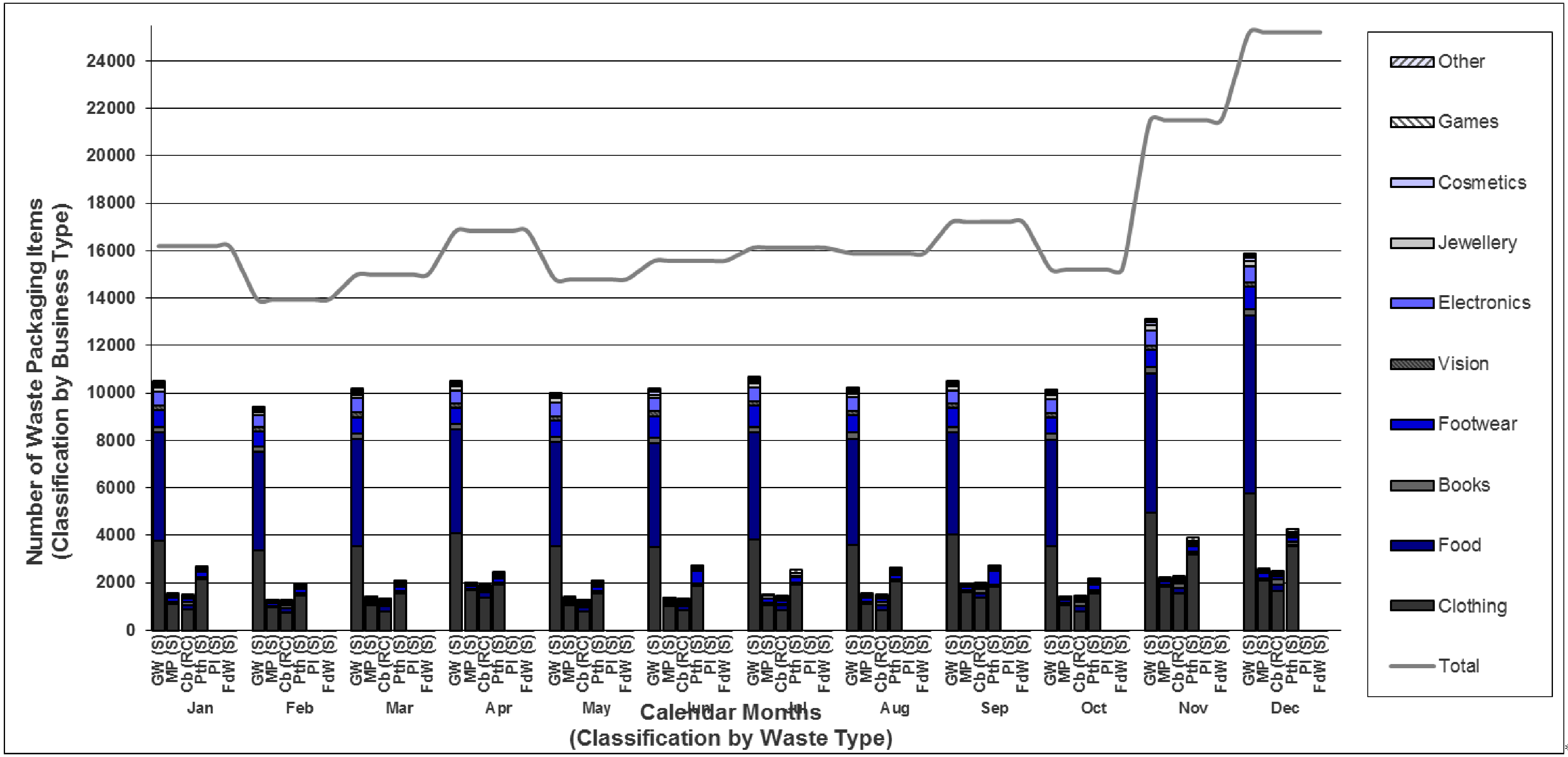
Table D1-12: Seasonal variation in the number of MCGs packaging items delivered to *WestQuay* businesses (classification by type of economic activity, store size and type of packaging).

	Jan				Feb				Mar				Apr				May				Jun			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	1315	4353	9743	**15411**	1204	5804	7408	**14416**	961	3955	8202	**13117**	930	5089	7632	**13651**	961	4096	7444	**12502**	1693	6956	11552	**20201**
Food	9619	93	372	**10084**	8448	84	336	**8868**	33622	93	372	**34087**	32794	90	360	**33244**	9353	93	372	**9818**	10508	90	360	**10958**
Books	84	452	3087	**3623**	76	408	2788	**3272**	84	452	3087	**3623**	81	437	2061	**2580**	84	452	2130	**2666**	81	437	2061	**2580**
Footwear	602	4154	0	**4756**	544	3052	0	**3596**	602	3379	0	**3981**	583	3270	0	**3853**	602	3379	0	**3981**	1886	6797	0	**8683**
Vision	13	421	0	**434**	12	380	0	**392**	13	288	0	**301**	13	279	0	**291**	13	288	0	**301**	13	279	0	**291**
Electronics	1019	146	53	**1218**	398	291	48	**737**	441	146	53	**640**	426	141	51	**619**	520	146	53	**720**	504	141	51	**696**
Jewellery	153	261	0	**414**	138	540	0	**678**	153	261	0	**414**	148	253	0	**401**	153	261	0	**414**	148	253	0	**401**
Cosmetics	250	0	0	**250**	226	0	0	**226**	250	0	0	**250**	242	0	0	**242**	256	0	0	**256**	242	0	0	**242**
Games	62	998	0	**1060**	56	294	0	**350**	62	326	0	**388**	60	315	0	**375**	62	326	0	**388**	60	315	0	**375**
Other	111	364	0	**475**	100	89	0	**189**	111	99	0	**209**	107	353	0	**460**	111	99	0	**209**	107	96	0	**203**
TOTAL	13228	11242	13255	37725	11202	10943	10580	32725	36299	8998	11714	57011	35385	10227	10105	55717	12115	9140	10000	31255	15242	15363	14025	44631

	Jan				Feb				Mar				Apr				May				Jun			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	1705	9260	11937	**22902**	1333	5339	8733	**15405**	930	3741	8879	**13550**	961	4778	8202	**13941**	2511	9328	15432	**27271**	2569	14083	35104	**51756**
Food	10859	93	372	**11324**	9353	93	372	**9818**	10092	90	360	**10542**	12127	93	372	**12592**	37938	103	669	**38710**	39628	172	372	**40173**
Books	84	452	2130	**2666**	84	452	3087	**3623**	244	909	2987	**4140**	252	939	6193	**7385**	244	909	5994	**7146**	252	939	3087	**4278**
Footwear	1174	6705	0	**7878**	602	5930	0	**6532**	583	3270	0	**3853**	602	5930	0	**6532**	1136	6570	0	**7706**	1949	8689	0	**10637**
Vision	13	288	0	**301**	13	288	0	**301**	13	279	0	**291**	13	288	0	**301**	13	279	0	**291**	13	288	0	**301**
Electronics	673	146	53	**872**	593	146	53	**793**	426	141	2880	**3448**	441	146	2976	**3563**	915	180	2880	**3975**	1178	362	53	**1594**
Jewellery	153	793	0	**946**	153	261	0	**414**	165	253	0	**418**	171	261	0	**432**	351	1131	0	**1483**	806	664	0	**1470**
Cosmetics	250	0	0	**250**	250	0	0	**250**	242	0	0	**242**	405	0	0	**405**	977	0	0	**977**	1009	0	0	**1009**
Games	62	326	0	**388**	62	326	0	**388**	60	1319	0	**1379**	62	1363	0	**1425**	137	1319	0	**1456**	142	1363	0	**1505**
Other	111	99	0	**209**	111	99	0	**209**	107	96	0	**203**	111	99	0	**209**	321	96	0	**417**	111	99	0	**209**
TOTAL	15084	18161	14493	47737	12555	12933	12245	37733	12863	10098	15106	38066	15146	13897	17743	46786	44544	19914	24974	89432	47657	26659	38616	112932

D2: Statistical Data Tables and Graphs for Waste Products

D2-1: Seasonal variation in the number of waste packaging units collected – Classification by type of business and type of packaging



GW: General Waste, MP: Mixed Paper, Cb: Cardboard, Pth: Polythene, Pl: Plastic, FdW: Food Waste, S: sacks, RL: roll cages.

Figure D2-1: Seasonal variation in the number of waste packaging items produced by *WestQuay* businesses.
(classification by type of economic activity and waste type)

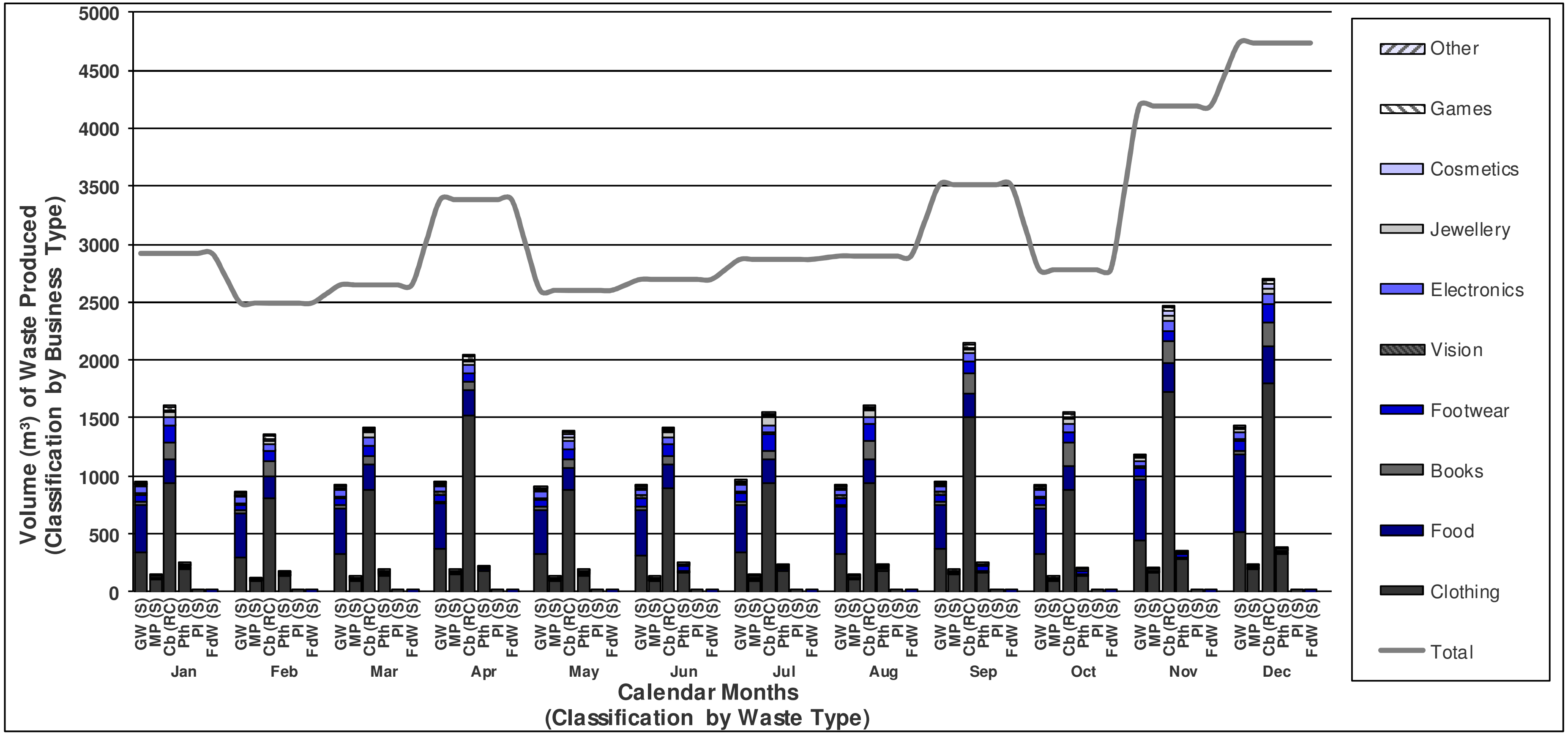
Table D2-1: Seasonal variation in the number of waste packaging units collected by *WestQuay* businesses. (classification by vehicle type and store size)

	Jan				Feb				Mar				Apr			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
General Waste (sacks)	4265	2781	3428	**10474**	3832	2504	3096	**9432**	4163	2684	3317	**10164**	4029	2657	3810	**10496**
Mixed Paper (sacks)	109	537	880	**1526**	92	433	747	**1272**	102	457	827	**1386**	99	502	1400	**2001**
Cardboard (roll cages)	219	300	930	**1449**	204	222	798	**1225**	235	239	811	**1285**	228	238	1385	**1850**
Polythene (sacks)	457	668	1563	**2689**	381	602	972	**1955**	422	620	1067	**2109**	408	698	1333	**2439**
Plastic (sacks)	9	4	4	**18**	8	4	4	**16**	9	4	4	**18**	9	4	4	**17**
Food Waste (sacks)	40	0	0	**40**	36	0	0	**36**	40	0	0	**40**	39	0	0	**39**
TOTAL	**5099**	**4290**	**6805**	**16196**	**4553**	**3765**	**5617**	**13936**	**4971**	**4004**	**6026**	**15002**	**4812**	**4099**	**7932**	**16842**

	May				Jun				Jul				Aug			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
General Waste (sacks)	4008	2684	3317	**10009**	4127	2829	3210	**10166**	4163	3184	3317	**10664**	4176	2719	3317	**10212**
Mixed Paper (sacks)	100	457	827	**1384**	96	443	800	**1340**	122	534	827	**1482**	126	515	880	**1521**
Cardboard (roll cages)	209	237	811	**1257**	224	237	819	**1280**	233	323	846	**1402**	235	292	926	**1453**
Polythene (sacks)	422	597	1067	**2086**	777	576	1384	**2737**	466	627	1430	**2523**	501	620	1519	**2640**
Plastic (sacks)	9	4	4	**18**	9	4	4	**17**	9	4	4	**18**	9	4	4	**18**
Food Waste (sacks)	40	0	0	**40**	39	0	0	**39**	40	0	0	**40**	40	0	0	**40**
TOTAL	**4788**	**3979**	**6026**	**14794**	**5272**	**4089**	**6217**	**15579**	**5033**	**4672**	**6424**	**16129**	**5087**	**4150**	**6646**	**15884**

	Sep				Oct				Nov				Dec			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
General Waste (sacks)	4089	2606	3810	**10504**	4101	2693	3357	**10150**	5451	3450	4230	**13131**	6718	4371	4778	**15868**
Mixed Paper (sacks)	99	477	1400	**1976**	102	493	827	**1421**	135	617	1452	**2204**	171	775	1625	**2570**
Cardboard (roll cages)	243	240	1462	**1944**	240	253	904	**1396**	313	305	1617	**2235**	393	371	1680	**2444**
Polythene (sacks)	770	606	1363	**2739**	428	627	1129	**2184**	637	943	2301	**3882**	694	1037	2542	**4273**
Plastic (sacks)	9	4	4	**17**	9	4	4	**18**	10	4	4	**18**	9	4	4	**18**
Food Waste (sacks)	39	0	0	**39**	40	0	0	**40**	39	0	0	**39**	40	0	0	**40**
TOTAL	**5249**	**3933**	**8039**	**17219**	**4920**	**4070**	**6221**	**15209**	**6585**	**5319**	**9604**	**21509**	**8025**	**6558**	**10629**	**25213**

D2-2: SEASONAL VARIATION OF WASTE PACKAGING VOLUME COLLECTED – CLASSIFICATION BY TYPE OF BUSINESS AND TYPE OF PACKAGING



* GW: General Waste, MP: Mixed Paper, Cb: Cardboard, Pth: Polythene, Pl: Plastic, FdW: Food Waste, S: sacks, RL: roll cages.

Figure D2-2: Seasonal variation in the volume (m³) of waste packaging items produced by *WestQuay* businesses.
(classification by type of economic activity and waste type)

Table D2-2: Seasonal variation in the waste volume (m³) produced by *WestQuay* businesses (classification by type of economic activity &waste type)

	Jan							Feb							Mar							Apr						
A: Surface (m²)	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total
Clothing	337	99	934	19	2	0	**1565**	302	85	799	13	1	0	**1319**	317	93	875	140	2	0	**1428**	366	150	1514	174	2	0	**2205**
Food	412	1	206	2	0	4	**624**	375	1	198	2	0	3	**579**	408	1	229	2	0	4	**643**	395	1	222	2	0	3	**623**
Books	22	7	151	5	0	0	**185**	20	6	136	5	0	0	**167**	22	7	73	5	0	0	**107**	21	7	71	4	0	0	**103**
Footwear	64	16	146	19	0	0	**245**	55	10	77	17	0	0	**159**	61	11	85	19	0	0	**176**	59	11	82	18	0	0	**171**
Vision	18	0	1	0	0	0	**20**	16	0	1	0	0	0	**18**	18	0	1	0	0	0	**20**	17	0	1	0	0	0	**19**
Electronics	52	1	73	6	0	0	**132**	46	1	62	5	0	0	**115**	51	1	68	6	0	0	**127**	50	1	66	6	0	0	**123**
Jewellery	15	7	38	6	0	0	**66**	13	7	34	5	0	0	**59**	14	7	38	6	0	0	**65**	14	7	36	6	0	0	**63**
Cosmetics	10	1	17	1	0	0	**29**	9	1	15	1	0	0	**26**	10	1	17	1	0	0	**29**	9	1	17	1	0	0	**28**
Games	7	4	24	9	0	0	**45**	6	4	22	8	0	0	**41**	6	3	19	11	0	0	**39**	6	3	19	8	0	0	**36**
Other	7	0	2	0	0	0	**9**	6	0	2	0	0	0	**8**	7	0	7	0	0	0	**14**	7	0	7	0	0	0	**14**
TOTAL	**943**	**137**	**1593**	**242**	**2**	**4**	**2920**	**849**	**114**	**1347**	**176**	**1**	**3**	**2491**	**915**	**125**	**1414**	**190**	**2**	**4**	**2648**	**945**	**180**	**2035**	**220**	**2**	**3**	**3385**

	May							Jun							Jul							Aug						
A: Surface (m²)	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total
Clothing	317	93	873	14	2	0	**1425**	315	90	894	16	2	0	**1469**	343	93	930	173	2	0	**1541**	322	99	931	184	2	0	**1536**
Food	394	1	200	2	0	4	**600**	392	1	208	2	0	3	**606**	405	1	215	2	0	4	**626**	405	1	215	2	0	4	**626**
Books	22	7	73	5	0	0	**107**	21	7	71	4	0	0	**103**	22	7	73	5	0	0	**107**	22	7	151	5	0	0	**185**
Footwear	61	11	85	19	0	0	**176**	84	11	94	51	0	0	**239**	81	16	149	20	0	0	**266**	64	16	146	19	0	0	**245**
Vision	18	0	1	0	0	0	**20**	17	0	1	0	0	0	**19**	18	0	1	0	0	0	**20**	18	0	1	0	0	0	**20**
Electronics	51	1	68	6	0	0	**127**	50	1	66	6	0	0	**123**	51	1	68	6	0	0	**127**	51	1	68	6	0	0	**127**
Jewellery	14	7	38	6	0	0	**65**	14	7	36	6	0	0	**63**	17	11	67	12	0	0	**107**	14	9	47	10	0	0	**81**
Cosmetics	10	1	17	1	0	0	**29**	9	1	17	1	0	0	**28**	10	1	17	1	0	0	**29**	10	1	17	1	0	0	**29**
Games	6	3	19	9	0	0	**37**	6	3	19	8	0	0	**36**	6	3	19	9	0	0	**37**	6	3	19	11	0	0	**39**
Other	7	0	8	0	0	0	**14**	7	0	2	0	0	0	**9**	7	0	2	0	0	0	**9**	7	0	2	0	0	0	**9**
TOTAL	**901**	**125**	**1383**	**188**	**2**	**4**	**2601**	**915**	**121**	**1408**	**246**	**2**	**3**	**2695**	**960**	**133**	**1543**	**227**	**2**	**4**	**2868**	**919**	**137**	**1599**	**238**	**2**	**4**	**2898**

	Sep							Oct							Nov							Dec						
A: Surface (m²)	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total	General Waste(S)	Mixed Paper(S)	Cardboard (RC)	Polythene (S)	Plastic (S)	Food (S)	Total
Clothing	361	144	1504	16	2	0	**2174**	317	93	875	14	2	0	**1427**	444	162	1720	286	2	0	**2614**	517	186	1802	319	2	0	**2826**
Food	389	1	201	2	0	3	**596**	402	1	208	2	0	4	**616**	528	1	250	3	0	3	**786**	675	1	323	3	0	4	**1006**
Books	21	8	184	8	0	0	**221**	26	9	205	11	0	0	**250**	25	8	198	10	0	0	**242**	26	9	205	11	0	0	**250**
Footwear	70	11	92	51	0	0	**223**	61	11	85	19	0	0	**176**	64	12	86	19	0	0	**181**	84	19	153	19	0	0	**275**
Vision	17	0	1	0	0	0	**19**	18	0	1	0	0	0	**20**	17	0	1	0	0	0	**19**	18	0	1	0	0	0	**20**
Electronics	50	1	75	8	0	0	**134**	51	1	78	8	0	0	**139**	55	1	75	8	0	0	**140**	61	1	85	6	0	0	**154**
Jewellery	14	7	36	6	0	0	**63**	14	7	38	6	0	0	**65**	22	9	57	8	0	0	**96**	20	9	49	10	0	0	**89**
Cosmetics	9	1	17	1	0	0	**28**	10	1	15	2	0	0	**27**	12	2	33	2	0	0	**49**	12	2	34	2	0	0	**50**
Games	7	4	26	9	0	0	**46**	7	4	24	9	0	0	**45**	7	4	31	13	0	0	**54**	7	4	34	13	0	0	**59**
Other	7	0	2	0	0	0	**9**	7	0	7	0	0	0	**14**	7	0	7	0	0	0	**14**	7	0	2	0	0	0	**9**
TOTAL	**945**	**178**	**2139**	**247**	**2**	**3**	**3514**	**914**	**128**	**1535**	**197**	**2**	**4**	**2779**	**1182**	**198**	**2458**	**349**	**2**	**3**	**4193**	**1428**	**231**	**2688**	**385**	**2**	**4**	**4737**

APPENDIX E: Greenhouse Gases (GHGs) Estimation

E1: Statistical Data Tables for Weekly Production of Greenhouse Gases - Scenario Analysis

E1-1: GREENHOUSE GASES PRODUCED DURING A STANDARD WEEK - CLASSIFICATION BY TYPE OF VEHICLE

Table E1.1: Greenhouse gases produced during a standard week by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	Standard Week – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	901.2	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	35.3%	34.8%	25%	27.7%	35.9%	28.3%	34.4%	6.98	2.85	0.76	1.59	22	159	156	112	**449**	132	954	936	672	**2694**	1689.0	1.1	16.8	1706.9	327.5	**2034.4**
	Via Nursling	4.9%	35.3%	34.8%	25%	27.7%	35.9%	28.3%	34.4%	6.98	2.85	0.76	1.59	22	159	156	112	**449**	132	954	936	672	**2694**	1863.7	1.2	18.6	1883.6	361.4	**2244.9**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				59.6				**59.6**	358				**358**	333.0	0.4	3.7	337.1	64.7	**401.7**
		100%				60%			60%	12.59				71.6				**71.6**	429				**429**	416.1	0.5	4.3	420.9	80.8	**501.7**
		100%				100%			100%	25.18				35.8				**35.8**	215				**215**	249.8	0.2	2.2	252.2	48.4	**300.6**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			42.3	63.5			**105.8**	254	381			**635**	528.4	0.4	5.6	534.4	102.5	**636.9**
		40%	60%			60%	52%		60%	12.59	3.97			48.6	72.9			**121.5**	292	437			**729**	645.2	0.5	6.7	652.4	125.2	**777.6**
		40%	60%			100%	100%		100%	25.18	7.94			24.3	36.5			**60.8**	146	219			**365**	358.4	0.2	3.2	361.8	69.4	**431.2**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		38.0	76.0	12.7		**126.6**	228	456	76		**760**	580.8	0.4	6.0	587.3	112.7	**699.9**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		43.1	86.3	14.4		**143.8**	259	518	86		**863**	701.7	0.5	7.2	709.4	136.1	**845.5**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		21.8	43.5	7.3		**72.5**	131	261	44		**435**	388.1	0.3	3.4	391.8	75.2	**467.0**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				218.4			**218.4**		1310			**1310**	1005.2	0.5	10.2	1016.0	194.9	**1210.9**
			100%				52%				3.97				227.1			**227.1**		1363			**1363**	1129.8	0.6	11.7	1142.1	219.1	**1361.2**
			100%				100%				7.94				113.6			**113.6**		681			**681**	588.1	0.3	5.3	593.6	113.9	**707.5**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			212.2	23.6		**235.8**		1273	141		**1415**	1012.1	0.5	10.2	1022.8	196.2	**1219.0**
			90%	10%			52%	40.3%			3.97	1.08			220.4	24.5		**244.9**		1323	147		**1470**	1133.3	0.6	11.6	1145.5	219.8	**1365.3**
			90%	10%			100%	40.3%			7.94	1.08			111.9	12.4		**124.3**		671	75		**746**	597.9	0.3	5.4	603.6	115.8	**719.3**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			156.7	235.0		**391.7**		940	1410		**2350**	1073.9	0.5	9.7	1084.1	208.0	**1292.1**
			40%	60%			52%	40.3%			3.97	1.08			161.1	241.7		**402.8**		967	1450		**2417**	1164.3	0.5	10.8	1175.6	225.5	**1401.1**
			40%	60%			100%	40.3%			7.94	1.08			94.3	141.4		**235.6**		566	848		**1414**	700.3	0.3	5.8	706.4	135.5	**842.0**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				831.7		**831.7**			4990		**4990**	1248.4	0.4	8.5	1257.2	241.2	**1498.4**

E1-2: GREENHOUSE GASES PRODUCED DURING A BUSY WEEK - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.1: Greenhouse gases produced during a busy week by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	Busy Week – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	3916.8																							Direct				Indirect	Grand
Last mile (kms)	6	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	6.0%	35.6%	32.9%	25.5%	146.3%	99.3%	85.5%	171.7%	36.84	7.88	2.30	7.93	30.0	179.4	165.9	128.2	**503.5**	180	1076	995	769	**3021**	2106.3	1.4	21.1	2128.8	408.4	**2537.3**
	Via Nursling	6.0%	35.6%	32.9%	25.5%	146.3%	99.3%	85.5%	171.7%	36.84	7.88	2.30	7.93	30.0	179.4	165.9	128.2	**503.5**	180	1076	995	769	**3021**	2138.1	1.4	21.4	2161.0	414.6	**2575.6**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				259.2				**259.2**	1555				**1555**	1447.5	1.7	15.9	1465.0	281.1	**1746.1**
		100%				60%			60%	12.59				311.1				**311.1**	1867				**1867**	1808.7	2.0	18.8	1829.5	351.0	**2180.5**
		100%				100%			100%	25.18				155.5				**155.5**	933				**933**	1085.6	1.0	9.5	1096.1	210.3	**1306.4**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			183.9	275.9			**459.8**	1103	1655			**2759**	2296.5	1.9	24.1	2322.5	445.6	**2768.1**
		40%	60%			60%	52%		60%	12.59	3.97			211.2	316.9			**528.1**	1267	1901			**3169**	2804.2	2.2	29.1	2835.6	544.0	**3379.6**
		40%	60%			100%	100%		100%	25.18	7.94			105.6	158.4			**264.0**	634	951			**1584**	1557.5	1.1	13.9	1572.4	301.7	**1874.1**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		165.1	330.2	55.0		**550.4**	991	1981	330		**3302**	2524.4	1.9	26.1	2552.4	489.7	**3042.1**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		187.5	375.0	62.5		**625.1**	1125	2250	375		**3750**	3049.6	2.2	31.3	3083.2	591.5	**3674.7**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		94.6	189.2	31.5		**315.3**	567	1135	189		**1892**	1686.9	1.1	14.9	1702.9	326.7	**2029.6**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				949.2			**949.2**		5695			**5695**	4369.0	2.3	44.4	4415.6	847.1	**5262.7**
			100%				52%				3.97				987.2			**987.2**		5923			**5923**	4910.3	2.6	51.0	4963.9	952.3	**5916.2**
			100%				100%				7.94				493.6			**493.6**		2961			**2961**	2555.8	1.2	23.1	2580.1	495.0	**3075.1**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			922.3	102.5		**1024.8**		5534	615		**6149**	4398.9	2.2	44.1	4445.3	852.8	**5298.2**
			90%	10%			52%	40.3%			3.97	1.08			958.1	106.5		**1064.5**		5749	639		**6387**	4925.5	2.6	50.6	4978.6	955.2	**5933.8**
			90%	10%			100%	40.3%			7.94	1.08			486.2	54.0		**540.2**		2917	324		**3241**	2598.7	1.2	23.3	2623.2	503.2	**3126.4**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			681.0	1021.5		**1702.4**		4086	6129		**10215**	4667.6	2.1	42.2	4711.9	904.0	**5615.9**
			40%	60%			52%	40.3%			3.97	1.08			700.3	1050.5		**1750.8**		4202	6303		**10505**	5060.1	2.3	46.9	5109.3	980.2	**6089.5**
			40%	60%			100%	40.3%			7.94	1.08			409.7	614.5		**1024.2**		2458	3687		**6145**	3043.7	1.3	25.4	3070.4	589.0	**3659.4**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				3614.9		**3614.9**			21690		**21690**	5425.9	1.6	36.7	5464.2	1048.3	**6512.5**

E2: Statistical Data Tables for Monthly Production of Greenhouse Gases - Scenario Analysis

E2-1: GREENHOUSE GASES PRODUCED IN JANUARY - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.1: Greenhouse gases produced in January by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	January – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	5557.9	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	36.0%	34.4%	24.7%	53.7%	49.6%	31.8%	34.9%	13.52	3.94	0.86	1.61	97	724	690	497	**2009**	585	4342	4143	2982	**12051**						**11361.7**
	Via Nursling	4.9%	36.0%	34.4%	24.7%	53.7%	49.6%	31.8%	34.9%	13.52	3.94	0.86	1.61	97	724	690	497	**2009**	585	4342	4143	2982	**12051**						**11533.4**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				367.9				**367.9**	2207				**2207**	2053.9	2.4	22.5	2078.8	398.8	**2477.7**
		100%				60%			60%	12.59				441.4				**441.4**	2649				**2649**	2566.5	2.9	26.7	2596.0	498.0	**3094.0**
		100%				100%			100%	25.18				220.7				**220.7**	1324				**1324**	1540.4	1.4	13.5	1555.4	298.4	**1853.8**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			261.0	391.4			**652.4**	1566	2349			**3914**	3258.7	2.6	34.3	3295.6	632.3	**3927.8**
		40%	60%			60%	52%		60%	12.59	3.97			299.7	449.6			**749.3**	1798	2698			**4496**	3979.1	3.1	41.3	4023.6	771.9	**4795.5**
		40%	60%			100%	100%		100%	25.18	7.94			149.9	224.8			**374.7**	899	1349			**2248**	2210.1	1.5	19.7	2231.3	428.1	**2659.3**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		234.3	468.6	78.1		**780.9**	1406	2811	469		**4686**	3582.0	2.7	37.0	3621.8	694.8	**4316.6**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		266.1	532.2	88.7		**887.0**	1597	3193	532		**5322**	4327.3	3.2	44.5	4374.9	839.3	**5214.3**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		134.2	268.4	44.7		**447.3**	805	1610	268		**2684**	2393.6	1.5	21.2	2416.4	463.6	**2880.0**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				1346.9			**1346.9**		8081			**8081**	6199.4	3.2	63.0	6265.6	1202.1	**7467.7**
			100%				52%				3.97				1400.7			**1400.7**		8404			**8404**	6967.5	3.7	72.4	7043.6	1351.4	**8395.0**
			100%				100%				7.94				700.4			**700.4**		4202			**4202**	3626.6	1.7	32.7	3661.1	702.4	**4363.4**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1308.7	145.4		**1454.1**		7852	872		**8725**	6241.9	3.2	62.6	6307.8	1210.2	**7517.9**
			90%	10%			52%	40.3%			3.97	1.08			1359.5	151.1		**1510.5**		8157	906		**9063**	6989.1	3.7	71.8	7064.5	1355.4	**8419.9**
			90%	10%			100%	40.3%			7.94	1.08			689.9	76.7		**766.6**		4139	460		**4599**	3687.5	1.7	33.0	3722.2	714.1	**4436.3**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			966.3	1449.4		**2415.7**		5798	8697		**14494**	6623.2	3.0	59.9	6686.0	1282.7	**7968.8**
			40%	60%			52%	40.3%			3.97	1.08			993.7	1490.6		**2484.3**		5962	8943		**14906**	7180.1	3.3	66.5	7249.9	1390.9	**8640.8**
			40%	60%			100%	40.3%			7.94	1.08			581.3	872.0		**1453.3**		3488	5232		**8720**	4318.9	1.8	36.0	4356.8	835.8	**5192.6**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				51295		**51295**			30777		**30777**	7699.2	2.3	52.1	7753.6	1487.4	**9241.0**

E2-2: GREENHOUSE GASES PRODUCED IN FEBRUARY - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.2: Greenhouse gases produced in February by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	February – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	4240.4	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.8%	35.8%	34.8%	24.6%	27.7%	41.4%	44.9%	34.4%	6.98	3.28	1.21	1.59	88	654	636	449	**1826**	528	3922	3814	2694	**10957**						**10337.8**
	Via Nursling	4.8%	35.8%	34.8%	24.6%	27.7%	41.4%	44.9%	34.4%	6.98	3.28	1.21	1.59	88	654	636	449	**1826**	528	3922	3814	2694	**10957**						**10493.9**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				280.7				**280.7**	1684				**1684**	1567.0	1.8	17.2	1586.0	304.3	**1890.3**
		100%				60%			60%	12.59				336.8				**336.8**	2021				**2021**	1958.1	2.2	20.3	1980.6	380.0	**2360.6**
		100%				100%			100%	25.18				168.4				**168.4**	1010				**1010**	1175.3	1.1	10.3	1186.7	227.7	**1414.3**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			199.1	298.6			**497.7**	1195	1792			**2986**	2486.2	2.0	26.1	2514.4	482.4	**2996.7**
		40%	60%			60%	52%		60%	12.59	3.97			228.7	343.0			**571.7**	1372	2058			**3430**	3035.9	2.4	31.5	3069.8	588.9	**3658.7**
		40%	60%			100%	100%		100%	25.18	7.94			114.3	171.5			**285.9**	686	1029			**1715**	1686.2	1.2	15.0	1702.3	326.6	**2028.9**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		178.7	357.5	59.6		**595.8**	1072	2145	357		**3575**	2732.9	2.1	28.3	2763.2	530.1	**3293.3**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		203.0	406.0	67.7		**676.7**	1218	2436	406		**4060**	3301.5	2.4	33.9	3337.8	640.4	**3978.2**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		102.4	204.8	34.1		**341.3**	614	1229	205		**2048**	1826.2	1.2	16.2	1843.6	353.7	**2197.3**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				1027.6			**1027.6**		6166			**6166**	4729.8	2.5	48.0	4780.3	917.1	**5697.4**
			100%				52%				3.97				1068.7			**1068.7**		6412			**6412**	5315.9	2.8	55.2	5373.9	1031.0	**6404.9**
			100%				100%				7.94				534.3			**534.3**		3206			**3206**	2766.9	1.3	25.0	2793.2	535.9	**3329.1**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			998.5	110.9		**1109.4**		5991	666		**6656**	4762.3	2.4	47.8	4812.5	923.3	**5735.8**
			90%	10%			52%	40.3%			3.97	1.08			1037.2	115.2		**1152.5**		6223	691		**6915**	5332.3	2.8	54.8	5389.9	1034.1	**6423.9**
			90%	10%			100%	40.3%			7.94	1.08			526.4	58.5		**584.8**		3158	351		**3509**	2813.4	1.3	25.2	2839.9	544.8	**3384.7**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			737.2	1105.8		**1843.1**		4423	6635		**11058**	5053.2	2.3	45.7	5101.1	978.6	**6079.8**
			40%	60%			52%	40.3%			3.97	1.08			758.1	1137.2		**1895.4**		4549	6823		**11372**	5478.1	2.5	50.7	5531.3	1061.2	**6592.5**
			40%	60%			100%	40.3%			7.94	1.08			443.5	665.3		**1108.8**		2661	3992		**6653**	3295.1	1.4	27.5	3324.0	637.7	**3961.7**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				3913.5		**3913.5**			23481		**23481**	5874.1	1.7	39.8	5915.6	1134.8	**7050.4**

E2-3: GREENHOUSE GASES PRODUCED IN MARCH - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.3: Greenhouse gases produced in March by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	March – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	4770	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	35.4%	34.6%	25.1%	27.7%	41.1%	29.1%	53.9%	6.98	3.26	0.78	2.49	97	706	690	501	**1995**	585	4236	4143	3009	**11972**						**11418.8**
	Via Nursling	4.9%	35.4%	34.6%	25.1%	27.7%	41.1%	29.1%	53.9%	6.98	3.26	0.78	2.49	97	706	690	501	**1995**	585	4236	4143	3009	**11972**						**11591.3**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				315.7				**315.7**	1894				**1894**	1762.7	2.1	19.3	1784.1	342.3	**2126.4**
		100%				60%			60%	12.59				378.9				**378.9**	2273				**2273**	2202.6	2.5	22.9	2228.0	427.4	**2655.4**
		100%				100%			100%	25.18				189.4				**189.4**	1137				**1137**	1322.1	1.2	11.6	1334.9	256.1	**1591.0**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			224.0	335.9			**559.9**	1344	2016			**3359**	2796.7	2.3	29.4	2828.4	542.6	**3371.0**
		40%	60%			60%	52%		60%	12.59	3.97			257.2	385.9			**643.1**	1543	2315			**3859**	3415.1	2.7	35.5	3453.2	662.5	**4115.7**
		40%	60%			100%	100%		100%	25.18	7.94			128.6	192.9			**321.6**	772	1158			**1929**	1896.8	1.3	16.9	1915.0	367.4	**2282.3**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		201.1	402.1	67.0		**670.2**	1206	2413	402		**4021**	3074.3	2.3	31.8	3108.4	596.3	**3704.7**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		228.4	456.7	76.1		**761.2**	1370	2740	457		**4567**	3713.9	2.7	38.2	3754.8	720.4	**4475.1**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		115.2	230.4	38.4		**383.9**	691	1382	230		**2304**	2054.3	1.3	18.2	2073.9	397.9	**2471.7**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				1155.9			**1155.9**		6936			**6936**	5320.6	2.8	54.0	5377.4	1031.7	**6409.1**
			100%				52%				3.97				1202.2			**1202.2**		7213			**7213**	5979.9	3.2	62.1	6045.1	1159.8	**7204.9**
			100%				100%				7.94				601.1			**601.1**		3607			**3607**	3112.6	1.4	28.1	3142.1	602.8	**3744.9**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1123.2	124.8		**1248.0**		6739	749		**7488**	5357.1	2.7	53.8	5413.6	1038.6	**6452.2**
			90%	10%			52%	40.3%			3.97	1.08			1166.8	129.6		**1296.4**		7001	778		**7779**	5998.3	3.1	61.6	6063.1	1163.2	**7226.3**
			90%	10%			100%	40.3%			7.94	1.08			592.1	65.8		**657.9**		3553	395		**3947**	3164.8	1.4	28.3	3194.6	612.9	**3807.4**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			829.3	1244.0		**2073.3**		4976	7464		**12440**	5684.3	2.5	51.4	5738.3	1100.9	**6839.1**
			40%	60%			52%	40.3%			3.97	1.08			852.8	1279.3		**2132.1**		5117	7676		**12793**	6162.3	2.8	57.1	6222.2	1193.7	**7415.9**
			40%	60%			100%	40.3%			7.94	1.08			498.9	748.4		**1247.3**		2993	4490		**7484**	3706.7	1.5	30.9	3739.2	717.3	**4456.5**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				4402.4		**4402.4**			26414		**26414**	6607.8	2.0	44.7	6654.5	1276.6	**7931.1**

E2-4: GREENHOUSE GASES PRODUCED IN APRIL - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.4: Greenhouse gases produced in April by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	April – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	5132.1	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	35.5%	34.5%	25.1%	43.7%	43.2%	29.5%	53.9%	11.01	3.43	0.79	2.49	94	687	668	485	**1935**	566	4125	4009	2912	**11611**						**11058.1**
	Via Nursling	4.9%	35.5%	34.5%	25.1%	43.7%	43.2%	29.5%	53.9%	11.01	3.43	0.79	2.49	94	687	668	485	**1935**	566	4125	4009	2912	**11611**						**11225.1**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				339.7				**339.7**	2038				**2038**	1896.5	2.2	20.8	1919.6	368.3	**2287.8**
		100%				60%			60%	12.59				407.6				**407.6**	2446				**2446**	2369.8	2.6	24.6	2397.1	459.9	**2857.0**
		100%				100%			100%	25.18				203.8				**203.8**	1223				**1223**	1422.4	1.3	12.5	1436.2	275.5	**1711.8**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			241.0	361.4			**602.4**	1446	2169			**3614**	3009.0	2.4	31.6	3043.1	583.8	**3626.9**
		40%	60%			60%	52%		60%	12.59	3.97			276.8	415.2			**691.9**	1661	2491			**4152**	3674.3	2.9	38.2	3715.3	712.8	**4428.1**
		40%	60%			100%	100%		100%	25.18	7.94			138.4	207.6			**346.0**	830	1245			**2076**	2040.7	1.4	18.2	2060.3	395.3	**2455.6**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		216.3	432.7	72.1		**721.1**	1298	2596	433		**4327**	3307.6	2.5	34.2	3344.3	641.6	**3985.9**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		245.7	491.4	81.9		**819.0**	1474	2948	491		**4914**	3995.8	2.9	41.1	4039.8	775.0	**4814.8**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		123.9	247.8	41.3		**413.1**	744	1487	248		**2478**	2210.3	1.4	19.6	2231.3	428.1	**2659.3**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				1243.7			**1243.7**		7462			**7462**	5724.5	3.0	58.1	5785.6	1110.0	**6895.6**
			100%				52%				3.97				1293.4			**1293.4**		7761			**7761**	6433.8	3.4	66.8	6504.0	1247.8	**7751.8**
			100%				100%				7.94				646.7			**646.7**		3880			**3880**	3348.8	1.5	30.2	3380.6	648.6	**4029.1**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1208.4	134.3		**1342.7**		7251	806		**8056**	5763.7	2.9	57.8	5824.5	1117.5	**6942.0**
			90%	10%			52%	40.3%			3.97	1.08			1255.3	139.5		**1394.8**		7532	837		**8369**	6453.6	3.4	66.3	6523.3	1251.5	**7774.8**
			90%	10%			100%	40.3%			7.94	1.08			637.1	70.8		**707.8**		3822	425		**4247**	3405.0	1.6	30.5	3437.1	659.4	**4096.4**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			892.3	1338.4		**2230.6**		5354	8030		**13384**	6115.8	2.7	55.3	6173.8	1184.4	**7358.3**
			40%	60%			52%	40.3%			3.97	1.08			917.6	1376.4		**2293.9**		5505	8258		**13764**	6630.1	3.0	61.4	6694.5	1284.3	**7978.8**
			40%	60%			100%	40.3%			7.94	1.08			536.8	805.2		**1341.9**		3221	4831		**8052**	3988.1	1.6	33.3	4023.0	771.8	**4794.8**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				4736.5		**4736.5**			28419		**28419**	7109.3	2.1	48.1	7159.6	1373.5	**8533.1**

E2-5: GREENHOUSE GASES PRODUCED IN MAY - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.5: Greenhouse gases produced in May by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	May – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	4082.5	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	35.3%	34.8%	25.0%	27.7%	37.5%	28.2%	34.4%	6.98	2.98	0.76	1.59	97	702	690	497	**1986**	585	4209	4143	2982	**11919**						**11428.5**
	Via Nursling	4.9%	35.3%	34.8%	25.0%	27.7%	37.5%	28.2%	34.4%	6.98	2.98	0.76	1.59	97	702	690	497	**1986**	585	4209	4143	2982	**11919**						**11601.2**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				270.2				**270.2**	1621				**1621**	1508.7	1.8	16.5	1527.0	293.0	**1819.9**
		100%				60%			60%	12.59				324.2				**324.2**	1945				**1945**	1885.2	2.1	19.6	1906.9	365.8	**2272.7**
		100%				100%			100%	25.18				162.1				**162.1**	973				**973**	1131.5	1.1	9.9	1142.5	219.2	**1361.7**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			191.7	287.5			**479.2**	1150	1725			**2875**	2393.6	1.9	25.2	2420.7	464.4	**2885.2**
		40%	60%			60%	52%		60%	12.59	3.97			220.2	330.3			**550.4**	1321	1982			**3303**	2922.8	2.3	30.4	2955.5	567.0	**3522.5**
		40%	60%			100%	100%		100%	25.18	7.94			110.1	165.1			**275.2**	661	991			**1651**	1623.4	1.1	14.5	1639.0	314.4	**1953.4**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		172.1	344.2	57.4		**573.6**	1033	2065	344		**3442**	2631.2	2.0	27.2	2660.3	510.4	**3170.7**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		195.5	390.9	65.2		**651.5**	1173	2345	391		**3909**	3178.6	2.3	32.7	3213.6	616.5	**3830.1**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		98.6	197.2	32.9		**328.6**	591	1183	197		**1972**	1758.2	1.1	15.6	1775.0	340.5	**2115.5**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				989.3			**989.3**		5936			**5936**	4553.7	2.4	46.2	4602.4	883.0	**5485.3**
			100%				52%				3.97				1028.9			**1028.9**		6173			**6173**	5118.0	2.7	53.2	5173.8	992.6	**6166.5**
			100%				100%				7.94				514.5			**514.5**		3087			**3087**	2663.9	1.2	24.0	2689.2	515.9	**3205.1**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			961.3	106.8		**1068.1**		5768	641		**6409**	4585.0	2.3	46.0	4633.3	888.9	**5522.3**
			90%	10%			52%	40.3%			3.97	1.08			998.6	111.0		**1109.6**		5992	666		**6657**	5133.8	2.7	52.7	5189.2	995.6	**6184.8**
			90%	10%			100%	40.3%			7.94	1.08			506.8	56.3		**563.1**		3041	338		**3378**	2708.6	1.2	24.3	2734.1	524.5	**3258.7**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			709.8	1064.7		**1774.5**		4259	6388		**10647**	4865.0	2.2	44.0	4911.2	942.2	**5853.4**
			40%	60%			52%	40.3%			3.97	1.08			729.9	1094.9		**1824.8**		4380	6569		**10949**	5274.1	2.4	48.8	5325.4	1021.7	**6347.1**
			40%	60%			100%	40.3%			7.94	1.08			427.0	640.5		**1067.5**		2562	3843		**6405**	3172.5	1.3	26.5	3200.2	613.9	**3814.2**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				376 7.8		**3767.8**			22607		**22607**	5655.4	1.7	38.3	5695.4	1092.6	**6787.9**

E2-6: GREENHOUSE GASES PRODUCED IN JUNE - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.6: Greenhouse gases produced in June by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	June – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	5392.5	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	35.4%	35.0%	24.7%	27.7%	55.2%	40.9%	43.8%	6.98	4.38	1.10	2.02	94	687	681	481	**1944**	566	4125	4086	2886	**11663**						**11040.8**
	Via Nursling	4.9%	35.4%	35.0%	24.7%	27.7%	55.2%	40.9%	43.8%	6.98	4.38	1.10	2.02	94	687	681	481	**1944**	566	4125	4086	2886	**11663**						**11207.6**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				356.9				**356.9**	2141				**2141**	1992.8	2.3	21.8	2017.0	387.0	**2403.9**
		100%				60%			60%	12.59				428.3				**428.3**	2570				**2570**	2490.1	2.8	25.9	2518.8	483.2	**3002.0**
		100%				100%			100%	25.18				214.1				**214.1**	1285				**1285**	1494.6	1.4	13.1	1509.1	289.5	**1798.6**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			253.2	379.8			**633.0**	1519	2279			**3798**	3161.7	2.6	33.2	3197.5	613.5	**3811.0**
		40%	60%			60%	52%		60%	12.59	3.97			290.8	436.2			**727.1**	1745	2617			**4362**	3860.7	3.0	40.1	3903.9	749.0	**4652.8**
		40%	60%			100%	100%		100%	25.18	7.94			145.4	218.1			**363.5**	872	1309			**2181**	2144.3	1.5	19.1	2164.9	415.3	**2580.2**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		227.3	454.6	75.8		**757.7**	1364	2728	455		**4546**	3475.5	2.6	35.9	3514.0	674.2	**4188.2**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		258.2	516.3	86.1		**860.6**	1549	3098	516		**5163**	4198.5	3.1	43.1	4244.8	814.4	**5059.1**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		130.2	260.4	43.4		**434.0**	781	1563	260		**2604**	2322.4	1.5	20.6	2344.5	449.8	**2794.3**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				1306.8			**1306.8**		7841			**7841**	6015.0	3.1	61.1	6079.2	1166.3	**7245.5**
			100%				52%				3.97				1359.1			**1359.1**		8154			**8154**	6760.3	3.6	70.2	6834.1	1311.2	**8145.2**
			100%				100%				7.94				679.5			**679.5**		4077			**4077**	3518.8	1.6	31.8	3552.1	681.5	**4233.6**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1269.8	141.1		**1410.8**		7619	847		**8465**	6056.2	3.1	60.8	6120.1	1174.2	**7294.3**
			90%	10%			52%	40.3%			3.97	1.08			1319.0	146.6		**1465.6**		7914	879		**8794**	6781.2	3.5	69.6	6854.3	1315.0	**8169.4**
			90%	10%			100%	40.3%			7.94	1.08			669.4	74.4		**743.8**		4016	446		**4463**	3577.8	1.6	32.0	3611.5	692.8	**4304.3**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			937.5	1406.3		**2343.8**		5625	8438		**14063**	6426.2	2.9	58.1	6487.1	1244.6	**7731.7**
			40%	60%			52%	40.3%			3.97	1.08			964.1	1446.2		**2410.4**		5785	8677		**14462**	6966.5	3.2	64.5	7034.2	1349.5	**8383.8**
			40%	60%			100%	40.3%			7.94	1.08			564.0	846.0		**1410.1**		3384	5076		**8460**	4190.5	1.7	35.0	4227.1	811.0	**5038.1**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				4976.9		**4976.9**			29861		**29861**	7470.1	2.2	50.6	7522.9	1443.2	**8966.1**

E2-7: GREENHOUSE GASES PRODUCED IN JULY - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.7: Greenhouse gases produced in July by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	July – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissons Produced (kg CO2e)					
Volume Carried (m^3)	5731.4	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	36.0%	34.4%	24.7%	27.7%	57.6%	39.1%	44.3%	6.98	4.57	1.05	2.05	97	724	690	497	**2009**	585	4342	4143	2982	**12051**						**11415.8**
	Via Nursling	4.9%	36.0%	34.4%	24.7%	27.7%	57.6%	39.1%	44.3%	6.98	4.57	1.05	2.05	97	724	690	497	**2009**	585	4342	4143	2982	**12051**						**11588.2**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				379.3				**379.3**	2276				**2276**	2464.7	2.9	27.0	2494.6	478.6	**2973.2**
		100%				60%			60%	12.59				455.2				**455.2**	2731				**2731**	1283.2	1.4	13.3	1298.0	249.0	**1547.0**
		100%				100%			100%	25.18				227.6				**227.6**	1366				**1366**	1821.2	1.7	16.0	1838.9	352.8	**2191.7**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			269.1	403.6			**672.7**	1615	2422			**4036**	3743.0	3.0	39.4	3785.4	726.3	**4511.7**
		40%	60%			60%	52%		60%	12.59	3.97			309.1	463.6			**772.7**	1855	2782			**4636**	1989.6	1.6	20.7	2011.8	386.0	**2397.8**
		40%	60%			100%	100%		100%	25.18	7.94			154.5	231.8			**386.4**	927	1391			**2318**	4061.4	2.7	36.2	4100.3	786.6	**4887.0**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		241.6	483.2	80.5		**805.3**	1450	2899	483		**4832**	4068.3	3.1	42.1	4113.4	789.2	**4902.6**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		274.4	548.8	91.5		**914.6**	1646	3293	549		**5488**	2182.5	1.6	22.4	2206.5	423.3	**2629.9**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		138.4	276.8	46.1		**461.3**	830	1661	277		**2768**	6974.3	3.2	63.0	7040.5	1350.7	**8391.2**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				1388.9			**1388.9**		8333			**8333**	6447.4	3.3	65.5	6516.2	1250.2	**7766.4**
			100%				52%				3.97				1444.5			**1444.5**		8667			**8667**	3483.8	1.8	36.2	3521.8	675.7	**4197.5**
			100%				100%				7.94				722.2			**722.2**		4333			**4333**	6776.6	3.1	61.2	6840.9	1312.4	**8153.3**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1349.5	149.9		**1499.5**		8097	900		**8997**	6484.3	3.3	65.1	6552.6	1257.1	**7809.8**
			90%	10%			52%	40.3%			3.97	1.08			1401.9	155.8		**1557.7**		8412	935		**9346**	3546.8	1.9	36.4	3585.0	687.8	**4272.8**
			90%	10%			100%	40.3%			7.94	1.08			711.4	79.0		**790.5**		4269	474		**4743**	7179.1	3.0	59.9	7242.0	1389.3	**8631.3**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			996.5	1494.7		**2491.1**		5979	8968		**14947**	6811.1	3.0	61.6	6875.8	1319.1	**8194.9**
			40%	60%			52%	40.3%			3.97	1.08			1024.7	1537.1		**2561.8**		6148	9223		**15371**	4200.4	1.9	38.9	4241.2	813.7	**5054.8**
			40%	60%			100%	40.3%			7.94	1.08			599.5	899.2		**1498.7**		3597	5395		**8992**	7699.2	2.3	52.1	7753.6	1487.4	**9241.0**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				5289.6		**5289.6**			31738		**31738**	7939.5	2.4	53.8	7995.6	1533.9	**9529.5**

E2-8: GREENHOUSE GASES PRODUCED IN AUGUST - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.8: Greenhouse gases produced in August by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	August – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	5119.3	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.9%	35.5%	34.7%	25.0%	53.7%	43.2%	31.3%	34.9%	13.52	3.43	0.84	1.61	97	706	690	497	**1991**	585	4236	4143	2982	**11945**						**11436.4**
	Via Nursing	4.9%	35.5%	34.7%	25.0%	53.7%	43.2%	31.3%	34.9%	13.52	3.43	0.84	1.61	97	706	690	497	**1991**	585	4236	4143	2982	**11945**						**11609.2**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				338.8				**338.8**	2033				**2033**	1880.4	2.2	20.6	1903.2	365.1	**2268.4**
		100%				60%			60%	12.59				406.6				**406.6**	2440				**2440**	979.0	1.1	10.2	990.3	190.0	**1180.3**
		100%				100%			100%	25.18				203.3				**203.3**	1220				**1220**	1389.5	1.3	12.2	1403.0	269.2	**1672.2**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			240.4	360.5			**600.9**	1442	2163			**3605**	2855.8	2.3	30.0	2888.1	554.1	**3442.2**
		40%	60%			60%	52%		60%	12.59	3.97			276.1	414.1			**690.2**	1657	2485			**4141**	1517.9	1.2	15.8	1534.9	294.5	**1829.4**
		40%	60%			100%	100%		100%	25.18	7.94			138.0	207.1			**345.1**	828	1242			**2071**	3098.7	2.0	27.6	3128.3	600.2	**3728.5**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		215.8	431.6	71.9		**719.3**	1295	2590	432		**4316**	3103.9	2.3	32.1	3138.3	602.1	**3740.4**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		245.1	490.2	81.7		**817.0**	1471	2941	490		**4902**	1665.1	1.2	17.1	1683.5	323.0	**2006.5**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		123.6	247.2	41.2		**412.0**	742	1483	247		**2472**	5321.1	2.5	48.0	5371.5	1030.5	**6402.0**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				1240.6			**1240.6**		7444			**7444**	4919.0	2.6	50.0	4971.5	953.8	**5925.3**
			100%				52%				3.97				1290.2			**1290.2**		7741			**7741**	2657.9	1.4	27.6	2687.0	515.5	**3202.5**
			100%				100%				7.94				645.1			**645.1**		3871			**3871**	5170.2	2.4	46.7	5219.3	1001.3	**6220.6**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1205.4	133.9		**1339.4**		7233	804		**8036**	4947.2	2.5	49.7	4999.3	959.1	**5958.5**
			90%	10%			52%	40.3%			3.97	1.08			1252.2	139.1		**1391.4**		7513	835		**8348**	2706.0	1.4	27.8	2735.2	524.8	**3260.0**
			90%	10%			100%	40.3%			7.94	1.08			635.5	70.6		**706.1**		3813	424		**4236**	5477.3	2.3	45.7	5525.3	1060.0	**6585.3**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			890.0	1335.1		**2225.1**		5340	8010		**13351**	5196.6	2.3	47.0	5245.9	1006.4	**6252.3**
			40%	60%			52%	40.3%			3.97	1.08			915.3	1373.0		**2288.3**		5492	8238		**13730**	3204.7	1.5	29.7	3235.8	620.8	**3856.6**
			40%	60%			100%	40.3%			7.94	1.08			535.4	803.2		**1338.6**		3213	4819		**8032**	5874.1	1.7	39.8	5915.6	1134.8	**7050.4**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				4724.8		**4724.8**			28349		**28349**	7091.7	2.1	48.0	7141.8	1370.1	**8511.9**

E2-9: GREENHOUSE GASES PRODUCED IN SEPTEMBER - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.9: Greenhouse gases produced in September by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	September – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	8447.7	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	6.3%	34.8%	34.0%	24.9%	144.7%	40.8%	39.1%	44.3%	36.44	3.24	0.89	2.26	124	683	668	490	**1965**	746	4099	4009	2937	**11791**						**10922.5**
	Via Nursling	6.3%	34.8%	34.0%	24.9%	144.7%	40.8%	39.1%	44.3%	36.44	3.24	0.89	2.26	124	683	668	490	**1965**	746	4099	4009	2937	**11791**						**11087.5**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				559.1				**559.1**	3355				**3355**	2115.3	2.5	23.2	2141.0	410.8	**2551.7**
		100%				60%			60%	12.59				671.0				**671.0**	4026				**4026**	1101.3	1.2	11.4	1114.0	213.7	**1327.7**
		100%				100%			100%	25.18				335.5				**335.5**	2013				**2013**	1563.1	1.5	13.7	1578.2	302.8	**1881.0**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			396.6	594.9			**991.6**	2380	3570			**5949**	3212.4	2.6	33.8	3248.8	623.3	**3872.1**
		40%	60%			60%	52%		60%	12.59	3.97			455.6	683.4			**1139.0**	2734	4100			**6834**	1707.5	1.3	17.7	1726.6	331.3	**2057.9**
		40%	60%			100%	100%		100%	25.18	7.94			227.8	341.7			**569.5**	1367	2050			**3417**	3485.7	2.3	31.1	3519.1	675.1	**4194.2**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		356.1	712.2	118.7		**1187.0**	2137	4273	712		**7122**	3491.6	2.6	36.1	3530.3	677.3	**4207.6**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		404.4	808.9	134.8		**1348.1**	2427	4853	809		**8089**	1873.1	1.4	19.2	1893.7	363.3	**2257.1**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		204.0	408.0	68.0		**679.9**	1224	2448	408		**4080**	5985.7	2.8	54.0	6042.5	1159.2	**7201.7**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				2047.2			**2047.2**		12283			**12283**	5533.4	2.9	56.2	5592.5	1072.9	**6665.4**
			100%				52%				3.97				2129.1			**2129.1**		12774			**12774**	2989.9	1.6	31.1	3022.6	579.9	**3602.5**
			100%				100%				7.94				1064.5			**1064.5**		6387			**6387**	5816.0	2.7	52.5	5871.2	1126.4	**6997.5**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1989.1	221.0		**2210.2**		11935	1326		**13261**	5565.1	2.8	55.9	5623.8	1078.9	**6702.7**
			90%	10%			52%	40.3%			3.97	1.08			2066.4	229.6		**2296.0**		12398	1378		**13776**	3044.0	1.6	31.3	3076.8	590.3	**3667.2**
			90%	10%			100%	40.3%			7.94	1.08			1048.6	116.5		**1165.1**		6292	699		**6991**	6161.5	2.5	51.4	6215.4	1192.4	**7407.8**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			1468.7	2203.1		**3671.8**		8812	13218		**22031**	5845.6	2.6	52.9	5901.1	1132.1	**7033.2**
			40%	60%			52%	40.3%			3.97	1.08			1510.4	2265.6		**3776.0**		9062	13594		**22656**	3604.9	1.7	33.4	3640.0	698.3	**4338.3**
			40%	60%			100%	40.3%			7.94	1.08			883.6	1325.4		**2208.9**		5301	7952		**13254**	6607.8	2.0	44.7	6654.5	1276.6	**7931.1**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				7796.6		**7796.6**			46780		**46780**	11702.4	3.5	79.2	11785.1	2260.9	**14046.0**

E2-10: GREENHOUSE GASES PRODUCED IN OCTOBER - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.10: Greenhouse gases produced in October by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	October – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	8301.5	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	63%	34.5%	33.8%	25.4%	112.8%	45.9%	35.9%	58.9%	28.42	3.65	0.97	2.72	128	706	690	519	**2044**	771	4236	4143	3115	**12264**						**11317.1**
	Via Nursling	63%	34.5%	33.8%	25.4%	112.8%	45.9%	35.9%	58.9%	28.42	3.65	0.97	2.72	128	706	690	519	**2044**	771	4236	4143	3115	**12264**						**11488.1**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				549.5				**549.5**	3297				**3297**	2275.9	2.7	24.9	2303.5	441.9	**2745.4**
		100%				60%			60%	12.59				659.3				**659.3**	3956				**3956**	1184.9	1.3	12.3	1198.6	229.9	**1428.5**
		100%				100%			100%	25.18				329.7				**329.7**	1978				**1978**	1681.7	1.6	14.7	1698.0	325.8	**2023.8**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			389.8	584.7			**974.4**	2339	3508			**5847**	3456.3	2.8	36.3	3495.4	670.6	**4166.0**
		40%	60%			60%	52%		60%	12.59	3.97			447.7	671.6			**1119.3**	2686	4029			**6716**	1837.1	1.4	19.1	1857.7	356.4	**2214.1**
		40%	60%			100%	100%		100%	25.18	7.94			223.9	335.8			**559.6**	1343	2015			**3358**	3750.3	2.5	33.5	3786.2	726.4	**4512.6**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		349.9	699.9	116.6		**1166.5**	2100	4199	700		**6999**	3756.6	2.8	38.8	3798.3	728.7	**4527.0**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		397.4	794.9	132.5		**1324.8**	2385	4769	795		**7949**	2015.3	1.5	20.7	2037.5	390.9	**2428.4**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		200.5	400.9	66.8		**668.2**	1203	2405	401		**4009**	6440.0	3.0	58.1	6501.1	1247.2	**7748.3**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				2011.8			**2011.8**		12071			**12071**	5953.4	3.1	60.5	6017.0	1154.4	**7171.4**
			100%				52%				3.97				2092.2			**2092.2**		12553			**12553**	3216.9	1.7	33.4	3252.0	623.9	**3875.9**
			100%				100%				7.94				1046.1			**1046.1**		6277			**6277**	6257.5	2.9	56.5	6316.8	1211.9	**7528.7**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			1954.7	217.2		**2171.9**		11728	1303		**13032**	5987.5	3.1	60.1	6050.6	1160.8	**7211.5**
			90%	10%			52%	40.3%			3.97	1.08			2030.6	225.6		**2256.2**		12184	1354		**13537**	3275.0	1.7	33.6	3310.4	635.1	**3945.5**
			90%	10%			100%	40.3%			7.94	1.08			1030.5	114.5		**1145.0**		6183	687		**6870**	6629.1	2.7	55.3	6687.2	1282.9	**7970.1**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			1443.3	2164.9		**3608.2**		8660	12990		**21649**	6289.3	2.8	56.9	6349.0	1218.1	**7567.1**
			40%	60%			52%	40.3%			3.97	1.08			1484.3	2226.4		**3710.6**		8906	13358		**22264**	3878.6	1.8	35.9	3916.2	751.3	**4667.6**
			40%	60%			100%	40.3%			7.94	1.08			868.3	1302.4		**2170.7**		5210	7815		**13024**	7109.3	2.1	48.1	7159.6	1373.5	**8533.1**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				7661.7		**7661.7**			45970		**45970**	11499.9	3.4	77.9	11581.2	2221.7	**13802.9**

E2-11: GREENHOUSE GASES PRODUCED IN NOVEMBER - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.11: Greenhouse gases produced in November by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	November – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	12409.4	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	62%	35.6%	33.7%	24.5%	122.6%	86.6%	66.4%	88.2%	30.88	6.87	1.79	4.07	129	743	702	511	**2085**	771	4459	4215	3066	**12511**						**10968.1**
	Via Nursling	62%	35.6%	33.7%	24.5%	122.6%	86.6%	66.4%	88.2%	30.88	6.87	1.79	4.07	129	743	702	511	**2085**	771	4459	4215	3066	**12511**						**11133.8**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				821.3				**821.3**	4928				**4928**	1810.4	2.1	19.8	1832.4	351.5	**2183.9**
		100%				60%			60%	12.59				985.6				**985.6**	5914				**5914**	942.6	1.1	9.8	953.4	182.9	**1136.4**
		100%				100%			100%	25.18				492.8				**492.8**	2957				**2957**	1337.8	1.3	11.7	1350.8	259.1	**1609.9**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			582.6	874.0			**1456.6**	3496	5244			**8740**	2749.4	2.2	28.9	2780.6	533.5	**3314.0**
		40%	60%			60%	52%		60%	12.59	3.97			669.2	1003.9			**1673.1**	4015	6023			**10039**	1461.4	1.1	15.2	1477.7	283.5	**1761.3**
		40%	60%			100%	100%		100%	25.18	7.94			334.6	501.9			**836.6**	2008	3012			**5019**	2983.3	2.0	26.6	3011.9	577.8	**3589.7**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		523.1	1046.2	174.4		**1743.7**	3139	6277	1046		**10462**	2988.4	2.2	30.9	3021.5	579.7	**3601.2**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		594.1	1188.2	198.0		**1980.4**	3565	7129	1188		**11882**	1603.2	1.2	16.5	1620.8	311.0	**1931.8**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		299.6	599.3	99.9		**998.8**	1798	3596	599		**5993**	5123.0	2.4	46.2	5171.6	992.1	**6163.7**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				3007.2			**3007.2**		18043			**18043**	4735.9	2.5	48.1	4786.4	918.3	**5704.7**
			100%				52%				3.97				3127.5			**3127.5**		18765			**18765**	2559.0	1.4	26.6	2586.9	496.3	**3083.2**
			100%				100%				7.94				1563.8			**1563.8**		9383			**9383**	4977.7	2.3	44.9	5025.0	964.0	**5989.0**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			2922.0	324.7		**3246.7**		17532	1948		**19480**	4763.0	2.4	47.8	4813.2	923.4	**5736.6**
			90%	10%			52%	40.3%			3.97	1.08			3035.4	337.3		**3372.7**		18213	2024		**20236**	2605.3	1.4	26.8	2633.4	505.2	**3138.6**
			90%	10%			100%	40.3%			7.94	1.08			1540.4	171.2		**1711.6**		9242	1027		**10269**	5273.4	2.2	44.0	5319.6	1020.5	**6340.1**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			2157.5	3236.2		**5393.7**		12945	19417		**32362**	5003.1	2.2	45.2	5050.6	968.9	**6019.5**
			40%	60%			52%	40.3%			3.97	1.08			2218.7	3328.1		**5546.8**		13312	19968		**33281**	3085.3	1.4	28.6	3115.3	597.7	**3713.0**
			40%	60%			100%	40.3%			7.94	1.08			1297.9	1946.9		**3244.8**		7788	11681		**19469**	5655.4	1.7	38.3	5695.4	1092.6	**6787.9**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				14529		**114529**			68718		**68718**	17190.4	5.1	116.4	17311.9	3321.1	**20633.0**

E2-12: GREENHOUSE GASES PRODUCED IN DECEMBER - CLASSIFICATION BY TYPE OF VEHICLE

Table E2.12: Greenhouse gases produced in December by vehicles delivering MCGs to 92 *WestQuay* businesses via the Nursling Consolidation Center.

Participation	Mandatory	December – 92 Businesses																											
n	92	Vehicles Mix				Fill Rates (tonnes)				Fill Rates (m3)				Number of Trips					Distance Travelled (kms)					Emissions Produced (kg CO2e)					
Volume Carried (m^3)	12038.9	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Art	Rigid	Van	D/K	Total	Art	Rigid	Van	D/K	Total	Direct				Indirect	Grand
Last mile (kms)	6																							CO2	CH4	N2O	Total	Total	Total
Current *WestQuay* load Last mile (6kms)	No Consolidation	4.7%	36.0%	33.8%	25.5%	50.2%	81.8%	73.1%	165.4%	12.64	6.49	1.96	7.63	102	781	735	555	**2172**	611	4687	4408	3328	**13035**						**11337.0**
	Via Nursling	4.7%	36.0%	33.8%	25.5%	50.2%	81.8%	73.1%	165.4%	12.64	6.49	1.96	7.63	102	781	735	555	**2172**	611	4687	4408	3328	**13035**						**11508.3**
Scenario A' UK average load - last mile Articulated lorries		100%				50%			50%	15.11				796.8				**796.8**	4781				**4781**	2391.4	2.8	26.2	2420.4	464.4	**2884.7**
		100%				60%			60%	12.59				956.2				**956.2**	5737				**5737**	1245.1	1.4	12.9	1259.4	241.6	**1501.0**
		100%				100%			100%	25.18				478.1				**478.1**	2869				**2869**	1767.1	1.7	15.5	1784.2	342.3	**2126.5**
Scenario B' UK average load - last mile Articulated & rigid lorries		40%	60%			50%	50%		50%	15.11	4.13			565.2	847.9			**1413.1**	3391	5087			**8479**	3631.7	3.0	38.2	3672.8	704.6	**4377.5**
		40%	60%			60%	52%		60%	12.59	3.97			649.3	973.9			**1623.2**	3896	5843			**9739**	1930.4	1.5	20.1	1951.9	374.5	**2326.4**
		40%	60%			100%	100%		100%	25.18	7.94			324.6	486.9			**811.6**	1948	2922			**4869**	3940.6	2.6	35.2	3978.3	763.2	**4741.6**
Scenario C' UK average load - last mile Vans, articulated & rigid lorries		30%	60%	10%		50%	50%	40.3%	50%	15.11	4.13	1.08		507.5	1015.0	169.2		**1691.6**	3045	6090	1015		**10150**	3947.3	3.0	40.8	3991.1	765.7	**4756.8**
		30%	60%	10%		60%	52%	40.3%	60%	12.59	3.97	1.08		576.4	1152.7	192.1		**1921.2**	3458	6916	1153		**11527**	2117.6	1.6	21.8	2140.9	410.7	**2551.6**
		30%	60%	10%		100%	100%	40.3%	100%	25.18	7.94	1.08		290.7	581.4	96.9		**969.0**	1744	3488	581		**5814**	6766.8	3.1	61.1	6831.0	1310.5	**8141.6**
Scenario D' UK average load - last mile Rigid lorries			100%				50%				4.13				2917.5			**2917.5**		17505			**17505**	6255.6	3.2	63.5	6322.4	1213.0	**7535.3**
			100%				52%				3.97				3034.2			**3034.2**		18205			**18205**	3380.1	1.8	35.1	3417.0	655.6	**4072.6**
			100%				100%				7.94				1517.1			**1517.1**		9102			**9102**	6575.0	3.0	59.3	6637.4	1273.4	**7910.8**
Scenario F' UK average load - last mile Rigid lorries & vans			90%	10%			50%	40.3%			4.13	1.08			2834.8	315.0		**3149.7**		17009	1890		**18898**	6291.4	3.2	63.1	6357.7	1219.8	**7577.5**
			90%	10%			52%	40.3%			3.97	1.08			2944.8	327.2		**3272.0**		17669	1963		**19632**	3441.3	1.8	35.3	3478.4	667.3	**4145.7**
			90%	10%			100%	40.3%			7.94	1.08			1494.4	166.0		**1660.5**		8966	996		**9963**	6965.6	2.9	58.1	7026.5	1348.0	**8374.5**
Scenario G' UK average load - last mile Rigid lorries & vans			40%	60%			50%	40.3%			4.13	1.08			2093.1	3139.6		**5232.7**		12558	18838		**31396**	6608.5	2.9	59.8	6671.2	1279.9	**7951.1**
			40%	60%			52%	40.3%			3.97	1.08			2152.5	3228.7		**5381.2**		12915	19372		**32287**	4075.4	1.9	37.7	4115.0	789.5	**4904.5**
			40%	60%			100%	40.3%			7.94	1.08			1259.2	1888.8		**3148.0**		7555	11333		**18888**	7470.1	2.2	50.6	7522.9	1443.2	**8966.1**
Scenario H' UK average load - last mile Vans				100%				40.3%				1.08				11111.0		**11111.0**			66666		**66666**	16677.2	4.9	112.9	16795.1	3222.0	**20017.0**

E3: Seasonal Variation in GHGs Production

E3-1: SEASONAL PRODUCTION OF GREENHOUSE GASES (NO CONSOLIDATION) - CLASSIFICATION BY TYPE AND SIZE OF BUSINESS

Table E3-1: Seasonal variation in the GHGs produced by vehicles delivering MCGs to *WestQuay* businesses – No Consolidation. (classification by type of economic activity and store size).

SEASONAL VARIATION IN TOTAL EMISSIONS (Kg CO2e) PRODUCED – CLASSIFICATION BY BUSINESS TYPE AND STORE SIZE
CURRENT SITUATION – NO CONSOLIDATION (from Distribution Centres to *WestQuay*)

	Jan				Feb				Mar				Apr				May				Jun			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	12150	56236	70406	**138793**	10974	50794	63593	**125361**	12150	56236	70406	**138793**	11758	54422	68135	**134315**	12150	56236	70406	**138793**	11758	54422	68135	**134315**
Food	43493	131	3824	**47447**	39284	118	3454	**42856**	43493	131	3824	**47447**	42090	126	3701	**45917**	43493	131	3824	**47447**	42090	126	3701	**45917**
Books	9485	4528	62639	**76652**	8567	4090	56577	**69234**	9485	4528	62639	**76652**	9179	4382	60619	**74179**	9485	4528	62639	**76652**	9179	4382	60619	**74179**
Footwear	3234	50883	0	**54118**	2921	45959	0	**48881**	3234	50883	0	**54118**	3130	49242	0	**52372**	3234	50883	0	**54118**	3130	49242	0	**52372**
Vision	1749	34708	0	**36457**	1579	31350	0	**32929**	1749	34708	0	**36457**	1692	33589	0	**35281**	1749	34708	0	**36457**	1692	33589	0	**35281**
Electronics	19487	3758	18315	**41560**	17601	3394	16543	**37538**	19487	3758	18315	**41560**	18858	3637	17725	**40219**	19487	3758	18315	**41560**	18858	3637	17725	**40219**
Jewellery	3013	11531	0	**14543**	2721	10415	0	**13136**	3013	11531	0	**14543**	2916	11159	0	**14074**	3013	11531	0	**14543**	2916	11159	0	**14074**
Cosmetics	2184	0	0	**2184**	1973	0	0	**1973**	2184	0	0	**2184**	2114	0	0	**2114**	2184	0	0	**2184**	2114	0	0	**2114**
Games	864	2988	0	**3852**	781	2699	0	**3480**	864	2988	0	**3852**	836	2892	0	**3728**	864	2988	0	**3852**	836	2892	0	**3728**
Other	289	548	0	**837**	261	495	0	**756**	289	548	0	**837**	280	530	0	**810**	289	548	0	**837**	280	530	0	**810**
TOTAL	**95947**	**165310**	**155185**	**416443**	**86662**	**149313**	**140167**	**376142**	**95947**	**165310**	**155185**	**416443**	**92852**	**159978**	**150179**	**403009**	**95947**	**165310**	**155185**	**416443**	**92852**	**159978**	**150179**	**403009**

	Jul				Aug				Sep				Oct				Nov				Dec			
A: Surface (m^2)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	12150	56236	70406	**138793**	12150	56236	70406	**138793**	11758	54422	68135	**134315**	12150	56236	70406	**138793**	11758	54422	68135	**134315**	12150	56236	70406	**138793**
Food	43493	131	3824	**47447**	43493	131	3824	**47447**	42090	126	3701	**45917**	43493	131	3824	**47447**	42090	126	3701	**45917**	43493	131	3824	**47447**
Books	9485	4528	62639	**76652**	9485	4528	62639	**76652**	9179	4382	60619	**74179**	9485	4528	62639	**76652**	9179	4382	60619	**74179**	9485	4528	62639	**76652**
Footwea	3234	50883	0	**54118**	3234	50883	0	**54118**	3130	49242	0	**52372**	3234	50883	0	**54118**	3130	49242	0	**52372**	3234	50883	0	**54118**
Vision	1749	34708	0	**36457**	1749	34708	0	**36457**	1692	33589	0	**35281**	1749	34708	0	**36457**	1692	33589	0	**35281**	1749	34708	0	**36457**
Electron	19487	3758	18315	**41560**	19487	3758	18315	**41560**	18858	3637	17725	**40219**	19487	3758	18315	**41560**	18858	3637	17725	**40219**	19487	3758	18315	**41560**
Jeweller	3013	11531	0	**14543**	3013	11531	0	**14543**	2916	11159	0	**14074**	3013	11531	0	**14543**	2916	11159	0	**14074**	3013	11531	0	**14543**
Cosmeti	2184	0	0	**2184**	2184	0	0	**2184**	2114	0	0	**2114**	2184	0	0	**2184**	2114	0	0	**2114**	2184	0	0	**2184**
Games	864	2988	0	**3852**	864	2988	0	**3852**	836	2892	0	**3728**	864	2988	0	**3852**	836	2892	0	**3728**	864	2988	0	**3852**
Other	289	548	0	**837**	289	548	0	**837**	280	530	0	**810**	289	548	0	**837**	280	530	0	**810**	289	548	0	**837**
TOTAL	**95947**	**165310**	**155185**	**416443**	**95947**	**165310**	**155185**	**416443**	**92852**	**159978**	**150179**	**403009**	**95947**	**165310**	**155185**	**416443**	**92852**	**159978**	**150179**	**403009**	**95947**	**165310**	**155185**	**416443**

E3-2: SEASONAL PRODUCTION OF GREENHOUSE GASES (CONSOLIDATION) - CLASSIFICATION BY TYPE AND SIZE OF BUSINESS

Table E3-2: Seasonal variation in the GHGs produced by vehicles delivering MCGs to *WestQuay* businesses –Consolidation.
(classification by type of economic activity and store size).

	Jan				Feb				Mar				Apr				May				Jun			
A: Surface (m²)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	11941	56663	71265	**139869**	10786	51179	64368	**126333**	11941	56663	71265	**139869**	11556	54835	68966	**135357**	11941	56663	71265	**139869**	11556	54835	68966	**135357**
Food	44887	446	4369	**49701**	40543	403	3946	**44892**	44887	446	4369	**49701**	43439	432	4228	**48098**	44887	446	4369	**49701**	43439	432	4228	**48098**
Books	9389	4542	63572	**77504**	8481	4102	57420	**70003**	9389	4542	63572	**77504**	9087	4395	61521	**75003**	9389	4542	63572	**77504**	9087	4395	61521	**75003**
Footwear	2749	51360	0	**54109**	2483	46390	0	**48873**	2749	51360	0	**54109**	2660	49704	0	**52364**	2749	51360	0	**54109**	2660	49704	0	**52364**
Vision	1776	34796	0	**36572**	1604	31429	0	**33033**	1776	34796	0	**36572**	1719	33674	0	**35393**	1776	34796	0	**36572**	1719	33674	0	**35393**
Electronics	19808	3775	18743	**42326**	17891	3410	16929	**38230**	19808	3775	18743	**42326**	19169	3653	18138	**40960**	19808	3775	18743	**42326**	19169	3653	18138	**40960**
Jewellery	3045	12528	0	**15573**	2750	11316	0	**14066**	3045	12528	0	**15573**	2947	12124	0	**15071**	3045	12528	0	**15573**	2947	12124	0	**15071**
Cosmetics	2254	0	0	**2254**	2036	0	0	**2036**	2254	0	0	**2254**	2182	0	0	**2182**	2254	0	0	**2254**	2182	0	0	**2182**
Games	864	3102	0	**3967**	781	2802	0	**3583**	864	3102	0	**3967**	836	3002	0	**3839**	864	3102	0	**3967**	836	3002	0	**3839**
Other	291	568	0	**859**	263	513	0	**776**	291	568	0	**859**	282	550	0	**832**	291	568	0	**859**	282	550	0	**832**
TOTAL	**97005**	**167781**	**157949**	**422735**	**87617**	**151544**	**142663**	**381825**	**97005**	**167781**	**157949**	**422735**	**93876**	**162369**	**152854**	**409098**	**97005**	**167781**	**157949**	**422735**	**93876**	**162369**	**152854**	**409098**

	Jul				Aug				Sep				Oct				Nov				Dec			
A: Surface (m²)	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total	<200	200< <500	>500	Total
Clothing	11941	56663	71265	**139869**	11941	56663	71265	**139869**	11556	54835	68966	**135357**	11941	56663	71265	**139869**	11556	54835	68966	**135357**	11941	56663	71265	**139869**
Food	44887	446	4369	**49701**	44887	446	4369	**49701**	43439	432	4228	**48098**	44887	446	4369	**49701**	43439	432	4228	**48098**	44887	446	4369	**49701**
Books	9389	4542	63572	**77504**	9389	4542	63572	**77504**	9087	4395	61521	**75003**	9389	4542	63572	**77504**	9087	4395	61521	**75003**	9389	4542	63572	**77504**
Footwea	2749	51360	0	**54109**	2749	51360	0	**54109**	2660	49704	0	**52364**	2749	51360	0	**54109**	2660	49704	0	**52364**	2749	51360	0	**54109**
Vision	1776	34796	0	**36572**	1776	34796	0	**36572**	1719	33674	0	**35393**	1776	34796	0	**36572**	1719	33674	0	**35393**	1776	34796	0	**36572**
Electron	19808	3775	18743	**42326**	19808	3775	18743	**42326**	19169	3653	18138	**40960**	19808	3775	18743	**42326**	19169	3653	18138	**40960**	19808	3775	18743	**42326**
Jeweller	3045	12528	0	**15573**	3045	12528	0	**15573**	2947	12124	0	**15071**	3045	12528	0	**15573**	2947	12124	0	**15071**	3045	12528	0	**15573**
Cosmeti	2254	0	0	**2254**	2254	0	0	**2254**	2182	0	0	**2182**	2254	0	0	**2254**	2182	0	0	**2182**	2254	0	0	**2254**
Games	864	3102	0	**3967**	864	3102	0	**3967**	836	3002	0	**3839**	864	3102	0	**3967**	836	3002	0	**3839**	864	3102	0	**3967**
Other	291	568	0	**859**	291	568	0	**859**	282	550	0	**832**	291	568	0	**859**	282	550	0	**832**	291	568	0	**859**
TOTAL	**97005**	**167781**	**157949**	**422735**	**97005**	**167781**	**157949**	**422735**	**93876**	**162369**	**152854**	**409098**	**97005**	**167781**	**157949**	**422735**	**93876**	**162369**	**152854**	**409098**	**97005**	**167781**	**157949**	**422735**