

Review of diesel spillage clean-up procedures

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Review of diesel spillage clean-up procedures

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**A Literature Review of Diesel Spillage Clean up
Procedures to Prevent Accidents**

**Client: Department for Transport (DfT), Transport,
Technology and Standards
Adrian Burrows**

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Executive summary

A study has been undertaken to review:

- spillage treatment products;
- procedures for clean-up and reporting of spillage incidents; and
- accident data relating to motorcyclists where a spillage was considered to be a contributory factor.

The study followed on from a KillSpills study into spillage treatments. This study reviewed the effectiveness of clean-up products and procedures used in the UK and elsewhere, investigated the cost effectiveness of identified products, and reviewed the effectiveness of procedures in place. Reporting systems in place for the general public to report spillages were reviewed and the impact of the environment on treatment effectiveness was also considered. Motorcycle accident statistics were reviewed which cite spillages as being a contributory factor and assessed for the annual cost of these accidents.

With regard to products and procedures, the following conclusions were made:

- No national guidelines currently exist in the UK to deal with hazardous material spillages on highways and lack of well-defined hazardous materials response policies and procedures.
- Different County Councils, Maintenance Area Contractors and other road authorities use a variety of proprietary absorbent products and follow different clean-up procedures that have been developed in house. Only a limited number of comparative studies have been conducted to assess the effectiveness of these absorbent products.
- There are no robust and clear consistent guidelines for reporting hazardous material spillages on highways which may delay reporting of spillages and valuable time could be lost in mobilizing the incident response units to clean-up the spillages.
- A response to a diesel spillage or an incident will be dependent upon the severity of the spillage. However, proper guidelines and documented practices are not available defining the roles of the parties involved to improve coordination and preparedness.
- There is a general lack of verification for the claims made about products while an independent assessment would assist the road authorities in developing rational policies and generally increase confidence in using proprietary products. Any advice should relate to treatment performance and environmental issues rather than name specific products. On-going trials at TRL of a limited number of products should assist with development of this advice.
- The Environment Agency (EA) currently allows the use of most of the proprietary absorbent granules for application on diesel spillages provided they do not contain any pollutants. The EA prefers inert and biodegradable products which are likely to cause minimum environmental issues. The used absorbents have to be collected, bagged and disposed of appropriately.

With regard to the motorcycle accident study, the following conclusions were made:

- The various sources of information used in this study have shown that the presence of road surface contaminants present a legitimate concern for motorcyclists.
- The estimated total value of prevention of all of the reported personal injury road accidents in Great Britain in 2008 (170,591 accidents) is £12,790m using 2008 prices and values. The corresponding estimated value for 2007 and 2006 was

£13,770m and £13,089m respectively. This estimate relates to the total value to the community of the benefits of prevention of road accidents.

- The total annual value of prevention of the motorcycle accident type where oil and/or diesel was recorded as a special condition at the accident site for the three years was £48.91m; £14.96m in 2006, £18.45m in 2007 and £15.50m in 2008. This report has shown that the estimated value for the prevention of these accidents is about 0.12% of the total for the period 2006 to 2008.

1 Introduction

1.1 Project background

Diesel spillages are hazards for all road users, particularly motorcyclists. Unfortunately, diesel spillages occur on the UK road network due to negligence of vehicle owners (overfilling or loose fuel caps), as a result of an accident or during transportation. The effect of such spillages is of concern to motorcyclists because they can cause differential skid resistance which may result in a motorcyclist losing control.

During 2008, motorcycle traffic was 40% greater than the 1994-1998 average baseline with increasing numbers of people turning to motorcycles to commute and for leisure. However, motorcyclists are at a much greater risk of death or serious injury than other road users. In 2008, the relative risk of a motorcycle rider being killed or seriously injured per kilometre travelled was 57 times higher than that of a car driver. Motorcyclists currently account for 19% of all road traffic deaths.

In 2005, the Government published a motorcycling strategy that set out to identify and address the many issues and challenges that motorcycling raises and, in particular, the safety of the rider. A sub-group of the National Motorcycling Council (NMC) was set up to deal with road safety and has been working with interested organisations to develop a clear understanding of the road safety risk of diesel spillage and to develop solutions. It is also entrusted with investigating the reporting options for diesel spillages and other highway defects. This action has been led within the sub-group by KillSpills (www.killspills.org.uk), a voluntary group of motorcyclists founded in the autumn of 2003. The group put together information to publicise the dangers of diesel spillages and has undertaken some research into accidents relating to diesel spillage on the road. Following their own improved rider awareness campaign, the group has claimed a reduction of 69% in motorcycle accidents relating to diesel spillages over the past 6 years.

Due to the lack of any current guidelines for spillage clean-up procedures and reporting, a survey was conducted in 2008 by KillSpills to collect information on the clean-up processes in place with the Local Councils and Emergency Services (The Motorcyclists Union, 2008). However, due to the wide range of products and procedures followed by different authorities, there was a requirement to test different products available on the market in order to assess from a performance and cost standpoint.

In order to achieve this aim, TRL Limited was commissioned by the DfT to conduct an in-depth literature review of the effectiveness of various diesel spillage products and their application procedures. The study also had to include a review of accident statistics and studies to identify the number of accidents related to oil/diesel spillages and to provide an estimate of the annual cost of these accidents.

The study is primarily focussed on motorcycles; however, benefits gained from the study will be applicable to all vehicle types.

1.2 Scope of study

The primary objective of the study was to conduct an in-depth literature review of the effectiveness of various diesel spillage products and the accident statistics and to provide an estimate of the annual cost of these accidents. In particular, to answer the question as to how effective these products are in reducing the impact of spillages on safety, with particular respect to motorcyclists. A detailed literature search and review was conducted using TRL's extensive library facility. The scope of the literature review includes the following:

- Clean-up products and procedures used in the UK and other countries (including those found in the KillSpills survey).

- The relative performance and cost effectiveness of the identified products.
- Effect of the clean-up process on the road surface and whether the type of road surface influences the effectiveness of a particular method.
- Environmental effects on performance (for example, rainfall and temperature).
- Methods for assessing treatment effectiveness.
- A review of accident statistics and studies to identify the number of injury accidents where oil and/or diesel spillage could have been a contributory factor.
- Provides an estimate of the annual cost of these accidents.

2 Diesel spillages: An overview

2.1 Causes of diesel spillages

Diesel spillages on road surfaces results in significant potential risk to road users, environmental damage and economic loss. Unfortunately, spillages occur frequently on the road network due to overfilling, negligence or during accidents. They are considered to be road surface contaminants among many others including lubrication system losses, wear and tear of tyres, goods transportation losses, loose grit and gravel, debris from accidents and other waste deposited by the road users. Well-maintained highways, a code of practice for highway maintenance management (DfT, 2005) addresses issues related to 'Safety' & 'Surface' inspections. It recommends that surface inspections are carried out to reduce the amount debris left on the road.

Diesel spillages can take up to 100 days to dissipate; hence, it remains on the road surface for a long period of time, often reappearing during rainfall. Diesel spillages occur in one of the many ways, including:

- Negligence of the driver refitting the filler cap or forgetting to refit the cap.
- When a driver fills the tank right up to the filler cap (necking it).
- Lack of anti-spill devices being fitted into the diesel tank in lorries
- Mechanical failures.
- During accidents, usually following accidents involving tankers or multi-vehicle pile-ups.
- Transport of diesel.
- Miscreants trying to steal fuel from tankers and other sources.
- Leakage from parked vehicles.

2.2 Effect of diesel spillages

Diesel spillages are hazards which threaten the safety of all road users, particularly motorcyclists. Diesel spillages on the road surface are a major concern to motorcyclists because they cause differential skid resistance and result in motorcycles losing control. Vehicles can skid, swerve and lose control on patches of diesel, endangering their drivers, passengers, other road users, pedestrians and property. These spillages usually occur on bends in the road and at hard braking locations, areas where motorcycle stability is most critical. Accidents can cause road closures which may lead to increased traffic congestion and journey time.

Diesel or other solvent spillages degrade the asphalt road surfaces if left untreated. It will ultimately lead to material loss under trafficking due to its inability to hold the aggregate particles together. The particles are then plucked out from the matrix, resulting in larger areas of ravelling or potholes over a period of time. Timely and effective treatment of the spillages may save the cost of repair of the area affected by the spillage (spillage area, elsewhere also called spill area or spilled area).

Diesel spillages also create a huge potential environmental risk if the spilt material enters into the road drainage system and subsequently into the water bodies. This contamination can endanger fish, aquatic animals and plants. Significant environmental clean-up costs can be inevitable if such risk of pollution is not prevented.

2.3 Traditional clean-up using sand

Traditionally diesel spillages on highways have been treated with sand because it is cheap and generally available in the highway depot ready for use. When spillages occur,

sand is spread over the spillage area and left to soak up the diesel by adsorption¹. It is then swept, collected and disposed of. Generally, a second layer of sand is applied to the spillage area to reduce the slipperiness due to the residual diesel soaked into the surface of the pavement. According to the KillSpills survey (The Motorcyclists Union, 2008), sand was voted the second most popular material used to clean-up spillages. However, according to Motorcycle Action Group (MAG), improper clean-up of sand may create a further risk to the safety of the road users.

Some drawbacks of using sand for cleaning diesel spillages include;

1. It allows diesel to leach out and contaminate surrounding land and watercourses.
2. Being inorganic, sand does not contribute to the biodegradation of the adsorbed diesel.
3. Adsorption capacity is much lesser than many sorbent products available on the market, thus requiring a significantly larger quantity to treat similar amount of spillages, thereby generating more waste.
4. Not suitable in wet conditions.

2.4 Legislation overview

The UK's Environment Agency (EA), Scottish Environment Protection Agency (SEPA) and Environment and Heritage Service (EHS, Northern Ireland) have onerous powers to fine individuals as well as companies in case of spillages of hazardous substances, if proved due to negligence or on purpose.

According to the Fire and Rescue Services Act 2004 (House of Parliament, 2004), it places no statutory duty on Fire and Rescue Services (FRS) to protect the environment. It allows FRS to take any appropriate action necessary if the event is one that causes or is likely to cause harm to the environment. The FRS is also required to comply with the requirements of environmental legislation, in particular the Water Resources Act 1991 (House of Parliament, 1991a).

National protocols and memoranda of understanding (MoU) between the EA and FRS sets out the roles and responsibilities of the EA and the FRS when working together, aimed at protecting the environment without compromising the FRS's role of protecting people. The FRS is also required to notify the EA when they become aware of spillages of more than 25 L of diesel.

The MoU between the Environment Agency and the Highways Agency (HA, undated) defines the role of HA in minimizing environmental risk. The Pollution Prevention Guidelines 22 (PPG22) (EA *et al*, 1999) provides guidelines on dealing with spillages on highways. It outlines the role of the EA in controlling pollution that results from road traffic accidents, spillages and illegal disposal of polluting substances on the highway. It offers limited advice on spillage containment, type of products available for the clean-up of spillages on highways.

Responsibility for spillage on the highway in England normally falls to the HA's Managing Agent Contractor (MAC) or the Local Authorities. FRS, EA, police and approved emergency service providers also share the responsibilities depending on the size of the spillage.

¹ **Adsorption** is the process of attraction of atoms or molecules from an adjacent gas or liquid to an exposed solid surface.

2.5 Spillage reporting system

2.5.1 Responsibility

In dealing with spillages on highways, a robust reporting system and an efficient response to spillage clean-up are of great importance. An effective spillage reporting system will enable the public or the highway patrol officers to report the occurrence of spillages on highways promptly and, hence, the spill response units will be able to attend more rapidly.

In England, HA and Local Authorities have the responsibility to clean-up spillages depending on the class of the road and jurisdiction. Both systems are hugely dependant on members of the public or individuals involved reporting the spillages. If this does not occur, then spillages are reported when the police, traffic officers or Local Authority workers come across them in the course of their normal duties.

2.5.2 Local Authority reporting protocols

In case of a spillage on local roads, the Local Authority (LA) needs to be informed either by a direct call to the LA main switch board from a member of the public or via the area Police control room. Some of the LAs have a dedicated phone number, through which spillages can be reported. Spillages are often, in the first instance, reported to the police who pass on the information to the Local Authority. Some counties have a Highways Operational Control (HOC) centre; the contact point for any spillage incident in their area of responsibility. Important information includes location, size, time of occurrence and the nature of spilled liquid. The LA highways department (or approved contractor) will then assess the severity of the spillage. For smaller spillages (generally less than 25 L), the LA approved contractor would attend the spillage to organise containment and clean-up. If the spillage is large (more than 25 L), then the FRS will be mobilised (if not already tasked by the police) to contain the spillage and prevent ingress into the water course. For large spillages the EA would also be informed.

Devon County Council has launched the "Spiller Killer" campaigns to increase awareness of the dangers of fuel spillages and encourage reporting of spillages. They also undertake promotional and educational drives which target the main sources of diesel spillages (i.e. haulage companies, drivers, farmers, bus companies and petrol stations). Similar campaigns have also been launched by Staffordshire's Road Safety & Sustainable Travel Unit.

2.5.3 Highways Agency reporting protocols

Spillages on the HA network are dealt with in a similar manner those to LA networks. The spillages are reported to one of the seven regional control centres, where the severity of the spillage is assessed by the controller on duty and details regarding the spillage are taken. The spillage can be reported through the national switchboard number, regional control centre number, the Police or from one of the many roadside emergency telephones located around the network. The control centre will then inform a HA Traffic Officer (HATO) from one of the 31 outstations spread across the network to attend to the spillage (if they are not the reporting party). An incident response team from the local area MAC will deal with containment and clean-up of the spillage. Large spillages (more than 25 L) require the attendance of the FRS and the EA.

3 Diesel spillage clean-up product types

3.1 Range of products

At present, there are a large number of products available on the market for use in case of diesel spillages on road surfaces. The products come in different forms such as loose or packed sorbents, booms, sheets, pads, pillows and washing agents. Bioremediation products are also available containing micro-organisms which will breakdown the hydrocarbon in carbon dioxide and water. Only limited comparative studies have been conducted to investigate the effectiveness of the products available in the UK and elsewhere. Most of the information available is from the product manufacturer. Despite there being no regulation or guidelines in place, it is important to know the sorbent capacity, clean-up performance, environmental hazards and disposal cost of the used product for each product.

3.2 Types of products

3.2.1 Sorbents

Sorbents are the most commonly available products on the market to clean-up oil or chemical spillage. According to the US Environmental protection Agency (EPA), sorbents are insoluble materials or mixtures of materials used to recover liquids through the mechanism of absorption, or adsorption, or both. Absorbents are materials that pick up and retain liquid distributed throughout its molecular structure causing the solid to swell (50% or more). Whereas adsorbents are insoluble materials that are coated by a liquid on its surface, including pores and capillaries, without the solid swelling more than 50% in excess liquid. They are broadly classified into three types according to the material from which they are made;

1. Inorganic sorbents
2. Natural organic sorbents
3. Synthetic or polymeric sorbents

Inorganic sorbents: Consisting of clay, sand and diatomaceous earth products. They are inexpensive and readily available in large quantities. These products are mainly applied on land spill clean-up.

Natural organic sorbents: The most common natural organic sorbents readily available today are wood chips, straw, hay, sawdust, cork, dried corn, wool, recycled newspaper and telephone books and modified or processed peat. Wool requires stringent storage requirements because it is known to attract insects and rodents. Cork is non-toxic and can be incinerated.

Synthetic sorbents: The most common synthetic sorbents are made from polyurethane, polyethylene and polypropylene, which may be stitch bonded or melt-blown. The synthetic sorbents have a very high initial capacity for hydrocarbons. Their reaction time is almost immediate to fast. The synthetic sorbents may be incinerated but they may not always be acceptable for landfill disposal.

The sorbents comes in different forms and are presented in Figure 3-1 and can be described as:

- **Booms** are cylindrically shaped and manufactured varying in length and width. They are used to control and contain spillages.
- **Socks or mini-booms** are cylindrically shaped and manufactured in varying lengths and widths. They are typically used to contain minor spillages or placed around machinery to contain leaks.
- **Pillows** are rectangular in shape and filled with sorbent material.

- **Pads and rolls** are flat sorbent sheets available in un-perforated or perforated rolls or in specific sizes.
- **Loose sorbents** are composed of sorbent material that is not contained in any type of mesh.



Figure 3-1: Range of absorbent product

(Source: Google images)

3.2.2 Surface cleaners/degreasers

Surface washing agent or degreasers are products that remove oil from solid surfaces, including asphalt surfaces, through a detergent mechanism. It does not involve dispersing or solubilising the oil in water. There are a number of products available on the market that claim to treat oil spillages on highways effectively and are environmentally friendly. The applications of these products are not permitted at present by the EA because most of the products contain pollutants that may enter the drainage system causing secondary pollution.

3.2.3 Bioremediation

There are a variety of bioremediation products available to mitigate the environmental impacts of oil spillages. The US EPA has defined bioremediation agents as microbiological cultures, enzyme additives or nutrient additives that significantly increase the rate of

bio-degradation to mitigate the effects of the discharge (US EPA, undated a). These micro-organisms degrade the hydrocarbons into carbon dioxide and water. The rate of bio-remediation is dependent on the climatic conditions favourable for the growth of these micro-organisms. Surveys conducted by the EA in the UK suggest that subsequent progression of bioremediation as an effective remediation technology is partly limited by uncertainty regarding the efficacy of the technique, operational constraints and the regulatory permissions required (Environment Agency, 2000).

They are generally classified, based on their approach to oil spillage bio-remediation, as:

- Bio-augmentation: Oil-degrading microorganisms are added to enhance the existing microbial population.
- Bio-stimulation: Nutrients or other growth-limiting co-substrates are added to increase the growth of indigenous oil degrading micro-organisms.

Bioremediation processes are not appropriate for use in oil spillage clean-up on highways as a primary response product. These products can be used effectively to treat adjoining soil contaminated by oil spillages where the treatment option of recovering the soil for disposal or treatment becomes very expensive and/or impractical.

3.3 Selection of appropriate absorbent

There are hundreds of products available on the market that the manufacturer claims to be suitable for clean-up of diesel spillages on road surfaces. Spillages on road surfaces can occur in many different ways and under varying geographical and environmental conditions. Identification of appropriate product type and form is most important to achieve satisfactory level of clean-up in a cost effective manner with minimal impact to the environment. Moreover, it is also necessary to understand the product and the manufacturer's claims about the product. The following are a few points to be considered when selecting the appropriate product type:

- The type of liquid spilled will determine the type of absorbent to be used. 'Oil absorbents' for oil or fuel spillages and 'chemical absorbents' for acid and base spillages.
- Effectiveness of the product in terms of cleaning the spillage and absorption/adsorption capacity. Higher capacity will reduce the amount of product required and will generate lesser waste for similar amount of spillages, reducing the cost of disposal. Additional savings could also be achieved in the reduced labour and time required.
- Acting time or the rate of absorption/adsorption reduces the time required for the application of the product so that the road can be opened to traffic with minimal disturbance. The absorption of oil is faster with lighter oil products.
- Oil retention ability is important to avoid secondary contamination during clean-up and transportation of the used product.
- Ease of application of the sorbents, manually or mechanically, using blowers or fans.
- Cost of the product will determine if the application of the product is viable and realistic.
- The products need to be environmental friendly and should not cause secondary pollution.

3.4 Disposal of used absorbents

The absorbent materials once applied on spillages, become contaminated and must be treated as a hazardous waste depending on the liquid absorbed. When washing agents are used, it is required by the EA that no effluent must be allowed to enter the surface drainage systems. All the effluents must be contained and collected from the road surface and disposed of as hazardous waste as described in PPG22 (EA *et al*, 1999).

Absorbent materials may be used to soak up the effluent and the waste shall be treated similar to those used to absorb diesel. The used materials can either be recycled or disposed of in accordance with the environmental regulations. Generally, spillage response units do not possess appropriate licenses to transport and dispose of hazardous waste. However, the resulting waste must be collected, bagged and secured in accordance with the standard operating procedures in place. Some of the used absorbent waste may be incinerated provided it meets the emission levels.

PPG22 requires professional approved contractors to remove the contaminated waste and transport it to a licensed site for disposal or recovery as soon as possible to prevent further risk to the environment. PPG22 also requires documentation of the movement of the waste with a transfer note under the Environmental Protection (Duty of Care) Regulations 1991 (Houses of Parliament, 1991b), or for special waste under the Special Waste Regulations 1996 (Houses of Parliament, 1996).

4 Diesel spillage clean-up procedures and response

4.1 Current situation

Currently, there are no national guidelines in the UK for cleaning up diesel spillages from road surfaces. A quick response may prevent incidents arising from the spillage, or damage to the pavement and reduce risk to environment or traffic congestion and delays. If the treatment is timely, the replacement of the section of the carriageway affected may be avoided or at least allow the replacement to be delayed until an off peak period without compromising the safety for the road users.

The survey conducted by KillSpills in 2008 (The Motorcyclists Union, 2008) indicated that different products and procedures are being used in the UK by various road authorities with mixed results. As part of this study, Local Authorities and MACs were contacted across the country seeking information on the type of procedures in place for cleaning up diesel spillages. However, only a few responses were received, which could have been due to the limited time frame of the project or to the lack of an in-place clean-up procedure.

4.2 General clean-up procedure

4.2.1 Overview

Small vehicular spillages occurring on road surfaces may not have to be contained or confined. Absorbent granules, oil absorbent pads or other similar approved products can be spread over the spillage area, brushed and swept clean. On the other hand, larger spillages may require more complex machines and resource mobilization to clean them up. For proprietary absorbent granules, the following four basic steps are generally followed:

1. Apply the absorbent to cover the spillage area.
2. Sweep back and forth with a stiff broom until the liquid is fully absorbed.
3. Collect the used sorbent with a shovel and dustpan.
4. Dispose of all used sorbent materials in accordance with local regulations.

During the extensive literature review, the basic procedure was found to be similar across Road Authorities with the steps described in the following sub-sections generally being common in their responses to spillages on highways.

4.2.2 Step by step clean-up procedure

4.2.2.1 Assessment of the spillage area and identification of spilled material

The spillage area needs to be assessed by the emergency response personal on arrival at the site. Issues such as the extent of the spillage area, the type of material, the amount of spillage and the risk to the public, property and/or the environment will determine the nature and seriousness of the situation together with the level of resources required to deal with the spillage effectively. It will also assist in selecting the appropriate safety measures, methodology and product type to clean-up the spillage. It is important to ensure that the spillage area is safe to enter. Traffic diversions may need to be in place in order to ensure the safety of the response personal. Appropriate protection clothing and equipment must be worn in accordance with the existing regulations.

4.2.2.2 *Contain the source of spillage*

After the initial site assessment and upon identification of the spilled material, the source of the spillage must be stopped immediately. All ignition sources must be turned off to prevent any risk of fire. Drain locations must be located and sealed off using drain seals or appropriate absorbent mats to avoid further risk to the environment.

4.2.2.3 *Confine the spillage*

The spillage should be enclosed by absorbent booms, banks of soil, sorbent granules or any material deemed safe for fencing in order to stop the spillage from spreading any further. The products used must be approved because failure of a product or method would be costly and increase the risk of an environmental impact.

4.2.2.4 *Maximum recovery of the spilled material*

In the case of large spillages, attempts should be made to recover the maximum amount of spilled liquid, where possible, before any clean-up action is taken.

4.2.2.5 *Cleaning up the spillage area*

Absorbent mats, rolls or pillows can be used to absorb larger pools of liquid. Proprietary absorbent granules, sand or grit can then be applied to cover the spillage area to absorb any free liquid preventing loss of surface skid resistance and minimise the damage on the road surface. Hydrophobic absorbents are recommended in wet conditions because they will absorb only the oil and repel water. After the spilled liquid has been absorbed, these materials are swept with brooms or a road sweeper depending on the area of spillage and time available. Washing agents can be used to clean-up the residual liquid soaked into the road surface provided all the effluent is collected from the area of application and disposed of appropriately. The amount of effluent to be disposed of can be extensive when road sweepers have been used.

In cases where the spilled liquid has affected the adjoining ground, control, containment and clean-up of the spillage often becomes more difficult. Bioremediation measures can be considered as an option to treat the soil in situ because excavation and transporting the soil to a treatment site often becomes more costly and impractical.

4.2.2.6 *Dispose the absorbents*

All absorbent materials should be collected from the spillage area and disposed of in accordance with the environmental regulations as described in section 3.4. When cleaning agents are used, it must be ensured that the effluent does not enter the road drainage system and any applied agent is subsequently removed.

4.2.2.7 *Inspection of the spillage area*

The spillage area should be inspected for any residual diesel remaining. If required, more absorbent can be used to ensure that all the diesel is cleaned up.

4.3 Fire and Rescue Service recommended procedure

The recommended national practice for a diesel spillage from the Fire and Rescue Service (FRS), as required by the HA (HA, 2007a), is as follows:

- Stem the leak.
- Contain the spillage by deploying booms around the source and block the drains.
- Apply absorbent granules/sand on the spillage area.
- Sweep up the absorbent granules.

- Scrub the carriageway using a mild detergent. Any effluent resulting from the clean-up activity must not be washed into surface water drains because it is an offence under the Water Resources Act, 1991 (Houses of Parliament, 1991a).

The FRS national guidance states that water must not be applied to treat diesel spillages because it will intensify the situation, diesel not being miscible with water. The water used may spread to the adjoining areas or enter the surface drainage system, increasing the potential risk to the environment.

4.4 Spill response management in the UK

Well-defined hazardous materials response policies and procedures, together with an appropriate level of training, allow first responders to accurately assess hazardous spillages and direct further responses. A response can involve emergency services, EA, MACs, police and the Road Authorities depending upon the severity of the spillage, each having a different role. Proper guidelines and documented practices need to be established in order to define the roles of each of the parties involved and to improve coordination and preparedness. Traffic incident management (TIM) units are developing appropriate procedures, implement technologies to record incidents more quickly, improve response times and manage the incident scene more effectively and efficiently.

The Area Management Memorandum No 95/07 (HA, 2007b) outlines the HA's requirements to ensure the rapid re-opening of running lanes following hydrocarbon fuel spillages. This AMM does not give any guidance on clean-up of spillages but requires the Service Provider (SP) to consider all available options to ensure quick reopening of the running lanes as a priority and may defer some work to a later time. The AMM requires a dynamic risk assessment and re-evaluation of the risk using emerging information at a number of stages during an incident. The risks most relevant to delay the rapid re-opening to traffic are as follows:

- A. Spillage of diesel as a result of the recovery.
- B. Excessive treatment of the pavement for the level of damage.
- C. Skid potential.
- D. Rutting.
- E. Binder loss leading to break up of the pavement material.

Risk factors, based on the probability of the likelihood of each risk, are entered in a risk matrix table and the overall risk is then calculated by summing the multiples of the value of the risk impact and the probability of them occurring for each of the five individual risks. Depending on the overall risk, appropriate actions have to be considered.

4.5 Spill response management in the USA

4.5.1 General

Research and Special Programs Administration (RSPA) is responsible for maintaining records of incidents involving spillages on highways including the Hazardous Material Information System within the US Department of Transport (NCHRP, 1994). Section 1910.120 of the Code of Federal Regulations (Federal Government of the United States, 2009a) requires all states to have an Incident Contingency Plan (ICP) and Incident Command System (ICS). In cases where the contaminant enters the natural sewer or the drainage systems, local sewer authorities are required to be informed. Fuel spillages greater than 25 L are treated as major spillages and require attention of the fire services and the US EPA.

The responsibility is split between Federal and State responses according to the size and severity of the spillage. Federal response units are responsible for large scale spillages

which are likely to cause an environmental disaster and state response units deal with smaller spillages. These response units form the building blocks of the National Contingency Plan.

The Emergency Response Guidebook (US DOT *et al*, 2008) outlines the response procedure to be followed in case of a flammable fuel spillage under Guide 128:

- Eliminate all ignition sources (no smoking, flares, sparks or flames nearby).
- All equipment used when handling the product must be grounded.
- Do not touch or walk through spilled material.
- Stop leak if you can do so without risk.
- Prevent entry into waterways, sewers, basements or confined areas.
- A vapour suppressing foam may be used to reduce vapour.
- Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.
- Use clean non-sparking tools to collect absorbed material.

Some of the incident management practices from the US DOT are presented in the following sub-sections.

4.5.2 Florida DOT

The preferred clean-up method of Florida DOT is to soak up as much material as possible using absorbent materials (State of Florida DOT, 2004). Light Portland cement dusting can be applied to deal with any thin film of fuel that may remain on the road surface. The department and other crash-scene responders may apply absorbents and sweep off travel lanes regardless of the quantity. It is not necessary to await a licensed clean-up contractor. The responsible party is accountable for vehicle fluid spillage, including the final removal and proper disposal of absorbents and, if needed, the subsequent site remediation.

Timely intervention is encouraged in order to limit the congestion impact and prevent the high probability of secondary incidents as a result of extended traffic blockage. The DOT's spillage clean-up quick action guide includes:

- identify spillage as a vehicle fluid;
- stop the leaking material at the source;
- contain and limit spillage from spreading;
- apply available absorbents;
- sweep material off travel lanes;
- second application, if necessary;
- gradually restore traffic flow;
- identify responsible party and mark location of material; and
- ensure proper notification is made to the State Warning Point.

4.5.3 Colorado DOT

According to the Colorado DOT's Guidelines Procedures for Hazardous Materials spills that occur on State and Federal highways within Colorado as a result of a highway transportation incident (State of Colorado DOT, 2005), appropriate reporting and clean-up is necessary depending on the size of the spillage. If spilled material has entered the sanitary sewer system, the local sewer authority must be informed. Appropriate actions shall be taken to protect the incident scene. The first response units shall include, but not be limited to, the following actions to stabilize the spillage and prevent from spreading and affecting additional soil and water resources:

- covering the spillage area with plastic;

- placing absorbent booms in affected water;
- placing clean soil berms and/or absorbent booms downhill of the spillage and/or between the spillage area and nearest waterway;
- neutralizing or chemical stabilizing, if appropriate; and
- diverting surface and storm water.

Spillages need to be remediated to Colorado Department of Public Health and Environment (CDPHE) and EPA approved thresholds where applicable, and requires approval from Colorado DOT in order to issue a "No Further Action" status. In cases where the adjoining soil is affected, excavation and off-site disposal is the preferred option.

4.5.4 Virginia DOT

The guidelines of Virginia DOT (State of Virginia DOT, 2000) to deal with spillages on its highways are:

- report the incident;
- determine the responsible party;
- determine the appropriate clean-up enforcement authority;
- clean up the discharge; and
- dispose of contaminated materials.

To control the discharge, the leakage or the source of spillage is stopped following procedures based upon the availability of a local fire department's equipment and training related to these activities.

The spillage is contained using shovels, absorbents and plastic sheeting. The DOT requires a minimum level of training (Hazardous Materials Operations Level) to use such containment equipment. It is also recommended to use air-monitoring equipment, such as combustible gas indicators and photo ionization devices, to provide for the health and safety of responders.

The clean-up procedures generally involve the use of granular absorbents, pads and booms, and dispersants to reduce the concentration of gasoline. The used absorbents should be placed in suitable containers and can only be disposed of in approved landfills. Containers are sealed and secured indicating its contents. The uses of dispersants are regulated.

5 Review of proprietary absorbent products: Vendor's information

5.1 Products

As a part of the literature review, a number of product manufacturers in the UK and elsewhere were contacted to gather information about their products suitable for the treatment of oil/diesel spillages on road surfaces. The products and their manufacturer's details are listed in Appendix A. The manufacturers were contacted through e-mail and telephone in order to gather information for the literature review and, if appropriate, to discuss their interest in participating in trials being undertaken under a separate project. Details regarding the chemical composition, health and safety implications, storage and handling etc, of the clean-up products described in section 5.2 and 5.3, can be found on the material data sheet (MSDS) provided by the manufacturers which are available in their respective company's websites. However the information given by the manufacturer has not been independently verified in any form due to the scope and timescale of the study.

5.2 Sorbents

5.2.1 *Imbiber Beads*

Imbiber Beads (Imbibitive Technologies Corp) are polymer based absorbent granules, which can be used to absorb a range of organic liquid spillages such as gasoline, diesel/jet fuels, etc. The polymer beads are solid (about the grain size of a salt or sugar) and non-porous. A list of compatible liquids provided by Imbibitive Technologies can be found using the link http://www.imbiberbeads.com/main/imbiberbeads_cct.php.

The company claims that the beads absorb compatible liquids into their molecular structure and swell up to three times their original diameter (up to 27 times in volume) and is hydrophobic. The beads will not release the absorbed liquid even when cut in half. There is also a reduction in vapour emission, giving a significant improvement in safety with a volatile spillage clean-up, and reducing the environmental impact.

A demonstration of the use of Imbiber Beads is shown in Figure 5-1 below,

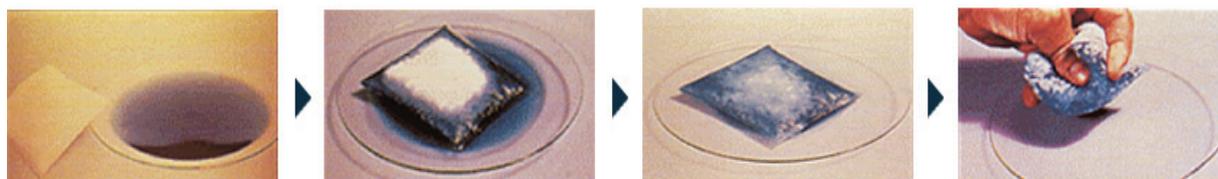


Figure 5-1: Imbiber beads in action

The company states that Imbiber Beads is the only product available that meets the F716 -82 (ASTM, 1982) and "EPA Oil Program" definitions for Absorption.

Some of the claimed benefits of Imbiber beads are listed below:

- Efficiently captures and contains organic liquids.
- Drastic reduction of potentially dangerous vapour release.
- Effective separation of oil/water (unaffected by water).
- Risk of ignition or explosions are greatly reduced.
- Ability to change colour in the presence of oils, fuels and solvents (imbicator only).
- Permanent immobilization of liquids.

- Safer storage/handling of hazardous materials.

Imbiber Beads, once used, should be disposed of as any other adsorbent, based on the existing local environmental regulation and the material adsorbed. Assessment conducted by independent bodies is provided in Product Case study 1.

Product Case Study 1: *Independent Assessment of Imbiber Beads*

Test conducted by Canada's Environmental Technology Verification Program (ETV) to verify claims made by Imbibitive Technology has concluded that the "Beads are a true absorbent and performs as the vendor states". The US Air Force conducted test through Air Force's Management and Equipment Evaluation (MEEP) Program and recommend the product for general Air Force use for spillage clean-up. The US Army Corps of Engineers states that the imbiber beads performed well during laboratory testing and are excellent absorbents (US Army Corps of Engineers, 1999).

5.2.2 Aqua N-Cap Polymer

Aqua N-Cap polymer (RTA Systems Inc) is a polymer-based absorbent to remediate and clean-up hydrocarbon spillages on water or solid surfaces. The company claims that the product can be used to treat a large variety of contaminants ranging from heavy oils to light fuels, chemicals and solvents.

Aqua N-Cap polymer is applied directly over the spillage area to absorb the diesel spilled. It then transforms the spillage into solid clusters, which is suitable for easy recovery. Heavier hydrocarbons such as crude oil will form a solid mat. A case study is presented in Product Case Study 6.

RTA Systems Inc claims Aqua N-Cap polymer is non-carcinogenic and takes 75% less product to absorb a spillage than clay based absorbent. Aqua N-Cap microencapsulated hydrocarbons are non-biodegradable, non-leachable and non-reactive. More details are given in the company website <http://www.tepcoproducts.com/>.

Aqua N-Cap Polymer is listed with the US EPA under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and may be authorized for use by Federal On-Scene Coordinators and Regional Response Teams.

5.2.3 Road Spill Organic Absorbent

Road Spill Organic Absorbent (Absorb Environmental Solutions) is a vegetable fibre-based organic absorbent. The company claims that it is capable of absorbing over five times its own weight in hydrocarbon or water based liquids. The company states it is an economical absorbent and competes successfully with other low cost absorbents such as "kitty litter". Road Spill Organic Absorbent has a lower bulk density which makes it economical to use along with the added capacity to remediate hydrocarbon spillages. It contains micro-organisms for the bioremediation of hydrocarbons, thus simplifying disposal because the spent absorbent soon turns to compost. It is a 100% natural product and is fully biodegradable. It also contains a gritty component to reduce slip and skid hazards. More details are given on <http://www.absorbenviro.com.au>.

5.2.4 KleenSweep

KleenSweep (Enretech Australasia Pty Limited), a natural, agricultural, cotton-based cellulose product for the absorption and encapsulation of hydrocarbon-based and water based liquid spillages on hard surfaces. It uses capillary absorbent technology which encapsulates and immobilises the hydrocarbon. It is manufactured from a specially treated cotton waste stream and from other natural cellulose fibres. The product is fully biodegradable and contains 97.5% recycled content.

Un-used KleenSweep can either be discarded into regular garbage, incinerated by approved agents, or biodegraded via commercial composting. However, the used product should be disposed according to the existing environmental regulation for the liquid absorbed. The company states that, under normal circumstances, if the product has been used to absorb light to medium-weight petroleum hydrocarbons, the solid mixture can usually be discarded into solid waste landfill in accordance with the local regulations.

The company claims the following benefits:

- FibreLock™ technology.
- Completely dries the floor – no secondary clean-up required.
- Encapsulates & eliminates leaching.
- Tested as to Australian, USEPA, ASTM, ISO, APHA, CGSB and other standards.
- Proven to outperform clays, polypropylene and sawdust products.
- Cost effective and reduces clean-up time by 50%.

The company also provides bioremediation products such as Enretech-1, which is a dual purpose oil/fuel absorbent and bioremediation agent for use on direct spillages or on hydrocarbon contaminated soil. It contains oil-degrading micro-organisms (no genetic modification or bioengineering) and contains all of the necessary components for microbial generation and maintenance. The company claims an average reduction in hydrocarbon levels of 82% in 77 days. More details can be found at <http://www.enretech.com.au/>. A case study is provided in Product Case Study 2.

Product Case Study 2: TPH Soil contamination - New Caledonia

61 m³ of soil was contaminated with fuel oil in New Caledonia. The initial level of the soil contamination was approximately 198,000 ppm TPH (total petroleum hydrocarbon). Enretech-1 was applied to the soil at 18 kg/m³ of contaminated soil. Tilling and moisture was added at regular intervals as per the standard application protocol. TPH reduction of 99.4% over 99 days was achieved.

5.2.5 SpillFix

SpillFix (Galuku International Pty Limited) is an organic solvent absorbent derived from coir fibre pith, a renewable resource produced as a by-product when coconut husks are processed. The range of products can be used for emergency hazardous and non-hazardous material spillages. According to the company, SpillFix can absorb and hold up to nine times its own weight in liquid due to its porous structure and large surface area created by a hollow channel structure (approximately 0.6 ha (6000 m²) in 1 L of coir). The product is hydrophobic and will remove hydrocarbons from an oil/water emulsion. One bag of SpillFix absorbent (9 kg) can absorb up to 50 L.

For cleaning oil spillages, SpillFix is applied on the spillage area until there is no free liquid or liquid migration. Sometime is allowed for SpillFix Solvent Absorbent to adsorb the spillage. The company recommends the use of spark-proof clean-up equipment if flammable liquids are involved. A suitable scoop/scrapper or broom is then used to clean-up the neutralised spillage. It does not contain carcinogenic crystalline silica (clay) or hazardous chemical and pesticide residue. It is non flammable. More information about this product can be found at <http://spillfix.com/default.html>.

5.2.6 Oil Spill Eater

Oil Spill Eater II (OSE II) is manufactured by Oil Spill Eater International. The company claims the product is environmentally safe and cost-effective bioremediation process for the removal of hazardous-waste spillages and contamination of any size, on soil, pavement and water. OSE II causes crude oil and other organic substances to rapidly

decompose, eventually biodegrading them to carbon dioxide and water. The company claims OSE II will eliminate the hazards generated by oil spillage, with no secondary cleanup requirement.

OSE II is claimed to be non-toxic to humans, animals, plants and marine life. It is non-poisonous, even if accidentally ingested, and non-irritating to the most sensitive skin. OSE II has a five-year shelf life when stored at temperatures below 120 °F (49 °C). Freezing does not harm OSE II; however, cold temperatures will reduce the reaction rate. The product is completely stable and reactive in an environment with the pH between 3.5 to 11.7.

OSE II is listed on the US Environmental Protection Agency's National Contingency Plan for Oil Spills. OSE II has been listed and utilized by the US Military's Defence Logistics since 1990. More details about this product are available at <http://www.osei.us/>.

5.2.7 Oil Eater (Spill O Sorb)

Oil Eater (also marketed as Spill O Sorb) is an absorbent product used for treatment of oil and chemical based liquids. The company claims it is produced from lightweight peat fibre which is completely natural and organic material obtained from renewable sources. The product is non-toxic and biodegradable. The company claim the benefits of using Oil Eater include:

- Efficient, environmentally safe, non-toxic and biodegradable.
- Instant soak up on land or water.
- Absorbs up to 10 times its own weight.
- A colour change from natural brown to black identifies the polluted material it has absorbed (although unclear whether it is the type or quantity of pollutant).
- Locks-on to oils on the water surface.
- Lightweight to handle, user friendly, non-slip and non-abrasive qualities.

The company states that one 25 kg bag of Oil Eater can treat a 200 L of oil spillage compared to 1000 kg of clay granules required. It also states that Oil Eater is 40 times lighter and 30% cheaper than the equivalent amount of clay granules requiring a fraction of the storage space and can be handled more easily. More information can be found at <http://www.sorbican.com/oil.htm>.

5.2.8 Biozorb

Biozorb oil eater (SpillTech) is a hydrocarbon absorbent product manufactured from premium Canadian sphagnum peat moss. The material is dehydrated through a proprietary steam process, which gives it unique absorption capacities. Peat moss is made up of small capillaries whose cells are full of water. When the peat is processed and the water is removed from these cells, the peat becomes "activated". Once "activated", the peat has a high capacity to absorb hydrocarbons into void cells which once contained water. Biozorb absorbs oil, and other hydrocarbons, with a wicking or hydraulic action that draws the hydrocarbon into the cells and encapsulates the oil. The encapsulation of hydrocarbon takes place almost immediately on contact.

The company claim the following:

- Meets Sanitary Landfill Disposal according to EPA regulations (USA).
- Meets biodegradability test ASTM G21-70 (now G21-09, ASTM 2009) and ASTM G22-76 (ASTM, 1976, withdrawn) and the paint filter liquid test (US EPA, undated b).
- Meets the toxicity characteristic leaching procedure (TCLP) outlined in US Code of Federal Regulations (Federal Government of the United States, 2009b).

- Contains no silica (silica particles are known carcinogens and are contained in clay products).
- Its ultra light weight makes it easy to handle and use, increasing workers' efficiency.
- Hydrophobic (repels water), so it will work on water and under rainy conditions.

Product details can be found at <http://www.spilltech.co.za/index.php/products/biozorb-peat-absorbents.html>. A case study is provided in Product Case Study 3.

Product Case Study 3: Diesel Spillage clean-up in Durban, South Africa

A truck and tanker had a small collision on the N2 near Edwin Swales Drive in Durban, South Africa. The guard pipes protecting the pump systems on the tanker had been damaged, spilling diesel.

The response team put containment measures in place and started placing Biozorb over the free phase product. Meanwhile, the spillage source was shut off. Once all the material was placed, the contaminated product was scooped up and placed in heavy-duty bags for safe disposal. A biological degreaser was then applied to remove the diesel stain.



5.2.9 Peat Sorb

Peat Sorb (Zorbit Technologies International) is an oil organic adsorbent produced from modified peat with a moisture content of 7%. Initially, it repels water and adsorbs oil on contact. Once the hydrocarbons are adsorbed, they are locked into the Peat Sorb and will biodegrade. Naturally occurring microorganisms and the humic acid in the Peat Sorb contribute to the breakdown of the oil products into carbon dioxide and water. Peat Sorb is lightweight for easy handling and transportation. The company states that one 25 lb bale of Peat Sorb will do the same job as 500 lb of clay, resulting in significant savings in time and labour and storage cost. A 10 L loose absorbent granular bag will absorb between 2 to 3 gallons of oil. More details are available at <http://www.peatsorb.com/>.

According to the company, the product has been tested in independent laboratories and meets the requirements of the TCLP, the paint filter test and the liquid release test (LRT). Peat Sorb is an effective vapour suppressant. The benefits claimed by the company include:

- Absorbs on contact and effective on land & water.
- Non-toxic, non-leaching, non-biodegradable.
- Lightweight and non-abrasive.
- Vapour suppressive.

5.2.10 Spill Hound

Spill Hound (Fleming Technical Limited) is a natural organic absorbent product derived entirely from renewable sources. It is a blend of natural plant fibre chemically modified to produce absorbents. It contains no clay or mineral based components. Oil is absorbed into the capillary structure and encapsulated. It does not migrate even in the presence of water or under mechanical pressure. The company states that the product can absorb solvents, oils and oil based paints and applicable for spillage containment and control even under wet or damp conditions.

The company claims that, when compared with conventional clay-based absorbents (kitty litter), Spill Hound is approximately five times faster at cleaning the spillage. It also claims that in controlled comparative laboratory tests, a measured oil spillage required 33 times more clay absorbent than Spill Hound in order to clean up the spillage. Further information about the product is available at

<http://www.spillhound.com/Spill%20Hound%20vs%20kitty%20litter.pdf>

The company also provides Spill Hound Recycling Centre and claims that that product can be recycled up to eight times. Its application includes:

- Encapsulation of hazardous hydrocarbon waste and sludge.
- Containment of oil & solvent-based paint spillages.
- Preferential absorption of oil in the presence of water.

5.2.11 Sphag Sorb

Sphag Sorb (Earth Care products) is a natural organic absorbent produced from sphagnum moss peat fibres in Canada. The company states that SPHAG SORB is 100% natural, organic and non-toxic and that it is also effective in vapour suppression. The product is compliant with Texas TCLP Test Method 1005, which is a leachate test. The product can be used to absorb and encapsulate oils, solvents, heavy metals, pesticides, herbicides and all other organic chemicals. Some of the product range contains several types of micro-organisms that can degrade aliphatic and polynuclear aromatic hydrocarbon chemicals.

Peat is a highly porous material with a porosity of approximately 95% and a large specific surface area, which gives it a greater absorption capacity than other common absorbents. The company claims that this product can typically absorb four times its own weight.

The company states that the product works by wicking action, absorbing hydrocarbons and solvents, and encapsulating these liquids on contact. Because Sphag Sorb is oleophilic (absorbs oil quickly) and hydrophobic (resists taking on water), it can absorb on land, on hard surfaces such as asphalt or concrete, in drums or tanks and on water. The product is environmentally friendly and non-toxic to plant or animal life. It meets land fill requirements of EPA and is biodegradable. For more information on the product is available at <http://www.sphagsorb.com/>.

5.2.12 Green Stuff

Green Stuff Absorbent (D2L Products) is a phenolic foam granule produced from a thermal-set plastic made from a phenolic resin compound with an open cell matrix and it is non-mineral based. The product can be used for cleaning up a number of liquids including diesel and motor oil spillage. The company states that the product is very light (90% lighter than clay) and absorbs up to 15 times its weight. It is a non-toxic and non-biodegradable. It is suitable for hazardous material waste disposal at approved landfills and for approved incineration operations. It will not leach out any hazardous chemicals into a landfill

The company claims that's Green Stuff absorbent products will typically absorb between 8 and 26 times more liquid than clay based kitty litter depending on the viscosity and weight of the liquid. Approximately 2 lb of Green Stuff absorbent is required to clean up 1 gallon of liquid. Green Stuff Absorbent does the same job ten times faster, weighs 90% less, requires 80% less storage space and costs 35% less than current clay/litter type absorbent. Further details are available at <http://www.greenabsorbents.com/>.

5.2.13 Oil-Dri

Oil Dri absorbents granules (Oil-Dri (UK) Limited) are clay based absorbents made from 100% natural kiln dried clay. They are available in both the traditional coarse formula as well as the finer grind. The product is applicable to oils, coolants, grease, water and other liquid spillages. Also available in cellulose based granular product that is made from recycled paper. According to the company, the level of silica dust in the clay absorbent granules is below the level set by the Office of Safety & Health Administration (OSHA).

The product can absorb approximately 0.58 l/kg and can be directly spread over the spillage area to allow it to absorb the spilt liquid. It can then be swept and collected for appropriate disposal. The disposal requirements are usually governed by the type of fluid that has been absorbed and the local regulation in place. More details can be found at <http://www.oil-dri.co.uk/>.

5.2.14 C.I.Agent

C.I.Agent (C.I.Agent Solutions) is a petroleum-based polymer, used to immobilize oil and oil based liquid spillages on land and water. The company claims the product is non-toxic, non-hazardous, non-corrosive and non-carcinogenic environmentally friendly product.

When the product is applied on oil spillages, it encapsulates the spillage through the rapid transformation of a liquid material into a cohesive rubber-like mass upon contact. This process can occur with a minimal volumetric increase and retains the liquid for easier removal. The company claims that the solidified mass can be used as a fuel or sold to companies that produce fillers to add strength and flexibility to their products. It can be 100% recyclable as raw material for asphalt, rubber and plastic production, or can be burned as fuel. It can also be disposed as a waste according to the existing local regulations.

The rate of application may vary with the viscosity of the spilled liquid; however, to solidify a hydrocarbon normally requires ratio of 4:1 C.I.Agent to hydrocarbon. The speed of solidification depends on the type of hydrocarbon, the amount of volatiles remaining, temperature and the viscosity of the liquid. Product Case Study 4 is shown below. The product is listed in the EPA, National Contingency List Product Schedule. More information on the product can be found at <http://www.ciagent.com>.

Product Case Study 4: Oil spillage on I 264 Overturned Trucks – Louisville, Kentucky USA

A tractor trailer overturned on the overpass of I 264 and US 31W, spilling diesel fuel onto the roadway and into a large storm drain that leads to a stream flowing into the Ohio River. C.I.Agent granules were placed at the entrance of the drain to prevent any other fuel from entering the drain. C.I.Agent marine booms were placed at several locations in the drain culvert. After the fuel was solidified on the surface, the local fire department used approximately 1,000 gallons of water to flush the diesel fuel from the drain. All diesel fuel was captured and solidified and no water was processed.

The clean-up process took about 3 h and required approximately 70 lb of C.I.Agent granules and three 6" x 24" C.I.Agent marine booms. The total cost of clean-up was estimated at \$4,685.



5.2.15 Pig Peat

Pig Peat Absorbent (New Pig Ltd) is manufactured from industrial organic peat moss and used for spillage response of oils, solvents and fuels. The company states that the loose absorbent is treated with a dust inhibiting agent in order to minimize airborne particles and help concentrate absorbent material at the spillage site. The product is sprinkled on the spillage area and can be swept up using a broom. It is not recommended for removing oils from water because the material, and anything absorbed by it, may sink over time. Some of the company claimed benefits include:

- The all-natural activated sphagnum peat moss.
- Absorbs up to 30 L of oil per 5 kg bag.
- Absorbs oil-based liquids, but not water.
- Does not leach absorbed oils.
- Incineratable.

The used product can be disposed of in accordance to the Title 40 of Code of Federal Regulation (Federal Government of the United States, 2009 b) and in accordance with federal, state and local regulations. The nature of the material recovered will determine the spent material as a hazardous material. Further information can be found at <http://www.newpig.com/>.

5.2.16 Rubberizer

Rubberizer (Haz Mat Response Technologies, Inc.) is a product classed as a sorbent used for hydrocarbon spillage treatment and containment. It contains hydrocarbon polymers plus additives. According to the company, it transforms the spilled hydrocarbon in a rubber like solid on contact and does not release the spillage contained in it. A pound of product will solidify into a rubber-like material up to 2/3 gallon of jet fuel diesel, gasoline, transformer oil, hydraulic oils, light crude and many other liquids. More details can be found at <http://www.rubberizer.com/>. Product case Study 5 is shown below. The company claimed benefits include:

- Works on land or water borne spillages.
- Light weight for rapid deployment and retrieval (specific gravity is approximately 0.4).
- Solidification in minutes and is hydrophobic.
- Permanently buoyant (both before and after sorption).
- Will not release solidified liquids under pressure.
- Minimal incineration residue (less than 0.1%).
- Little volume increase of sorbed liquids (15% in laboratory tests, nominally 25% in field applications).

Product Case Study 5: Soil Spill Highway Maintenance Department, California

Responding to a highway spillage of approximately 30 gallons of diesel fuel, on a rainy day, department employees deployed two 2.25" diameter by 20' long Rubberizer boom. These booms were placed on the spill side of the fire department berm containing both diesel and significant quantities of water. Rubberizer® particulate was spread onto the diesel floating behind the berm also. The sorbed and solidified diesel was retrieved and filled less than one 55 gallon drum.

5.2.17 Oko-Pur

Oko-Pur (Airbank, Italy) is an absorbent product to absorb oil, grease, petrol, gas oil, paints and chemicals. The product is available both as powder and as granules. According to the company, 8 kg OKO PUR can absorb up to between 30 and 80 kg of liquid depending on the viscosity of the spilled liquid. The product is hydrophobic (can absorb oil in water). The product is approved by German Ministry of Transport in terms of road safety. More information can be found at <http://www.airbank.it/>. Oko-Pur coarse granules can be used on roads and other traffic areas under adverse conditions (wind, rain, etc.). Some of the company claims include:

- It is hydrophobic and retains the oil.
- It floats on the water even when saturated.
- It is harmless for the flora and the fauna.
- Certificated by German hygiene's office and from the control authority of the MPA-NRW materials.
- It absorbs between 3.7 and 10 times its own weight, according to the product with which it is dealing.

5.2.18 Isol8

Isol8 (Environmental Absorbents) is an oil/diesel spillage treatment product manufactured from renewable organic resources. According to the company, Isol8 possesses a fibrous honeycomb structure, thus locking in spilled liquids and preventing leaching. It is non-abrasive and is suitable for cleaning hands as well as most types of surfaces. The product is manufactured from 100% recycled natural material. The product is environmentally friendly and can be incinerated as a way of disposal of the used product. The company claims that one bag weighed approximately 1.4 kg (10 L) can absorb approximately 7.5 L of oil. Further information can be found at <http://www.isol8.co.uk/index.htm>.

5.2.19 Absodan

Absodan (Steeley Bentonite & Absorbents Ltd/TOLSA UK, Ltd.) is a granular absorbent for controlling and treating spillages on roads. According to the company, the product remains granular even when saturated. The granules are manufactured from

microgranular Danish moler clay which has a high surface area to volume ratio. They may generate some dust, as with any other clay based absorbent. The company claims they are certified for European Road Safety. The used product is advised to be stored in sealed containers before disposing off in accordance with the existing local environmental regulations. There is a range of products from this company suitable for use on diesel/fuel spillages on roads including Superwhite Multizorb, New Safety Tread, and E-Sorb. Some of the products from this company are marketed as ACRO Absorbent granules.

Road Service Direct (RSD), an Executive Agency within the Department of the Environment for Northern Ireland, has a tender award in place for the supply of absorbents from Arco International. Further details of the product can be found at <http://www.arco.co.uk/>.

5.2.20 Eliminator Absorbents

Eliminator Absorbents (Ross Environmental Products Limited) is an absorbent used for treatment of fuel and other liquid spillages. The product is manufactured from reclaimed cotton fibres, nut pith with hydrocarbon eating microbes. According to the company, it absorbs oil based liquids and most chemicals while repelling water. It encapsulates and begins bioremediation of the absorbed fuel spillage, converting hazardous hydrocarbons into water vapour and carbon dioxide. Once the spillage is absorbed, it is prevented from leaching up to saturation point. Some of the company claims include:

- Absorbs up to eight times more than the clay based absorbents.
- Reduces volatility of flammable spillages.
- Passes the European three-point directive for landfill disposal.
- Recyclable in conjunction with a spill station.
- Certified 100% bio-organic material makes it safe for the environment.
- Eliminator Absorbent passes EPA Paint Filter and TCLP tests.

According to the company, there is no cost for collection and disposal of the used absorbents because they become available for re-use after the bacteria have bioremediated the oil into carbon dioxide and water. Traces of oil remaining after the application of the absorbents can be removed using Eliminator Degreaser, a bacterially active degreaser. The surface can be washed off using the product and allowed to run down the drains because the products will bioremediate the oil spillage absorbed. More details of the product can be found at

<http://www.rossenvironmentalproductsltd.co.uk/index.htm>.

5.2.21 Stardust

Stardust absorbents (Paradigm International Inc.) are manufactured from wholly processed inert inorganic mineral, amorphous alumina silicate. According to the company, a larger surface area is achieved when compared to their volume because of the amorphous structure of Stardust absorbent granules. The product instantly absorbs liquids of various viscosity including chemical, mineral, petroleum, animal, and vegetable oils. When the product is applied to spillages, it turns them into solid. It can be then swept with a broom and collected for disposal. The company claims the product is not injurious to humans, animals, soil, concrete, asphalt, tiles or plants. It contains no reactive chemicals, non-toxic, non-flammable, or biodegradable. More information about this product can be found at <http://www.stardustabsorbent.com/stardust.html>. Some of the company claimed benefits include;

- 7 to 20 times the absorption capacity of clay-based products.
- Non-selective, eliminating the need to stock a wide variety of absorbents.
- Unlike clay-based (kitty litter-type), it does not qualify as a carcinogen nor as a substance causing silicosis.

- Meets EPA standards for the TCLP (Toxicity Characteristic Leaching Procedure) test and Liquid Release Tests (LRT).

5.2.22 Oil Solidifier

Oil solidifier is an "Oil Gelling" agent capable of treating oil spillage response and leaked oil in various fields. Gelling agents are chemicals that react with oil to form rubber-like solids. The solidifier is different to conventional products such as oil absorbents or oil dispersants. It can solidify the oil spillages just like rubber within only a few minutes to an hour of application as shown in Figure 5-2.

Solidifiers are dry high molecular weight polymers that have a physical attraction to oil. Non-polar hydrocarbon polymers are attracted to non-polar petroleum hydrocarbons, thus they prefer to be oil-wet rather than water-wet. They are soluble in excess liquid (solvent) but, with continued application, will increase the viscosity of the oil to the point that it forms a solid mass. Currently, oil solidifier products in the USA should meet the criteria prepared by the National Response Team, which are available at <http://www.epa.gov/oem/docs/oil/ncp/SorbSolidifierFactsheet2007finalV6.pdf>,

Some of the manufacturer's claims include:

- Insoluble in water.
- Specific gravity of less than 1.0.
- Composed primarily of polymers (with few other additives).
- Contain less than 5 ppm of heavy metals and chlorinated hydrocarbons.
- Do not release solidified liquids under pressure.
- Product itself is nontoxic to wildlife and other species.

The US EPA (2009) states that large quantities of the material must often be applied, as much as three times the volume of the spillage, thus making it impractical for large spillages and sometimes uneconomical. There are a number of companies that produce oil gelling based oil solidifiers and some of them are listed here:

- Extol Hydro Technologies Ltd <http://www.extolhydro.com/>
- American Products Enterprises Corporation <http://www.americanproducts1.com/>
- Climate Clean-up Group <http://www.oil.spills.climatecleanup.com/>



Figure 5-2: Oil solidifier in action

(Source: <http://www.extolhydro.com/>)

5.3 Detergents/Degreasers

5.3.1 TERRACAP 3000/4000

TERRACAP 3000 and 4000 additives (RTA Systems Inc) are used to remediate and clean-up fuel, oil, and other hydrocarbon spillages from hard surfaces. The products are non-

hazardous liquids that use a microencapsulation* process in which the hazardous characteristics of the waste are quickly eliminated. This two-part solution rapidly desorbs, emulsifies and binds spilled materials into a solid, inert, stable residue resistant to water leaching. The resultant silica (sand) matrix effectively locks the hazardous components into a stable, environmentally-safe residue. The company outlines a two-step process for the application of the product:

- STEP 1: The TERRACAP 3000 Additive, which has a strong affinity for hydrocarbons, reacts within seconds when applied to a spillage.
- STEP 2: The TERRACAP 4000 Additive is applied as a curing agent immediately following application of TERRACAP 3000 to create a solid residue.

TERRACAP 3000/4000 is typically applied at a ratio of 1:1:1 (3000:4000:contaminant) on a volume basis. The by-products of the treatment are 40-45% (by volume) solid silica residue and 55-60% water. Both the solid residue and the water achieve neutral pH. The residue is non-leachable, non-extractable and does not retain any of the encapsulated hydrocarbon characteristics. According to the company, the product contains no hazardous ingredients as defined by OSHA in Title 29 of Code of Federal Regulations (Federal Government of the United States, 2009a). More details of the products are given at <http://www.tepcoproducts.com/>. Product Case Study 6 is an example of the use of this product.

Product Case Study 6: Oil spillage I-35, Oklahoma City

In an incident involving a tractor trailer had spilled more than 75 gallons of diesel on the I-35 in Oklahoma City. An Environmental service contractor, Boomer Environmental, contained the spillage by applying Aqua N-Cap polymer granules. The source of the spillage was plugged and the truck was towed off. The contractor spread the absorbents into the spillage areas. A total of 80 lb of the product was applied and allowed to absorb the diesel. The contractor then swept up the used product and placed it into containers. The entire diesel was absorbed but some diesel had soaked into the asphalt, creating a strong diesel odour and residue.

Following a request by Boomer Environmental, RTA Systems applied the TERRACAP 3000/4000 additives to the spillage areas including a 2 ft wide by 300 ft long (0.6 m x 90 m) strip of highway where the truck had leaked. The TERRACAP 3000 additive was successfully applied to eliminate the residual diesel smell. The TERRACAP 4000 additive was spray applied within 1 to 2 min following the TERRACAP 3000 additive application to complete the diesel micro encapsulation process. The total time for application was 20-25 min. Boomer Environmental used a Bobcat street sweeper attachment to clean-up the solid residue.

Aqua N-Cap was applied by hand at a rate of approximately 1-1.5 lb/gal and approximately 80 lb were used. The TERRACAP 3000/4000 additives were spray applied at a rate of 2 gal/min at 25-30 psi using a fan nozzle.

5.3.2 Road Bio

Road Bio (Oil Technics Limited) is a spill detergent that removes oil spillages from road surfaces, without causing an emulsion or contributing to surface erosion. The product is a blend of biodegradable surfactants and is non flammable low foaming aqueous cleaning agent designed for the removal of oil spillages on roads and highways.

The product may cause serious damage to eyes and irritation to skin. The company sources states it is not classified as hazardous to environment. The product is stored ideally between -5 °C and 50 °C. The product is to be disposed of in accordance with the local regulations via an approved waste carrier.

* Microencapsulation process is a two-step process that encloses contaminants on a molecular level in an inert amorphous silica matrix.

The product can be applied using a brush or by jetting. For brush applications, the product should be used neat or diluted 1:20 on the spillage area at a rate of 0.5 l/m² of Road Bio. For jetting applications with a back-pack, a dilution of between 4 and 8% should be applied at a rate of 0.5 l/m². Road Bio should be poured over the spillage, brushed in and left for 5-10 min before rinsing off with a clean water jet. Product Case Study 7 is provided.

The Company claims that the product is also approved by German Ministry of Environment Umweltbundesamt (UBA). It was also assessed by Rijkwaterstaat (Dutch Road Authority) in 1998-99 for its cleaning effectiveness, road erosion, environmental aspects and pricing (Section 6.2.2). The results showed that Road Bio as an excellent road surface cleaning agent. Further details can be found at <http://www.oiltechnics.co.uk/Approvals/OTL/DutchRijkwaterstaat.pdf>.

Product Case Study 7: Cooking oil spill on the Dublin M9

According to a letter from SSI Environmental, Ireland of the company's website, 7 tonnes of cooking oil had spilled on the M9, Carlow to Dublin road. The contractor requested for products available to break down cooking oil that would not affect the road surface. Sand was applied on the road which had no effect on it at all.

The contractor had two tanks, each with a 1000 L of water on an open back truck with a generator. This water was then mixed with Road Bio to a ratio of 15:1 (water: Road Bio) and applied to the spillage. The product broke the oil down immediately. From the time Road Bio was applied, the road was reopened within 6 hours



5.3.3 Petro Clean

Petro Clean (Alabaster Environmental Corporation) is a product used for the treatment of any hydrocarbon or fuel spillage. Petro-Clean contains surfactant, nutrients and hydrocarbon degrading bacteria. Petro Clean is a pH-neutral blend of non-ionic surfactants and emulsifiers. The company states that it can be used effectively with microbial or bioremediation products. According to the company, it can immediately break up the spillage on contact encapsulating and render the spillage non-flammable.

Petro-Clean Concentrate is mixed approximately one part product and nine parts water to treat fuel spillages. The product should be sprayed evenly over the fuel spillage area and flushed with more water. Petro-Clean is normally applied through power washers or even garden-type sprayers in diluted solution under any environmental condition and acts like a general degreaser. The manufacturer estimates that the product contains active microbes at approximately 50 billion per gallon. Product Case Study 8 is given.

The company claims that the product is accepted by the Florida Department of Environmental Protection for remediation of petroleum contaminants in groundwater and soil, in situ and ex situ. Petro Clean is on the US EPA's NCP product schedule as a surface washing agent. More information in regard to this product can be found on the

web site of EPA Oil Spill Program at <http://www.epa.gov/oilspill> as well as on the company website at <http://www.alabastercorp.com/petroclean.htm>.

Product case Study 8: US Army Contracting Command Overseas Remediation

Large amounts of hydrocarbons had accumulated around and underneath various large cemented areas as well as within soil or non-cemented areas in an overseas US Army Military Base due to years of accumulation. The total TPH ranged from minimal detection levels to well over 100,000 mg/kg. The concrete itself had a saturated amount of hydrocarbons accumulated within it. Very large volumes of bioremediation products were supplied, including products BCC#1 Concentrate (Sold as CS2 or Super Concentrate) and microbial blend AB with Booster. The US Army Contracting Command indicated that satisfactory remediation of the spillage affected areas had been achieved.

5.3.4 Bio route

Bio-route (Field International UK Limited) is a biodegradable surfactant for treating oil and diesel spillages. The product is suitable for removal of oil and diesel spillages from asphalt and other porous surfaces. According to the company, when the product is applied on oil spillages, it immediately starts to release oil from the surfaces allowing the enzymes to digest the oil and jetted off with water. Even after jetting off with water, it will continue to break down the oil, speeding up the process of degradation, which in turn supports the environment. Its application includes asphalt surfaces, including roads, driveways, car parks, footpaths and other areas.

Some of the company claimed benefits include:

- 100% bio-degradable.
- Ecologically and environmentally friendly.
- Safe under Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP) and control of substances hazardous to health (COSHH).
- Free from hazardous chemicals.
- Breaks down hydrocarbon spillages.
- Harmless to animals and humans.

According to the company, the product is applied on the area of the diesel/oil spillage and then brushed. It is then left for 5-10 min before rinsing with a water jet. 1 L can clean approximately 20 ft². More information on this product can be found at <http://www.biofield.co.uk/>.

5.3.5 Bio-Zyme Road Wash

Bio-Zyme Road Wash (Bio Zyme) is a surfactant for removing diesel and oil spillages from roads and other surfaces. It removes oil spillage on roads without causing emulsions. According to the company, use of Bio Zyme has no risk to the environment.

Some of the company claimed benefits includes,

- Removes hydrocarbon spillages rapidly.
- Free from hazardous constituents
- Non-flammable
- Quick Break and forms no emulsion or foam.

The product is applied on the area of the diesel/oil spillage and then brushed. It is then left for 5-10 min before rinsing with a water jet applied through jetting or spray. 1 L can clean approximately 2 to 2.5 m². More about the product can be found at <http://www.blue-diamond.co.uk/products/Biozyme/roadwash.html>.

5.3.6 F500 Argosfire

F-500 (Argos Fire Protection Services) is a Micelle Multipurpose Encapsulator agent known as a fire suppression product in the municipal fire department market. According to the company, F-500 is used in a variety of applications from the extinguishing Class A and Class B fires, to polar and non-polar solvents, soil washing, surface washing and bioremediation enhancement. For use on treating diesel spillages on pavements, F-500 is mixed with water in a ratio of 1:8:32 (F-500: spilled diesel: water). The company states that the F-500 will act on the immediately encapsulating the spilled diesel. F-500 can also be used in hazardous spillage control and vapour suppression. The company also claims that F-500 is the only carbon footprint reducing fire suppression product available. The company states the product can be applied through portable equipment or fixed system applications. More details can be found at <http://www.argosfire.co.uk/>.

5.4 Cost Comparison

An attempt has been made to provide the cost in terms of unit quantities of the product despite the variability in the absorption capacities and the amount of product required to treat a spillage area. However in some cases, the costs for treating a certain amount of diesel are provided direct. The costs provided in Table 5-1 were calculated from the cost obtained from the respective manufacturers but are not always comparable.

The cost of the product should not be viewed in isolation because the amount of product required and treatment effectiveness are also important factors that need to be considered. A more effective product could have advantages in a number of ways including:

- Less product required, reducing the waste material to be disposed of. The cost of disposal for a tonne of the used absorbent granules is approximately £645 (including documentation but excluding VAT <http://www.envirogreen.co.uk/>).
- Higher absorbency will reduce the amount of material to be carried by the ISU, easier to handle, hence likely to increase efficiency.
- Faster treatment of spillages reducing the duration of closure and increasing the JTR. This will reduce cost of traffic delays and congestion.
- Avoids the need for surfacing replacement completely or at least delays the replacement to an off-peak period.

Table 5-1: Basic cost of the diesel spillage treatment products

Product	Product cost (from Manufacturer)	Claimed absorption per kg/L of the product
Imbiber Beads	1 kg for £9.2	up to 4 L
Aqua N-Cap™ Polymer	1 kg for \$19.8 = £13.0†	up to 4.16 L
TERRACAP™ 3000/4000	1 L for \$10.0 = £6.6†	treats up to 10 L of diesel*
Road Spill	1 kg for \$2.75 = £1.8†	over 5 times its weight
Kleen Sweep	1 kg of ENR012 1 for \$4.85 = £3.2†	Not available
	1 L of ENR022 for \$3.48 = £2.3†	Not available
SpillFix	1 kg for £2.78	up to 5.55 L
Oil Spill Eater	1 L for \$26.43 = £17.4†	treats up to 50 L of diesel
Oil Eater (Spill O Sorb)	£1.95-£2.10 for 10 L spillage	up to 8 L
Spill hound	1 kg for £3.97	up to 3-3.5 L
Sphag Sorb	1 L for £0.46	typically 4 times its weight
Green Stuff	1 kg for \$2.54 = £1.7†	up to 15 times its weight
Oil-Dri	1 bag (15L) for £2.25	up to 0.58 L
Pig Peat	1 kg for £1.0	up to 6 L
Isol8	1 L for £0.4	up to 0.75 L
Absodan	1 kg for £0.6	Not available
Eliminator	1 kg for £1.28	up to 5 L of 40w SAE Oil.
Road Bio	1 L for £0.42 to £0.78†	2 m ² spillage area
Petro Clean	1 L for \$4.5 = £3.0†	Not available
Bio Zyme	1 L for £2.4	2 to 2.5 m ² spillage area

* After the spillage is initially absorbed with an absorbent

† Using an exchange of £1 = \$1.5218, as on 7 April 2010

6 Review of diesel spillage clean-up: Non-vendor's information

6.1 Information from County Councils and Maintenance Area Contractors

6.1.1 Surrey County Council

Spillage reporting system: Incidents occurring in Surrey County Council are reported via the contractor's Incident Call Centre. Once the site is visited, any closures required needs to be agreed with senior County staff.

Absorbent product used: The Council uses proprietary absorbent products such as Spillex and Stardust (see Section [5.2.21](#)) absorbents for minor diesel spillage clean-up. No independent assessments have been carried out to check the manufacturer's claims. However, the Council expressed the view that Stardust is a good product and very absorbent. According to the Council, the ability to recycle unused Stardust product is an added advantage. Large incidents are contracted to specialist companies.

Clean-up procedure and disposal: The Council follows the manufacturer's recommended procedure to apply the product to the spillage areas. The used products are disposed of in accordance with the environmental regulations.

6.1.2 Department of the Environment, Northern Ireland

Spillage reporting system: All spillages are reported firstly to the Roads Service Direct (RSD) local network maintenance section office, usually by telephone during normal office hours. Any spillages outside normal hours are picked up via the emergency telephone system. The local section staff or the emergency operator will transfer the call to the local RSD depot or the duty after-hours supervisor for action. The supervisor will assess the situation and will either deal with the spillage directly or will involve other agencies, such as the Northern Ireland EA or the FRS, as required.

Absorbent product used: RSD is currently using spillage treatment products supplied by Acro International under a tender award in place.

Clean-up procedure and disposal: Currently there is no clean-up procedure in place but RSD, in conjunction with the Roads Service Network Maintenance Sections, are currently drafting a procedure for dealing with spillages on the highway that is to be based on Pollution Prevention Guideline 22 (EA *et al*, 1999). Various methods have been used depending on the size of the spillage. Localised spillages of a large quantity of material are normally contained and absorbed by the proprietary products or by the use of sand and sandbags. For long lengths of spillages, either gritters with sand are used to give the road surface traction or detergents to wash the oil spillage of the surface sprayed from mobile sprayers. In both these operations, the material is not collected for disposal.

According to RSD, proprietary absorbents are effective for clean-up of small spillages, which can be contained in an area. The sand spread used on large spillages gives grip and prevents vehicles from skidding and the action of the vehicle tyres will result in the road surface being cleaned and the material being displaced to the verge. The detergent cleans the oil and again with the action of the vehicle tyres the material is displaced to the verge.

Any collected hazardous wastes are returned to the local RSD depot and subsequently disposed of via a Customer Service Agreement with the Disposal Services Agency and their nominated waste contractor. All disposals comply with the Duty of Care and Hazardous Wastes Regulations (Houses of Parliament, 1991b).

6.1.3 Managing Agent Contractor for Area 3 (Enterprise Mouchel)

Spillage reporting system: Spillages are recorded by the Incident Support Units and are entered onto the Network Control Centre Report. Locations of spillages are recorded with reference to marker posts along the highway. This data is then geo-coded to establish coordinate values, and then a point file is created in MapInfo to display graphically the locations.

Absorbent product used: The proprietary absorbent product currently used is Safety Tread absorbent clay granules supplied by Parkers. The company is also trialling "Zorb", which is claimed to be 100% environmentally friendly and has been issued to specific crews in the HA Area 3.

6.2 Diesel spillage clean-up and effectiveness: Comparative studies

6.2.1 KillSpills/IHIE diesel spillage clean-up survey, 2008

An electronic diesel clean-up survey was conducted between 28 August and 30 September 2008 by KillSpills (The Motorcyclists Union, 2008). The survey was aimed at collecting information regarding various options and products used to clean-up diesel spillages on road surfaces by Local Authorities and Emergency Services. There were a total of 102 replies out of which 82 confirmed having an in-house diesel-spillage clean-up policy. The results of the survey are reproduced in Table 6-1.

Table 6-1: Killspills survey result summary.

Choice of sorbent	1 st	2 nd	3 rd	4 th	5 th	6 th	Total
Sand	42	0	0	0	0	0	42
Absorbent granules	27	26	11	1	0	0	65
HSE spillages kit	6	4	1	0	0	0	11
Grit stone dust	5	9	0	0	0	0	14
Water	3	0	0	4	1	1	9
Clay mat	2	4	2	1	0	0	9
Cement	1	2	0	0	0	0	3
ELCEF fibre coconut husks	1	0	0	0	0	0	1
Absorbent mats	0	5	12	5	1	0	23
Salt (grit salt)	0	1	0	0	0	0	1
Soil/Earth	0	1	0	0	0	0	1

From the survey results, it was noted that sand was the most popular material used to clean up diesel spillages as a first choice followed by absorbent granules. However, absorbent granules were the most widely used after sand followed by absorbent mats.

Among the sand users, the majority of them use whatever sand is available to them at the time, followed by building sand, sharp sand and grit based sand. Respondents used absorbent mats mainly for localised spillages and preferred sand for larger areas, generally spread using gritters. It was also observed that higher cost of the absorbents products could have an impact on the choice of sand over absorbent granules and pads. A number of County Councils have found absorbent granules very effective, working satisfactorily in all weather conditions.

Devon County Council use grit dust as the first choice to clean-up diesel spillages and, according to the studies conducted by the Council, it provides an effective and a cheap option and improved grip post-treatment compared to sand.

It was concluded from the study that different road authorities use different products to clean-up diesel spillages with mixed effectiveness. Some authorities have spillage clean-up procedures in place while others do not.

The observation of the survey information in the report is that the popularity of sand may well have been based on cost and availability of material rather than on treatment effectiveness and overall cost implications. However, it is not clear whether this information was requested in the KillSpills survey.

6.2.2 Dutch study

A study in 1998-1999 (Rijkswaterstaat, undated) aimed at testing the effectiveness of liquid cleaning agents to be used on Dutch motorways, where the surfacing is generally porous asphalt, known there as 'Zeer Open Asphalt Beton' (ZOAB), to clean-up oil spillages. Due to its open texture, oil spillages can easily get into the pores and affect the bitumen. Absorbent granules are less effective and cannot be used on ZOAB.

In total, 20 cleaning agents were tested during this trial. The products were tested for their effectiveness, damage to bituminous road surface and impact on the environment such as soil and groundwater. Cost of the product was also taken into account during the assessment.

The effectiveness of the product was based on the removal of the oil from a ZOAB road surface using the modified Baumgartner test. The test determines the proportion of oil that can be removed from a glass surface by a cleaning agent. Damage to the bituminous road surface was assessed in terms of changes to the properties of the binder. The ZOAB cores were subjected to diluted cleaning agent for 6 days and binder penetration was determined on the recovered binder. Environmental assessment was done in terms of disintegration, mobilisation, pH value, presence of organic solvents and toxicity in the soil.

Based on the results of the Dutch study, weighting factors were assigned and based on the overall scores, cleaning agents were classed excellent, good or not acceptable. The list of the products tested and the final result of the assessment are reproduced in this report and shown in Table 6.2.

6.2.3 Jacobs study

Jacobs UK Limited conducted research in 2008 aimed to study the 'Effect of diesel spillage on Thin Surface Course System (TSCS)' for the Highways Agency (Jacobs UK, 2008). The effectiveness of absorbent techniques and effect of diesel on TSCS were assessed during the study. The following absorbent materials were evaluated:

1. Kiln dried sand;
2. Elcef fibre;
3. Hy sand Sealspill;
4. Eski dry granules; and
5. Industrial detergent and water.

Slabs of TSCS and Hot Rolled Asphalt (HRA) were manufactured and the test surface was soaked with diesel for two hours. The mass of each specimen was measured before and after soaking. Texture depth and skid resistance was measured before and after the absorbent granules were applied on the test surface and swept clean. Scuffing test and wheel tracking test were also conducted after conditioning the test specimens.

It was concluded from the study that none of the products used absorbed significant quantities of diesel from the pores. The surfaces were found to be slippery even after treatment with pendulum test values of less than 40. Washing with industrial detergent and water was reported to be most effective but termed unsafe for traffic. Texture depth was affected by the diesel and treatment had the effect of clogging the pores of the TSCS surface. Mass loss was also reported to be significant and the probability of surface failure was less than 7 days.

Table 6-2: Result of comparative study in the Netherlands

Cleaning Agent	Cleaning Effectiveness	Erosion	Environmental Aspects	Price	Final Assessment
Bio Nonex	A	C	B	C	B
Oil Control	A	C	C	C	C
Chrisal	A	C	C	B	C
Eco-press	B	B	C	C	C
TriStar	B	A	C	B	C
WAF	B	A	C	A	C
Lavor	B	B	A	A	A
Vetrij	B	C	A	A	A
Corvet	B	A	C	A	C
Aqua-sol	B	A	A	C	A
Indufoam	B	A	A	B	A
Slikoff	B	A	C	B	C
TurcoPlaudit	B	B	B	A	B
OilX	B	B	B	C	B
Super Tec Clean	B	A	C	C	C
Soix25	B	A	C	C	C
ElynolBI	B	B	B	B	B
Aquaquick	B	A	C	B	C
Road Bio	B	A	A	A	A
Q-4D	B	C	C	B	C

Note: A= Excellent, B=Good, C=Not Acceptable

6.2.4 Highways Agency's diesel trials: Ongoing study at TRL

TRL have been contracted by the Highways Agency to conduct trials for diesel absorption in order to investigate the effectiveness of proprietary absorbents currently available on the market in clean-up of diesel spillages on highways. The trials, which are on-going, are looking into suitable products and application procedures that may prevent replacement of the sections of road affected by diesel spillage and return the pavement in serviceable condition or delay the works to an off peak period to minimise traffic congestion and delays. From a review of literature during the study, three absorbent granules and three washing agents were selected for the trial on a newly laid thin

surfacing course (TSC) section 40 mm thick on the TRL test track. Products selected for the trials are given in Table 6-3 below:

Table 6-3: Products tested during HA’s diesel absorption trials

Product type	
Absorbent granules	Washing agent
Imbiber Beads	Argos F-500
SpillHound	Road Bio
Orb sorb (control)	Solve Free
Sphag Sorb	Newpig Safety Tread
Isol8	Spill Sorb

The trial site was divided into test areas of 1.5 m long and 1.5 m wide, which were then referenced alphanumerically. The alphabet signifies the product type and the number refers to a specific test area. Each product was trialled on four test areas where diesel was spilled and cleaned up after 15 mins, 30 mins, 60 mins and 120 mins by applying the selected proprietary products. The trials were conducted with the assistance of the product manufacturers and under the supervision of independent Incident Support Unit (ISU) staff. All the activities were timed and recorded.

The trial typically involved the following methodology,

1. Pre-trial measurement of the test areas in terms of texture depth and surface friction using standard assessment techniques.
2. Spillage of diesel (2 litres) on each of the test areas.
3. Application of the products, individually and in combination of a washing agent and imbiber beads after the stipulated time intervals.
4. Assessment of the duration for which the product must be left on the spillage area, after application and before clean-up.
5. Clean-up of the used products. Absorbent granules were swept using stiff brooms and collected by shovels. Where washing agents were used, effluent was collected using a wet vacuum.
6. Extract cores from each test area for visual and laboratory assessment (binder properties).
7. Post-trial measurement of the test area for surface friction.

The application and the clean-up procedures followed for each of the products trialled were in accordance with the guidance provided by the manufacturer and agreed by the ISU team. At the time of writing this report, on-site trials had been completed and the laboratory tests are in progress. The results of the trial are likely to be produced shortly.

The method developed for these trials is being evaluated as a predictor of product effectiveness and could form the basis of an assessment procedure for other products for use on the highway in the future. It is expected that the outcome of the project will be a Guideline document for use by Incident support Units in the treatment of all spillages. This document should identify best practise for the application of absorbents together with a ranking system for the products tested. It is anticipated that this project will be completed by the third quarter of 2010.

6.3 UK Environment Agency’s views

The UK Environment Agency (EA) was contacted to seek its views and advice on the proprietary absorbents materials and washing agents that can be used to clean-up diesel

spillages on highways. As a general principle, the EA always advise on complete containment and subsequent correct waste disposal over washing materials away, regardless of how 'non-polluting' the clean-up products claim to be. The EA promotes containment as the best practice and its long-standing partnership with the FRS is based on providing pollution prevention equipment to contain spillages and clean-up products for disposal not for washing away.

Inert or non-polluting sorbent products in a powder/granular form or bioremediation products that contain natural bacteria which break hydrocarbons into carbon dioxide and water may be acceptable to the EA. A small quantity of sorbent may be left on the spillage area to soak up any residual diesel in order to prevent it from further degrading the road surface.

The EA advice discourages the use of washing agents because it can present a potential risk to the environment and cause secondary contamination. It is often difficult to assess the risk associated with the effluents and it depends on many variables which may not be easy to identify on site. When washing agents are used to clean-up spillages, no effluent must be allowed to enter the drainage system. The effluents should be collected and disposed of according to the regulation to avoid any possible risk to the environment. The EA expressed its concerns about the possible misuse of these washing agents which could lead to pollution of the water environment. However, if robust contractual agreements could be established between the HA and its contractors, the application of washing agents could be considered in dry weather conditions only, or by emergency services in major incident scenarios where the treatment would have strict controls on containment.

6.4 French practice

6.4.1 General

Similar to the UK, the problems related to the spillages of hydrocarbon on roads in France are acknowledged. However, compared to the UK, there are a number of guidelines available in France to assist the road owners and the emergency incident support units dealing with spillages. The information contained in this section has been extracted from the translation of a French document guidance Note (CETE de l'Est, 2001).

6.4.2 Regulatory requirements

A working group, chaired by Road and Motorway Technical Studies Department (SETRA), has conducted a number of investigations and proposed regulatory measures to control the use of absorbent products to treat spillages. A series of circular produced by the Ministry of Public Works, Transport and Housing (MetI-DR) and the Directorate for Road Traffic and Safety (DSCR), (dated 8/03/99, 29/11/99 and 17/02/00) describes the results of investigation on absorbents and outline the conditions of application of these absorbent products on the national road network.

In accordance with the methodology defined in these circulars, the absorbent products are required to be labelled accordingly and to have a chemical signature. The measurement of the absorbent capacity of these products must be carried out following the standard 'Essais des eaux-Determination du pouvoir absorbant tous liquides'.

Specification for absorbents to be used on spillages occurring on roads is covered under NF P 98-190, Material et Produits de la route, "*Produits Absorbants Destines a un usage Routier*". This specification had been developed by road and motorways operators, suppliers and distributors of absorbents, and technical representative of various ministries.

The authorisation of products for application on national road network is defined by the MetI-DR and the DSCR. The list of authorised absorbents is available from SETRA, Direction d'Etudes, "*Techniques de construction de chaussées*". The manufacturers are obliged to provide product security sheet (FDS) and the detailed technical sheet of the product, defining in particular the conditions of usage of their products.

6.4.3 Clean up procedure

The following procedures are followed when cleaning hydrocarbon spillages on the national road network:

- confine the spill;
- mark the spillage area to prevent traffic usage;
- apply the absorbent product in sufficient quantity and mix it with a brush;
- allow to work for 15 to 20 minutes depending on the weather conditions and the type of the absorbent product;
- recover the used absorbents with a brush;
- repeat the process if there is a significant amount of pollutant remaining; and
- sprinkle the treated surfaces with a maximum quantity of 30 g/m² of absorbent products to remain on the road before re-opening to traffic.

In France, the hydrocarbon spillages on the road surface are generally less than 100 g/m² except where fuel tanks ruptures or fuel tankers are involved. Such spillages do not require significant quantities of absorbents and the following quantities are given for reference but not in absolute terms, depending on the absorbent capacity:

- 100 g/m² of absorbent product with an absorbency of 100%.
- 30 g/m² of absorbent product with an absorbency of 300%.

6.4.4 Re-opening to traffic

In cases of significant hydrocarbon spillages, after treatment and before re-opening the road to traffic, the technical body of the Ministry of Equipment must be informed, who will then decide if the road is suitable to be re-opened to traffic based on the integrity of the surface layer and the friction offered by it. The treated surface roughness measure with a friction pendulum, in accordance with NF P 18-578, should have a minimum value of Skid Resistant Value Test (SRT)_{before treatment} ≥ 0.90 SRT wet surface_{after treatment}, i.e., a temporary maximum decrease of the surface friction by 10% is tolerated.

7 Review of accident data

7.1 Introduction

This section describes the various accident data sources and provides an analysis of these data and gives an estimated value of the prevention of these accidents.

The vulnerability of motorcyclists compared to other road users is well recognised. Although there has been a general rise in motorcycle traffic since the 1994-98 average baseline the motorcycle casualty rate for all severities has declined (DfT, 2009a). There has been a smaller decline in motorcyclist fatalities per 100 million vehicle kilometres. The number of reported killed or seriously injured (KSI) was 7% lower in 2008 compared with the 1994-1998 average baseline, while the number of motorcyclist fatalities increased by 5.5% over the same period. When accounting for the increase in motorcyclist traffic (44% in 2008) the fatality and KSI rates have fallen over this period.

Motorcycling accounts for 1% of all road traffic in Great Britain. However, the relative risk of a motorcycle rider being killed or seriously injured per kilometre travelled was 57 times higher in 2008 than for car drivers (DfT, 2009b). Motorcyclists form 19% of all reported road traffic fatalities.

KillSpills are a small voluntary group of motorcyclists who campaign for the reduction of diesel being spilled onto the roads. Research carried out by KillSpills (The Motorcycle Union, 2007) found that, in the period 2000 to 2005 in the UK, there were 3,000 accidents involving all vehicle types in which 617 road users were either killed or seriously injured that could have been related to the spillage of oil and/or diesel onto the road. Also, KillSpills claim that there has been a 69% reduction in oil and/or diesel spillage related motorcycle accidents in the past six years through improved rider awareness highlighted by their various publicity campaigns.

This report provides a comprehensive overview on the number of motorcycle accidents that may have been attributed to oil/diesel spillage on the road. The various accident databases and sources of accident information that have been used for this study are described in Section 7.2 and include STATS19, the On the Spot Accident Database (OTS), Motorcycle Accidents In-Depth Study (MAIDS) and an in-depth study of motorcycle accidents.

The results from the STATS19 analysis are reported in Section 7.3.1 giving an overview for the period 2000 to 2008 for various road contaminants including frost and/or ice, flooding, oil and/or diesel and mud. Three accident types were developed and details relating to these accident types are provided where oil and/or diesel were recorded as a special condition at the accident site and also for those where a deposit on the road surface was recorded by the police officer to be a contributory factor in the accident.

Section 7.3.2 gives illustrations of accidents in the On the Spot (OTS) database where there was a deposit on the road surface. An In-depth study of Motorcycle accidents (Clarke *et al*, 2004) and the MAIDS report (ACEM, 2004) were reviewed with relevance to road surface contamination in Section 7.3.3 and Section 7.3.4, respectively.

7.2 Data sources

7.2.1 STATS19

STATS19 is the national database of records of reported road accidents to and by the police involving personal injury. Since 1949, the police have recorded statistical details of road accidents throughout Great Britain in this database, which thus forms a principal resource for research into road safety. The basic details of the people, vehicles and roads involved in these accidents are recorded, and since 2005 the factors which contributed to accident causation are included. Further details of the STATS19 database are available in

DfT (2009a). All of the analyses of the STATS19 data in this report relate to reported road accidents and, for simplicity, the use of the term reported has been kept to a minimum.

The STATS19 system is updated regularly to ensure that it continues to meet the evolving needs of users, including researchers. In 2005, as part of the latest revision of the system, another section was added to the STATS19 form where police reporting officers could enter 'Contributory Factors'. The Contributory Factors in a road accident are the key actions and failures that led directly to the actual impact. They show why the accident occurred and provide important indications about how accidents may be prevented in future, so offer valuable extra information for road safety research. However, these data are conceptually more complex than the 'traditional' STATS19 variables such as driver age or road number.

The STATS19 variable 1.24, 'Special conditions at site', records whether oil and/or diesel were present at the accident scene. Also, there is a contributory factor (102) which records where there was a deposit on the road (e.g. oil, mud, chippings etc.). The contributory factor record can include any deposit arising from human (or animal) activity which has made sections of the road surface slippery or which has caused traction control problems for a vehicle.

The results of the STATS19 analysis and annual estimates of the costs of the accidents are reported in Section 7.3.1.

7.2.2 OTS

The On The Spot study gives more detailed data from a sample of collisions which are attended by expert accident investigators. The UK's On the Spot (OTS) accident data collection project started in 2000 and continues to investigate 500 crashes per year. Investigations are undertaken minutes after the collision has occurred to gather all the perishable information. The OTS database provides a unique insight into the prevailing factors (e.g. temporary highway factors, weather etc.) that have been seen to cause crashes and the associated human injuries and vehicle and infrastructure damage that have been witnessed by the crash investigation teams. The accidents where oil and/or diesel were present at the accident scene are reported in Section 7.3.2.

7.2.3 In depth study of motorcycle accidents

Clarke *et al.* (2004) considered the detailed files for 1,003 accidents from the Midlands Police Forces involving motorcyclists of all ages and injury severity covering the period 1997 to 2002. This study was reviewed for information on accidents involving oil and/or diesel deposits and is reported in Section 7.3.3.

7.2.4 MAIDS report

The MAIDS study involved the collection of 'on the spot' accident data from five European countries: France, Spain, Germany, Italy and The Netherlands. The data were collected using the OECD common methodology designed for two-wheeled motor vehicle accident investigation for a period of three years. The OECD common methodology is intended to provide a system capable of identifying risk factors affecting motorcyclists. The MAIDS data used in this study comprise 921 accidents involving motorcycles.

The MAIDS report was updated in April 2009 and that report (ACEM, 2009) has been reviewed as part of this project. Any results where road surface contamination by oil and/or diesel was recorded as a contributory factor in the accident are reported in Section 7.3.4.

7.3 Results

7.3.1 STATS19 analysis

7.3.1.1 General

Sections 7.3.1.2 to 7.3.1.4 give an overview of the STATS19 data for the years 2000 to 2008 of accidents involving motorcycles, pedal cycles and other vehicles where oil and/or diesel was recorded as a special condition at the accident site and/or where a deposit on the road was reported as contributing to the accident have been analysed.

For completeness, these sections also look at other road contaminants such as ice and flood water. The location, accident severity and estimated values for prevention of the accident types are provided.

7.3.1.2 The presence of oil and/or diesel in motorcycle and pedal cycle accidents

The annual proportion of fatal, serious and slight accidents during the period 2000 to where the presence of oil and/or diesel was recorded as a special condition at the accident site is shown in Table 7-1.

Table 7-1: The proportion of accidents by severity during the years 2000 to 2008 where oil and/or diesel was present at the site

Accident severity	2000	2001	2002	2003	2004	2005	2006	2007	2008	All years
Fatal	0.1%	0.1%	0.0%	0.2%	0.1%	0.2%	0.2%	0.3%	0.3%	0.2%
Serious	0.3%	0.3%	0.3%	0.2%	0.3%	0.5%	0.5%	0.5%	0.5%	0.4%
Slight	0.2%	0.2%	0.2%	0.2%	0.2%	0.4%	0.4%	0.4%	0.4%	0.3%
All severities (Total)	558	537	540	439	520	748	727	748	701	5,518

As part of the quinquennial review of the collection of STATS19 data implemented in 2005, the presence of oil and/or diesel and mud at the scene of the accident was moved from Road Surface Conditions to Special Conditions at Site. This enabled the reporting police officers to record the presence of oil and / or diesel or mud together with the overall condition of the road surface (e.g. dry, wet, frost and/or ice etc.).

The data for the years 2000 to 2004 in Table 7-1 relates to the presence of oil and/or diesel recorded as a road surface condition where there were no other special conditions at site recorded. It is possible that, for the years 2000 to 2004, the presence of oil and/or diesel were under-reported because the reporting police officer may have recorded one of the following to describe the road surface; dry; wet and/or damp; snow; frost and/or ice; or flood (surface water over 30 mm deep).

There were 5,518 accidents during the period 2000 to 2008 where the presence of oil and/or diesel was recorded as a special condition at the accident site; this is 0.4% of all accidents during the period. The proportion of accidents where oil/diesel deposits on the road were recorded increased in the later years for all accident severities. This finding is contrary to the claim by KillSpills which reported a reduction in accidents relating to spillages following their leaflet campaign with Trucks and Motorcyclists.

The presence of oil and/or diesel on the road surface is of particular concern to the riders of motorcycles and pedal cycles. To quantify this concern the accidents have been

classified into three types according to the casualties involved which were defined as follows:

1. Motorcycles: these accidents resulted in at least one motorcycle rider or passenger being injured. These accidents may also include some pedal cycle casualties and other road user casualties.
2. Pedal cycles: these accidents resulted in at least one pedal cycle rider or passenger being injured. These accidents do *not* include motorcycle casualties but may include other road user casualties.
3. Others: all of the remaining accidents. These accidents include all types of road user casualties except motorcycle or pedal cyclist casualties.

During the period 2005 to 2008 there were 2,924 accidents where the presence of oil and/or diesel was recorded as a special condition at the accident site. Table 7-2 shows the proportions of these accident types per year where oil and/or diesel were recorded as a special condition at the accident site.

Table 7-2: The proportion of accident types where oil and/or diesel was present by year

Accident type	2005	2006	2007	2008	All years (total)
Motorcycle	26%	25%	28%	30%	806
Pedal cycle	1%	2%	1%	1%	32
Other	73%	73%	71%	69%	2,086
All	748	727	748	701	2,924

From 2005 to 2008, there were 806 accidents where a motorcyclist was injured, 32 accidents where a pedal cyclist was injured and 2,086 accidents where another road user was injured where oil and/or diesel was present. There has been a gradual increase in the proportion of motorcycle accidents involving oil and/or diesel deposits on the road in recent years.

An analysis of the accidents where there was oil and/or diesel present showed that the road surface was wet and/or damp for the majority of the other accidents and about one-half of the motorcycle and pedal cycle accidents (83%, 51%, and 47%, respectively).

The proportion of accident types per year where oil and/or diesel was recorded as a special condition at the accident site for urban and rural locations is shown in Table 7-3.

Table 7-3: The proportion of accident types where oil and/or diesel was present by urban or rural location

Accident type	Urban	Rural	All (total)
Motorcycle	53%	47%	806
Pedal cycle	66%	34%	32
Other	34%	66%	2,086
All	39%	61%	2,924
Reported accidents involving motorcycles, 2008 *	67%	33%	21,972

* Note: This is all motorcycle accidents not just where oil and/or diesel were present, taken from DfT, 2009a; Tables 23a and 23b.

About half of the motorcycle accidents where the oil and/or diesel were recorded as a special condition at the accident site occurred in urban areas. In comparison with all motorcycle accidents (DfT, 2009a), those where there was an oil and/or diesel spillage were more likely to be in rural areas (47% compared with 33%) which is a similar finding to Clarke *et al.* (Section 7.3.3). Two-thirds of the pedal cycle accidents occurred in urban areas and, conversely, two-thirds of the other accidents occurred in rural areas. The class of road where the accident occurred is shown in Table 7-4 for each of the accident types. The motorcycle and other accident types occurred more frequently on A class roads and the pedal cycle accidents occurred more frequently on unclassified roads.

Table 7-4: The proportion of accident types where oil and/or diesel was present by road class

Accident type	Motorways	A	B	C	Unclassified	All (total)
Motorcycle	2%	58%	12%	8%	20%	806
Pedal cycle	0%	38%	19%	3%	41%	32
Other	4%	46%	19%	10%	20%	2,086
All	4%	49%	17%	10%	20%	2,924

The type of road where the accident occurred is useful for calculating the estimated value of prevention of reported road accidents. The accident severity of each of the accident types where oil and/or diesel was recorded as a special condition at the accident site, in terms of built-up, non built-up and motorway roads is shown in Table 7-5.

Table 7-5: The type and severity of accidents where oil and/or diesel was present for built-up, non built-up and motorway roads

Accident Type	Accident severity	Built-up* roads	Non built-up† roads	Motorways‡	All roads (total)
Motorcycle	Killed or seriously injured	48%	48%	4%	181
	Slight	68%	31%	2%	625
Pedal cycle	Killed or seriously injured	67%	33%	0%	6
	Slight	77%	23%	0%	26
Other	Killed or seriously injured	32%	66%	3%	313
	Slight	48%	48%	4%	1773

* Built-up roads are those roads other than motorways with speed limits of 40 miles per hour or less.

† Non built-up roads are those roads other than motorways with speed limits greater than 40 miles per hour or less.

‡ Motorway class road

The majority of the slight motorcycle accidents where oil and/or diesel were recorded as a special condition at the accident site occurred on built-up roads. The effects of oil and/or diesel spillages on non built-up roads were more likely to result in serious injuries for motorcycle accidents, possibly due to the higher speed limit on these roads.

The majority of the pedal cycle accidents where oil and/or diesel were recorded as a special condition at the accident site occurred on built-up roads.

The estimates of the values for prevention of road accidents and casualties for use in appraisal of transport schemes (DfT, 2009b) give an estimate of the total annual value of road

accidents. The approach encompasses all aspects of the valuation of casualties, including human costs, which reflect pain, grief, suffering; the direct economic costs of lost output; and the medical costs associated with road accident injuries. Appendix B gives the average value of prevention per reported road accident for the years 2006 to 2008 by different types of road. These figures use the June 2006, June 2007 and June 2008 prices, respectively, for the accidents that occurred during the period 2006 to 2008. The average annual value (in £m) of prevention of each of the accident types, where oil and/or diesel was present as a special condition at the accident site, by accident severity and in terms of road type are shown in Table 7-6. The detailed calculations for this table are reproduced in Appendix C giving the breakdown of the estimated values by accident severity and also for built-up, non built-up and motorway roads.

Table 7-6: The average value (£m) of prevention of the accident types for the years 2006 to 2008 where oil and/or diesel were recorded as a special condition at the site

Accident Type	2006 (£m)	2007 (£m)	2008 (£m)	All years (£m)
Motorcycle	14.95	18.45	15.51	48.91
Pedal cycle	0.43	0.57	0.46	1.46
Other	31.09	36.13	35.45	102.67

The total estimated value of prevention of accidents where motorcyclists are killed or injured, where oil and/or diesel were recorded as a special condition at the accident site, for the three years was £48.91m with £14.95m in 2006, £18.45m in 2007 and £15.51m in 2008.

7.3.1.3 Other road surface contaminants

For completeness, all accidents where other road contaminants were present at the accident site are considered in this section. These contaminants are frost and/ice, or flood (over 30 mm deep) or mud.

The annual proportion of fatal, serious and slight accidents during the period 2000 to 2008, where frost and/or ice or a flood (over 30 mm deep) were present on the road surface, are shown in Table 7-7 and Table 7-8, respectively.

Table 7-7: The proportion of all accidents by severity where frost and/or ice on the road surface was recorded for 2000 to 2008

Accident severity	2000	2001	2002	2003	2004	2005	2006	2007	2008	All years
Fatal	1.0%	1.9%	0.9%	1.0%	1.2%	1.2%	0.7%	1.1%	2.0%	1.2%
Serious	1.2%	2.4%	0.8%	1.8%	1.5%	1.5%	1.1%	1.2%	2.0%	1.5%
Slight	1.3%	2.3%	0.9%	2.0%	1.5%	1.7%	1.1%	1.5%	2.3%	1.6%
All severities (Total)	2,924	5,306	2,053	4,208	3,069	3,327	2,013	2,569	3,870	29,339

Table 7-8: The proportion of all accidents by severity where a flood of more than 30 mm on the road surface was recorded for 2000 to 2008

Accident severity	2000	2001	2002	2003	2004	2005	2006	2007	2008	All years
Fatal	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.3%	0.2%
Serious	0.2%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%
Slight	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%
All severities (Total)	520	263	342	190	290	183	258	312	331	2,689

There were 29,339 accidents during the period when frost and/or ice on the road surface were recorded in STATS19; this number is 1.6% of all accidents during this period (DfT, 2009a). The slight annual variations in the proportions of fatal, serious and slight accidents for the years 2000 to 2008 when frost and/or ice were recorded as present on the road surface are probably due to the variable nature of weather conditions each year in Britain.

There were 2,689 accidents during the years 2000 to 2008 where a flood of more than 30 mm on the road surface was recorded in STATS19; this number is 0.2% of all accidents during this period. The annual proportions of accidents for all severities are broadly similar.

The annual proportion of fatal, serious and slight accidents during the period 2000 to 2008, where mud was a special condition at the accident site is shown in Table 7-9.

Table 7-9: The proportion of accidents by severity during the years 2000 to 2008 where mud was present at the site

Accident severity	2000	2001	2002	2003	2004	2005	2006	2007	2008	All years
Fatal	0.1%	0.1%	0.0%	0.1%	0.1%	0.2%	0.1%	0.2%	0.1%	0.1%
Serious	0.2%	0.1%	0.1%	0.1%	0.1%	0.3%	0.4%	0.3%	0.4%	0.2%
Slight	0.2%	0.2%	0.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.4%	0.2%
All severities (Total)	399	341	304	266	408	660	657	591	696	4,322

There were 4,322 accidents during the period 2000 to 2008 where the presence of mud was recorded as a special condition at the accident site; this number is 0.3% of all accidents during the period.

The annual number of accidents where mud was recorded as a special condition at the accident site appears to be increasing. The reasons for this are unclear; they could be related to higher traffic flows or possibly more construction sites alongside the road.

7.3.1.4 Deposit on the road surface assigned as a contributory factor in the accident

Contributory factors have been assigned in STATS19 accidents since 2005 (Section 7.3.1). The Police attending the scene of the accident can assign up to six factors which, in their opinion, contributed to the accident. The contributory factor 102, deposit on road (DfT, 2004) includes any deposit on the road arising from human (or animal) activity which has made sections of the road surface slippery or which has

caused traction control problems for a vehicle. Table 7-10 shows the proportions of the accident types where this contributory factor was assigned.

As would be expected, there were more accidents with the contributory factor 102, deposit on the road surface, assigned than those where oil and/or diesel was recorded as a special condition at the accident site because this contributory factor covers more types of deposit on the road. The proportion of motorcycle accidents where a deposit on the road surface was a contributory factor was lower than the proportion of motorcycle accidents where there was oil and/or diesel at the accident site (Table 7-2). This reduction may infer that the presence of oil and/or diesel on the road surface was not always considered a contributory factor by the reporting Police Officer who attended the accidents.

Table 7-10: The proportion of accident types where a deposit on the road surface was a contributory factor by year

Accident type	2005	2006	2007	2008	All years (total)
Motorcycle	20%	20%	20%	23%	826
Pedal cycle	1%	1%	1%	1%	41
Other	79%	79%	79%	76%	3,166
All	983	1,027	998	1,025	4,033

An analysis of the accidents where a deposit on the road surface was a contributory factor showed that the road surface was wet and/or damp for the majority of the other accidents and about one-half of the motorcycle and pedal cycle accidents (78%, 51%, and 51% respectively).

During the period 2005 to 2008, there were 4,033 accidents where the contributory factor 102, a deposit on road surface, was assigned to the accident. The proportion of these accident types for urban and rural locations is shown in Table 7-11.

Table 7-11: The proportion of accident types where a deposit on the road surface was a contributory factor by urban or rural location

Accident type	Urban	Rural	All (total)
Motorcycle	43%	57%	826
Pedal cycle	46%	54%	41
Other	20%	80%	3,166
All	25%	75%	4,033

The values for prevention of road accidents and casualties for use in appraisal of transport schemes (DfT, 2009b) give an estimate of the total annual value of road accidents. The approach is described in section 7.3.1.2 and further details are available in Appendix B.

The average estimate of the annual value (in £m) of prevention of each of the accident types, where a deposit on the road was a contributory factor, by accident severity and in terms of road type are shown in Appendix C.

The total estimate of the annual value of prevention of the motorcycle accident type where a deposit on the road surface was a contributory factor was £55.84m; £16.91m in 2006, £19.76m in 2007 and £19.17m in 2008. These estimates are higher than those given for oil and/ diesel spillages because this contributory factor includes other deposits on the road surface.

7.3.2 On the Spot data

7.3.2.1 General

The On the Spot (OTS) accident data collection project has investigated approximately 500 crashes per year since it began in 2000. On-scene investigations are undertaken minutes after a collision has occurred in order to gather all perishable information. The OTS database provides a unique insight into the prevailing factors (e.g. temporary highway factors, weather etc.) that have been seen to cause crashes and the associated human injuries and vehicle and infrastructure damage that result. It is the intention that OTS data be used in research of the causes of crashes, their subsequent injuries and the associated costs to society.

Currently there are 4,560 accidents held in the OTS database, of which 454 involve motorcycles. This subset of accidents was interrogated for possible oil or diesel spillage involvement. Five reported an oil or diesel contaminant as being at least partially causative; these are shown below as case studies.

It is interesting to note that, for three of the five cases, the road was wet and/or damp. This ratio is slightly higher than the proportion of motorcycle accidents (51% for both) in the STATS19 data where oil and/or diesel were present at the accident site and where a deposit on the road surface was a contributory factor (Section 7.3.1.2).

7.3.2.2 Accident Case Study 1

A 27 year old male motorcyclist was riding a 600 cc Kawasaki ZZR in moderate traffic along a three lane motorway. It was daylight at the time and the road surface was damp from previous showers. He was travelling at motorway speeds in lane two when he noticed a patch of oil directly ahead of him. The rider moved across his lane and braked in an attempt to avoid the oil, but by performing this manoeuvre he actually lost control as he rode over it. The motorcycle and rider fell down to the offside and both slid along the carriageway to rest. At the time of the incident the rider was wearing designated motorcycling trousers, gloves, jacket and helmet. He suffered slight injuries as a result of this accident.

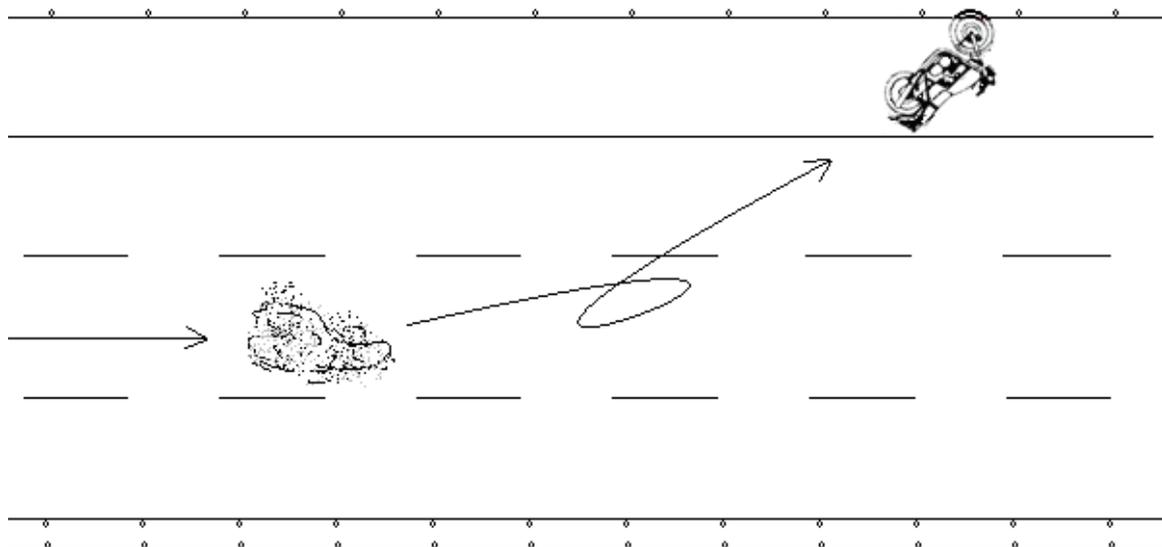


Figure 7-1: Scenario sketch plan



Figure 7-2: Kawazaki ZZR at the accident scene

7.3.2.3 Accident Case Study 2

A 70 year old male motorcyclist was riding a Honda Bali scooter along a single carriageway road on a bright and sunny day. The speed limit at this location is 60 mph. The rider had just exited a major roundabout and was travelling around a slight left hand bend when he noticed a piece of vehicle debris in the road ahead of him. He moved left to avoid it and as he did so his tyres slipped on a patch of diesel that was contaminating the road surface. The rider subsequently lost control of the motorcycle causing them both to fall to their nearside and slide to a halt. At the time of this incident, the rider was wearing a cotton jacket, shorts, sandals and a helmet. He suffered slight injuries during this incident.

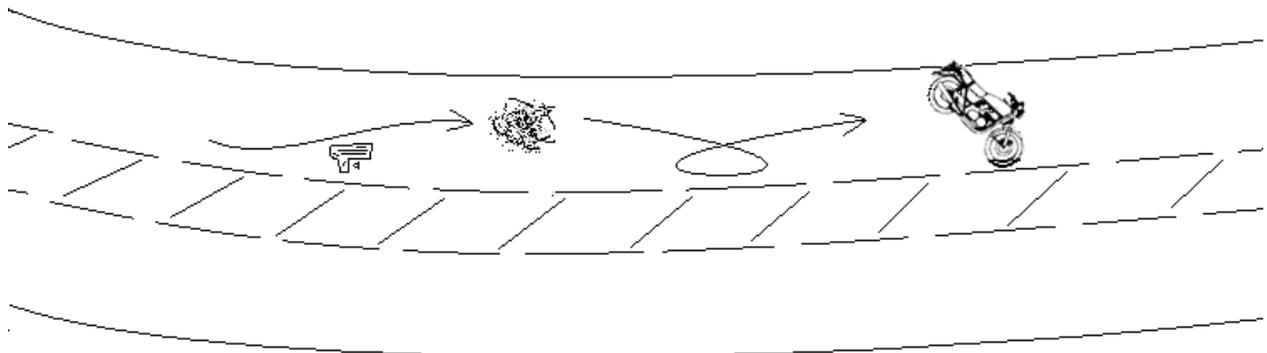


Figure 7-3: Scenario sketch plan



Figure 7-4: Accident scene, note appearance of road surface

7.3.2.4 Accident Case Study 3

The 33 year old male rider of a 125 cc Aprilia SR scooter was riding along a single carriageway A-class road on a warm afternoon. This road is located near a town centre; is subject to a 30 mph speed limit; and was dry at the time. At the end of this road the rider braked on the approach to a medium sized roundabout. As he did so, the wheels of the scooter passed over an area of spilt diesel fuel, causing them to lose traction. The rider lost his balance and both he and his scooter fell down to their nearside. At the time of the incident, the rider was wearing a designated motorcycling jacket and boots, cotton trousers and a helmet. He suffered slight injuries to his legs and was taken to hospital for x-rays as a precaution.

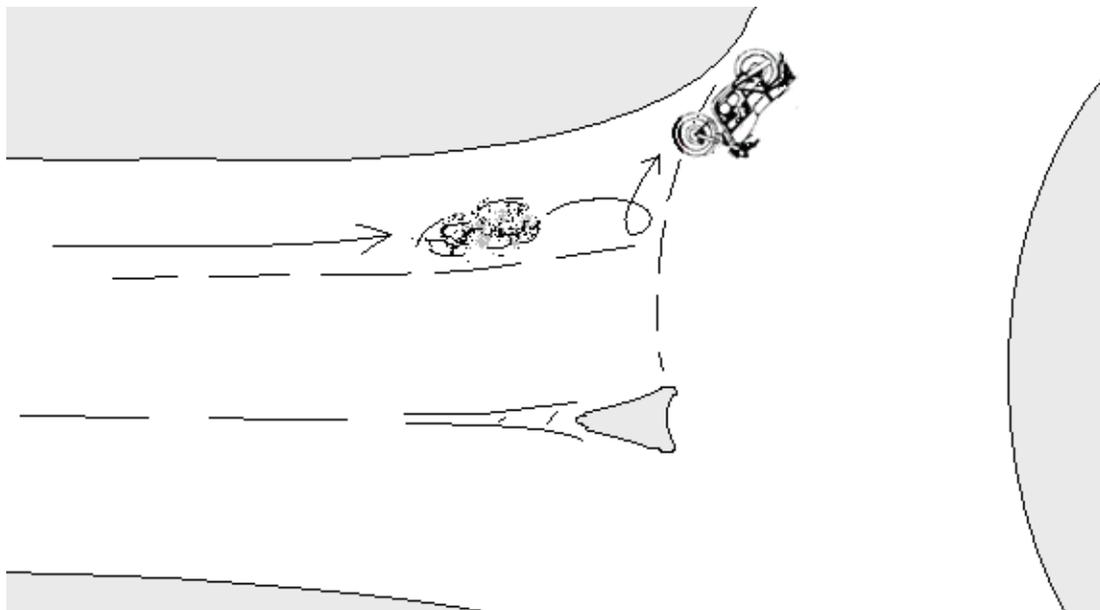


Figure 7-5: Scenario sketch plan

7.3.2.5 Accident Case Study 4

A 32 year old male rider of a Honda Deauville 650 cc motorcycle was travelling along the offside of queuing traffic on a 60 mph limit A-class road. At the time, the traffic was

congested due to 'rush hour' conditions and the road surface was damp from earlier rain. As the motorcyclist was riding at low speed along the centre lines, his tyres lost traction on a patch of gravel and oil causing him to drop to the ground and detach from the motorcycle. He slid for some metres before coming to rest. At the time of the incident, the rider was wearing a leather motorcycle jacket, designated motorcycling trousers, boots and gloves, and a helmet. He suffered slight injuries to his legs and abdomen.

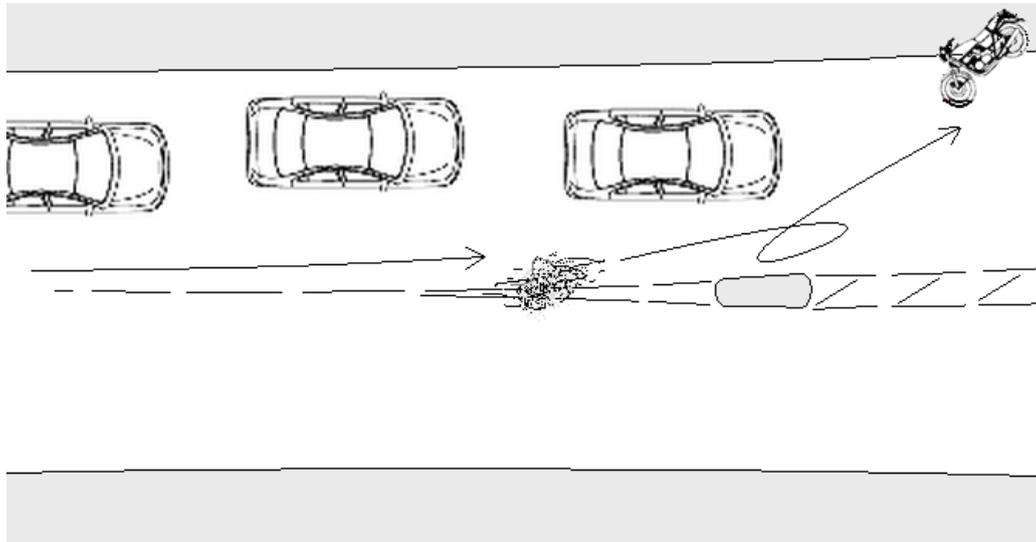


Figure 7-6: Scenario sketch plan



Figure 7-7: Collision investigation at the accident scene

7.3.2.6 Accident Case Study 5

A 25 year old male was riding a black Yamaha motorised tricycle along a straight A-class road in a built-up urban area. The speed limit on this road is fixed at 30 mph and, at the time of the incident, it was in darkness and the road surface was wet from earlier showers. The tricycle rider was following a silver Saab 95 car on the approach to a traffic signal controlled junction. As both vehicles neared the signals, they turned red and the Saab 95 in front braked to rest. In turn, the tricycle rider attempted to brake heavily but was unable to slow his vehicle due to a diesel contamination of the road surface. As a result, he collided with the rear of the Saab 95 car causing himself serious injuries, namely a fracture to the left wrist (scaphoid bone), that was possibly caused by bracing against the handlebars before impact.

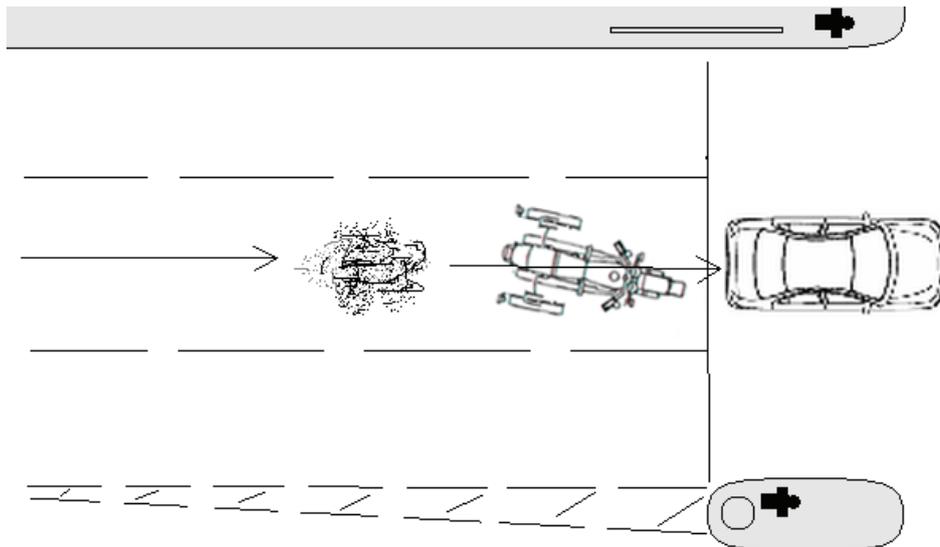


Figure 7-8: Scenario sketch plan



Figure 7-9: Accident scene and tricycle *in situ*

7.3.3 In depth study of motorcycle accidents

Clarke *et al.* (2004) considered the detailed files for 1,003 accidents from the Midlands Police Forces involving motorcyclists of all ages and injury severity covering the period 1997 to 2002 and each case was summarised and entered into a motorcycle accident database. In addition, a 25 item questionnaire was completed by a sample of relatively experienced motorcyclists recruited through the Motorcycle Action Group ('MAG'). 147 completed questionnaires were returned and their results analysed and included in the study.

Road surface contaminants are mentioned in Clarke *et al.*'s analysis of the questionnaire results. They are grouped with other causes of slippery road surfaces (e.g. wet or icy) for which questionnaire responses indicate that riders' perceive them to be a larger hazard than they actually are in accidents. Slippery road surfaces were mentioned as being a hazard by 17% of the questionnaire respondents, whereas 14.7% of the causes

listed in Clarke's motorcycle accident database involved slippery road surfaces (such as wet and icy weather and oil and diesel spillages on the road).

It is also generally noted within this study that there is "some evidence of a problem" with motorcyclists losing control due to oil, diesel, gravel, or mud surface contaminants; with particular reference to this contributing to losses of control on rural bends. Although any reported occurrences of this problem have been far outweighed by accidents caused by inappropriate speed or a general lack of experience.

7.3.4 MAIDS report

The Association of European Motorcycle Manufacturers (ACEM) in association with the European Commission and other partners conducted an in-depth study of moped and motorcycle accidents (MAIDS) in France, Germany, Netherlands, Spain and Italy during 1999 to 2000, which is reported in ACEM (2004). The aim of this study was to understand the nature and causes of motorcycle accidents more fully. The data in all five countries was collected using the methodology developed by the Organisation for Economic Co-operation and development (OECD) for on-scene in-depth motorcycle investigations.

The OECD methodology includes a full reconstruction of the accident: vehicle inspections; witness interviews; and subject to the applicable privacy laws, the full cooperation and consent of both the injured person and the local authorities, the inclusion of relevant medical records for the injured riders and passengers.

A measure of exposure for the MAIDS study was provided by collecting comparative information on 923 riders of motorcycles and mopeds that were not involved in accidents in the same samples areas. This exposure information established the significance of the data collected from the accident involved motorcyclists.

A total of 921 accidents were investigated and the data collection protocol for each MAIDS case involved travelling to the accident scene to collect on-scene information and information about the physical environment. The roadway was found to be dry and free of any contaminants in the majority of cases (780/921) and wet in 73 cases. Gravel sand was reported in 23 of the accidents and oil, ice, mud and snow in seven, five, three and two of the cases respectively. The remainder of the MAIDS cases were categorised as either other (26) or unknown (2) with regard to roadway contamination.

An environmental cause was recorded as the primary accident contributing factor for 71 of the MAIDS cases. However, there are no further details reported with regard to the type of contamination of the road surface.

8 Summary and findings

8.1 Review of diesel spillage clean-up products and procedures

The effectiveness of the proprietary products to clean-up diesel spillages and applications procedures practiced in the UK has been reviewed. It was found that a number of products are available on the market that the manufacturers claim to be suitable for application in case of diesel spillages or incidents involving hazardous material spillages on highways. The products can be in the form of loose absorbent granules, booms, pillows, washing agents or bioremediation process.

Proprietary absorbent granules were found to be most popular among the agencies involved. The popularity of products for treatment of spillages may well be based on the cost of treatment product rather than the cost effectiveness. The Area Maintenance Memorandum 95/07 (AMM) (HA, 2007b) states that proprietary absorbents can treat a greater volume of spillage hence likely to reduce the overall cost of treatment compared to traditional absorbents. However the AMM does not provide any guidance on selection or clean-up procedure.

The use of washing agents is not encouraged by the EA and, according to the AMM, its use of washing agents is unlikely to provide the quickest re-opening of running lanes.

Bio-remediation products were found to be unsuitable as a primary response product as it is often difficult to quantify the result of the treatment on site and the rate of bioremediation depends on the climatic conditions favourable for the growth of these microorganisms. Surveys conducted by the EA in the UK suggest that subsequent progression of bioremediation as an effective remediation technology is partly limited by uncertainty regarding the efficacy of the technique, operational constraints and the regulatory permissions required. However, there is no product approval scheme to provide assistance on selecting the appropriate proprietary product that could be used to clean-up diesel spillages.

It was concluded from the study that no national guidelines currently exist in the UK to deal with hazardous material spillages on highways. Well-defined hazardous materials response policies and procedures and appropriate level of training will allow first responders to accurately determine the hazardous spillages and direct further response.

It was found that different County Councils, Maintenance Area Contractors and other road authorities use a variety of proprietary absorbent product and follow different clean-up procedures developed in house. Only a limited number of comparative studies have been conducted to assess the effectiveness of these absorbent products.

There are no robust and clear guidelines for reporting hazardous material spillages on highways. Because the system heavily relies on the general public and individuals responsible, lack of clear guidelines may delay reporting of spillages and valuable time could be lost in mobilizing the incident response units to clean-up the spillages.

A response to a diesel spillage or an incident can involve various parties depending upon the severity of the spillage, each with a different role (as stated in PPG22; EA et al, 1999). However, proper guidelines and documented practices are not available defining the roles of the parties involved to improve coordination and preparedness.

General lack of verification of the product claims means that an independent assessment would assist the road authorities by increasing the confidence in using a product. Neither the EA nor the HA currently has an approved list of products suitable for use to clean-up spillages on highways. However, any advice should relate to treatment performance and environmental issues rather than name specific products. On-going trials at TRL of a limited number of products under an HA project should assist with the development of guidance on treatment effectiveness and a method for assessment of spillage products.

Currently, the EA allows most of the proprietary absorbent granules for application on diesel spillages as long as they do not contain any pollutant. The EA prefers inert and biodegradable products which are likely to cause minimum environmental issues. The used absorbents must be collected, bagged and disposed of appropriately. Some amount of absorbents is generally allowed to be left on the road surface if required. However, the application of washing agents is not permitted but, if used, all the effluents must be collected from the road surface and disposed of in accordance with the environmental regulations in place.

8.2 Review of accident data

The presence of oil and/or diesel on the road surface is of particular concern to the riders of motorcycles and pedal cycles. An overview of the STATS19 data for the period 2000 to 2008 revealed that the proportion of all reported personal injury accidents, where the presence of frost and/or ice or a flood of more than 30 mm on the road surface was 1.6% and 0.2%, respectively. The corresponding proportions where the presence of mud or oil and/or diesel as a special condition at the accident site was recorded were 0.3% and 0.4%, respectively.

The analysis has considered STATS19 data for the period from 2005 to 2008. These years were chosen for two reasons; the contributory factors data in STATS19 was introduced in 2005 and the estimated value of prevention of accidents was available for the years 2006 to 2008. The contributory factors include information about whether a deposit on the road was assigned to the accident. The accidents were classified into three types according to the casualties involved which enabled the analysis to focus on accidents involving motorcycles and pedal cycles. These were:

1. Motorcycles: these accidents involved at least one motorcycle rider or passenger casualty and could include some pedal cycle casualties and other road user casualties
2. Pedal cycles: these accidents involved at least one pedal cycle rider or passenger casualty. These accidents do *not* include motorcycle casualties but may include other road user casualties.
3. Others: all of the remaining accidents. These accidents include all types of road user casualties except motorcycle or pedal cyclist casualties.

Overall, there were 2,924 accidents during this period where the presence of oil and/or diesel was recorded as a special condition at the accident site; 806 motorcycle accidents, 32 pedal cycle accidents and 2,086 other accidents.

The annual number of accidents where oil and/or diesel or mud was recorded as a special condition at the accident site appears to be increasing. This finding is contrary to the claim by KillSpills reporting a reduction in diesel related accidents following their leaflet campaign. The reasons for this difference are unclear; they could be related to higher traffic flows or possibly more construction sites alongside the road.

In comparison with all motorcycle accidents (DfT, 2009a) reported to the Police, those where there was an oil and/or diesel spillage were more likely to be in rural areas; this is a similar finding to Clarke *et al.* (Section 7.3.3). A similar pattern was found for pedal cycle accidents.

The OTS data has provided valuable illustration of a variety of accident circumstances that all involve road surface contaminants. There are a limited number of cases of this type, but conveniently each involves a different scenario and thus provides an insight into the types of accident that populate STATS19 database.

The Clarke *et al.* report puts little emphasis on surface contaminants as an accident cause and only gives them two brief mentions throughout the study. It is apparent that the focus is on rider and driver behaviour as this seems to dwarf any contribution to accident precipitation that is made by road surface contamination.

The MAIDS study of 921 motorcycle accidents reported that the highway was found to be dry and free of any contaminants in the majority of cases. Gravel sand was reported in 23 of the accidents and oil, ice, mud and snow in seven, five, three and two of the cases respectively. An environmental cause was recorded as the primary accident contributing factor for 71 of the MAIDS cases. However, there are no further details reported with regard to the type of contamination of the road surface.

9 Conclusions

The study reviewed spillage treatment products and procedures for reporting of spillage incidents and reviewed accident data relating to motorcyclists where a spillage was considered to be a contributory factor.

With regard to products and procedures, the following conclusions were made:

- No national guidelines currently exist in the UK to deal with hazardous material spillages on highways and lack of well-defined hazardous materials response policies and procedures.
- Different County Councils, Maintenance Area Contractors and other road authorities use a variety of proprietary absorbent products and follow different clean-up procedures that have developed in house. Only a limited number of comparative studies have been conducted to assess the effectiveness of these absorbent products.
- There are no robust and clear consistent guidelines for reporting hazardous material spills on highways which may delay reporting of spillages and valuable time could be lost in mobilizing the incident response units to clean-up the spillages.
- A response to a diesel spillage or an incident will be dependent upon the severity of the spillage. However, proper guidelines and documented practices are not available defining the roles of the parties involved to improve coordination and preparedness.
- There is a general lack of verification of product claims and an independent assessment would assist road authorities by increasing confidence in using proprietary products. Any advice should relate to treatment performance and environmental issues rather than name specific products. On-going TRL trials of a limited number of products should assist with development of this advice.
- Currently, the EA allows most of the proprietary absorbent granules for application on diesel spillages as long as they do not contain any pollutant. The EA prefers inert and biodegradable products which are likely to cause minimum environmental issues. The used absorbents must be collected, bagged and disposed of appropriately.

With regard to the motorcycle accident study, the following conclusions were made:

- The various sources of information used in this study have shown that the presence of road surface contaminants do present a concern for motorcyclists.
- The estimated total value of prevention of all of the reported personal injury road accidents in GB in 2008 (170,591 accidents) is £12,790m using 2008 prices and values. The corresponding estimated value for 2007 and 2006 was £13,770m and £13,089m, respectively. These estimates relate to the total value to the community of the benefits of prevention of road accidents.
- The total annual value of prevention of the motorcycle accident type where oil and/or diesel was recorded as a special condition at the accident site for the three years was £48.91m: £14.96m in 2006, £18.45m in 2007 and £15.50m in 2008. This report has shown that the estimated value for the prevention of these accidents is about 0.12% of the total for the period 2006 to 2008.

Acknowledgements

The work described in this report was carried out in the Infrastructure and Safety Divisions of the Transport Research Laboratory. The authors are grateful to Cliff Nicholls and Jackie Knowles who carried out the technical review and auditing of this report. The authors are also grateful to Jackie Knowles who has carried out the technical review of the accident data section of this report.

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Product Websites

The following websites were accessed as part of this review in March 2010:

<http://www.imbiberbeads.com/>

<http://www.peatsorb.com/>

<http://www.tepcoproducts.com/>

<http://www.spillhound.com/>

<http://www.absorbenviro.com.au/>

<http://www.sphagsorb.com/>

<http://www.enrettech.com.au/>

<http://www.greenabsorbents.com/>

<http://spillfix.com/>

<http://www.oil-dri.co.uk/>

<http://www.osei.us/>

<http://www.ciagent.com/>

<http://www.sorbican.com/>

<http://www.newpig.com/>

<http://www.spilltech.co.za/>

<http://www.rubberizer.com/>

<http://www.airbank.it/>

<http://www.isol8.co.uk/>

<http://www.steetley.co.uk/>

<http://www.rossenvironmentalproductsLtd.co.uk/>

<http://www.extolhydro.com/>

<http://www.americanproducts1.com/>

<http://www.oil.spills.climatecleanup.com/>

<http://www.oiltechnics.co.uk/>

<http://www.alabastercorp.com/>

<http://www.biofield.co.uk/>

<http://www.blue-diamond.co.uk/>

<http://www.argosfire.co.uk/>

Appendix A Products and manufacturers for clearing up spillages

Table A-1: List of manufacturers contacted

Product	Manufacturer	Agent	Treatment type	Responded
Imbiber Beads	Imbibitive Technologies America Inc. O/A IMBTEC AMERICA 4800 James Savage Rd. Midland, MI, U.S.A. 48642-6528	IAC Limited, 16 Baker Street 4800 London. W1U 6TS	Polymer based absorbent granules	✓
TERRACAP™ 3000/4000 Aqua N-Cap™ Polymer	RTASCO 8001 Mid America Blvd., Suite 125 Oklahoma City, OK 73135 support@rtasco.com		Polymer based absorbent granules Detergent/degreaser	✓
Road Spill Organic Absorbent	Absorb Environmental Solutions PO Box 8099, Woolloongabba		Organic	
Kleen Sweep	Enretech Australasia Pty Ltd. P.O. Box 1154 Moss Vale, NSW Australia 2577		Organic absorbents/ Bioremediation	✓
SpillFix	Galuku International Pty Ltd. PO Box N253 Grosvenor Place, Sydney NSW 1220 Australia	Water Clean Ltd Unit1, Marlborough Road Wrexham Industrial Estate Wrexham, LL13 9RJ	Organic (coir pith fibre)	✓
Oil Solidifiers	13020 S. Ridgewood, Palos Park, Il. Moss Vale, NSW 60464, USA		Polymer based	
Oil Spill Eater	Osei Corporation PO Box 515429 Dallas, Texas 75251, USA URL: www.osei.us		Bioremediation	✓

Table A-1: List of manufacturers contacted (Cont.)

Product	Manufacturer	Agent	Treatment type	Responded
Oil Eater (Spill O Sorb)	Sorbican, 27 Priory Lane, Hartley Winthey, Hook, Hants, RG27 8EX	GKL Solutions Ltd 26 Holbrook Road, Fareham Hampshire PO16 0TL E Mail: sales@gklsolutionsltd.co.uk	Organic (Peat fibre) Granules	✓
Biozorb	Spill Tech House 604/608/610 Umbilo Road Congella KwaZulu-Natal, 4001 Tel: 031 206 0919		Organic (Peat fibre) Granules	
Peat Sorb	Zorbic Technologies (International) 2155 Leanne Blvd. Suite 241 Mississauga, Ontario L5K 2K8 mbond@peatsorb.ca		Natural organic Granules	✓
Spill hound	Fleming Technical Limited, Croft Business Park, Bromborough, Wirral, CH62 3NY topdog@spillhound.com		Natural organic Granules	✓
Sphag Sorb	Earth Care Products 7430- 52 Street Edmonton, Alberta Canada. T6B-2G3		Natural organic Granules	✓
Green Stuff	140-11 Keyland Ct Bohemia, NY 11716 URL: http://www.greenabsorbents.com Email: sales@greenabsorbents.com		Polymer based absorbent granules	
Oil-Dri	Oil-Dri (UK) Limited Bannisters Row, Wisbech Cambridgeshire, PE13 3HZ Website: www.oil-dri.co.uk		Natural Clay kiln dried	✓

Table A-1: List of manufacturers contacted (Cont.)

Product	Manufacturer	Agent	Treatment type	Responded
CI Agent	C.I.Agent Solutions 11760 Commonwealth Drive, (866) 242-4368 Toll Free Louisville KY 40299 www.ciagent.com		Polymer based absorbent granules	✓
Pig Peat Absorbents	New Pig Ltd. Hogs Hill, Watt Place Hamilton Int. Tech. Park Blantyre, G72 0AH		Natural organic Granules	✓
Rubberizer	Haz-Mat Response Technologies, 4626 Santa Fe St. San Diego, CA 92109 www.rubberizer.com		Polymer based absorbent plus additives	
OKO-Pur	AIRBANK Via Luigi Bay 29121, PIACENZA P. IVA 01536470337 CENTRALINO (10 R.A.)		Absorbent Granules	
Isol8	Environmental Absorbents Manor Farm, Hutton Conyers Nr Ripon, North Yorkshire HG4 5DX Email: sales@isol8.co.uk		Renewable organic	✓
Superwhite Multizorb/ New Safety Tread/ Absodan /E-sorb. Elcef fibres	Steeley Bentonite & Absorbents West Carr Road Retford, Nottinghamshire DN22 7ZF Email: info@steeley.com		Clay based granular absorbent	
Eliminator	Ross Environmental Products Ltd Unit 207 A Foley Industrial Estate Lisle Avenue, Kidderminster Worcestershire, DY11 7DH		Natural Cotton fibre	✓

Table A-1: List of manufacturers contacted (Cont.)

Product	Manufacturer	Agent	Treatment type	Responded
Road Bio	Oil Technics Limited Linton Business Park, Gourdon, Aberdeenshire, Scotland UK DD10 0NH		Detergent Degreaser	✓
Petro Clean	ALABASTER CORP. U.S.A. 281-487-5470 alabastercorp@gmail.com		Bioremediation (Surfactants and emulsifier)	✓
Bio Route	Units 5/6, Gordleton Farm Silver Street, Sway, Lymington Hants, SO41 6DJ www.biofield.co.uk			
Bio Zyme	Rolwey House bdsales @ rolwey.com School Close Chandlers Ford Phone Eastleigh 023 80258966 Hants, SO53 4BY			✓
F500 Argosfire	Argos Fire protection Services Argos House, Unit 4 Kingfisher Road Venny Bridge, Pinhoe Exeter, RX4 8JN		Fire suppression/vapour control	✓

Appendix B Average value of prevention per reported accident for the years 2006 to 2008

The estimates of the values for prevention of road accidents and casualties are used in appraisal of transport schemes (DfT, 2009) and give an estimate of the total value of road accidents per year. The approach encompasses all aspects of the valuation of casualties, including human costs, which reflect pain, grief, suffering; the direct economic costs of lost output; and the medical costs associated with road accident injuries. Tables B-1, B-2 and B-3 give the average value of prevention per reported road accident for the years 2006 to 2008 by different types of road. The three tables give the values as calculated using June 2006, June 2007 and June 2008 prices respectively.

Table B-1: The average value of prevention per reported accident: GB June 2006

Accident severity	Accident location			
	Built-up roads	Non built-up roads	Motorways	All roads
Fatal	£1,625,440	£1,729,690	£1,800,580	£1,690,370
Serious	£186,900	£213,450	£217,040	£196,020
Slight	£18,970	£22,430	£26,600	£20,120

Source: Francis (2007)

Table B-2: The average value of prevention per reported accident: GB June 2007

Accident severity	Accident location			
	Built up roads	Non built up roads	Motorways	All roads
Fatal	£1,769,900	£1,930,740	£2,145,280	£1,876,830
Serious	£207,120	£231,110	£235,690	£215,170
Slight	£21,000	£24,750	£29,490	£22,230

Source: Bartlett (2008)

Table B-3: The average value of prevention per reported accident: GB June 2008

Accident severity	Accident location			
	Built up roads	Non built up roads	Motorways	All roads
Fatal	£1,806,200	£1,973,600	£2,064,500	£1,906,200
Serious	£209,800	£234,500	£243,500	£218,100
Slight	£21,500	£25,200	£29,900	£22,600

Source: Ganeshan (2009)

Appendix C Numbers of accidents by road class

Tables C-1 and C-2 give the numbers of accidents where oil and/or diesel were recorded as special condition at the accident site. And where a deposit on the road surface was recorded as a contributory factor in the accident respectively

Table C-0-1: Numbers of accidents by road class where oil and/or diesel were recorded as present as a special condition at the accident site.

Year	Accident type	Accident severity	Built-up roads	Non built-up roads	Motorways	All roads
2005	Motorcycle	Fatal	-	-	-	-
		Serious	21	15	1	37
		Slight	109	50	1	160
	Pedal cycle	Fatal	-	-	-	-
		Serious	0	1	0	1
		Slight	3	3	0	6
	Other	Fatal	2	4	0	6
		Serious	24	62	1	87
		Slight	229	206	16	451
2006	Motorcycle	Fatal	2	0	0	2
		Serious	19	23	2	44
		Slight	93	42	4	139
	Pedal cycle	Fatal	-	-	-	-
		Serious	1	0	0	1
		Slight	9	3	0	12
	Other	Fatal	0	4	0	4
		Serious	25	45	2	72
		Slight	219	220	14	453
2007	Motorcycle	Fatal	1	1	0	2
		Serious	24	23	4	51
		Slight	103	50	4	157
	Pedal cycle	Fatal	-	-	-	-
		Serious	1	1	0	2
		Slight	6	0	0	6
	Other	Fatal	0	5	0	5
		Serious	30	38	4	72
		Slight	209	221	23	453
2008	Motorcycle	Fatal	1	0	0	1
		Serious	19	24	1	44
		Slight	117	50	2	169
	Pedal cycle	Fatal	-	-	-	-
		Serious	2	0	0	2
		Slight	2	0	0	2
	Other	Fatal	1	5	0	6
		Serious	17	43	1	61
		Slight	192	200	24	416

Table C-0-2: Numbers of accidents by road class where a deposit on the road surface was recorded as a contributory factor in the accident.

Year	Accident type	Accident severity	Built up roads	Non built up roads	Motorways	All roads
2005	Motorcycle	Fatal	-	-	-	-
		Serious	20	20	0	40
		Slight	90	62	0	152
	Pedal cycle	Fatal	0	1	0	1
		Serious	0	3	0	3
		Slight	3	4	0	7
	Other	Fatal	1	6	0	7
		Serious	24	75	1	100
		Slight	230	432	11	673
2006	Motorcycle	Fatal	2	0	0	2
		Serious	21	29	1	51
		Slight	81	61	3	145
	Pedal cycle	Fatal	-	-	-	-
		Serious	2	2	0	4
		Slight	7	2	0	9
	Other	Fatal	0	6	0	6
		Serious	27	79	2	108
		Slight	240	447	15	702
2007	Motorcycle	Fatal	1	1	0	2
		Serious	22	29	4	55
		Slight	84	58	2	144
	Pedal cycle	Fatal	-	-	-	-
		Serious	2	2	0	4
		Slight	5	0	0	5
	Other	Fatal	1	7	0	8
		Serious	31	61	4	96
		Slight	221	443	20	684
2008	Motorcycle	Fatal	-	-	-	-
		Serious	20	43	1	64
		Slight	99	70	2	171
	Pedal cycle	Fatal	-	-	-	-
		Serious	1	2	0	3
		Slight	3	2	0	5
	Other	Fatal	1	7	0	8
		Serious	23	63	1	87
		Slight	216	453	18	687

Appendix D Average value of prevention per reported accident type for the years 2006 to 2008

Table D-1: The average value (£m) of prevention of the accident types for the years 2006 to 2008 where oil and/or diesel were recorded as a special condition at the site by severity and road type

Year	Accident Type	Accident severity	Built-up roads (£m)	Non built-up roads (£m)	Motorways (£m)	All roads (total £m)
2006	Motorcycle	Fatal	3.25	0.00	0.00	3.25
		Serious	3.55	4.91	0.43	8.89
		Slight	1.76	0.94	0.11	2.81
	Pedal cycle	Fatal	0.00	0.00	0.00	0.00
		Serious	0.19	0.00	0.00	0.19
		Slight	0.17	0.07	0.00	0.24
	Other	Fatal	0.00	6.92	0.00	6.92
		Serious	4.67	9.61	0.43	14.71
		Slight	4.15	4.93	0.37	9.46
2007	Motorcycle	Fatal	1.77	1.93	0.00	3.70
		Serious	4.97	5.32	0.94	11.23
		Slight	2.16	1.24	0.12	3.52
	Pedal cycle	Fatal	0.00	0.00	0.00	0.00
		Serious	0.21	0.23	0.00	0.44
		Slight	0.13	0.00	0.00	0.13
	Other	Fatal	0.00	9.65	0.00	9.65
		Serious	6.21	8.78	0.94	15.94
		Slight	4.39	5.47	0.68	10.54
2008	Motorcycle	Fatal	1.81	0.00	0.00	1.81
		Serious	3.99	5.63	0.24	9.86
		Slight	2.52	1.26	0.06	3.84
	Pedal cycle	Fatal	0.00	0.00	0.00	0.00
		Serious	0.42	0.00	0.00	0.42
		Slight	0.04	0.00	0.00	0.04
	Other	Fatal	1.81	9.87	0.00	11.67
		Serious	3.57	10.08	0.24	13.89
		Slight	4.13	5.04	0.72	9.89

Table D-2: The average value of prevention of the accident types for the years 2006 to 2008 where a deposit on the road surface was a contributory factor by severity and road type

Year	Accident Type	Accident severity	Built-up roads (£m)	Non built-up roads (£m)	Motorways (£m)	All roads (total £m)	
2006	Motorcycle	Fatal	3.25	0.00	0.00	3.38	
		Serious	3.92	6.19	0.22	10.00	
		Slight	1.54	1.37	0.08	2.92	
	Pedal cycle	Fatal					
		Serious	0.00	0.00	0.00	0.00	
		Slight	0.37	0.43	0.00	0.78	
	Other	Fatal	0.13	0.04	0.00	0.18	
		Serious					
		Slight	0.00	10.38	0.00	10.14	
2007	Motorcycle	Fatal	5.05	16.86	0.43	21.17	
		Serious	4.55	10.03	0.40	14.12	
		Slight					
	Pedal cycle	Fatal	1.77	1.93	0.00	3.75	
		Serious	4.56	6.70	0.94	11.83	
		Slight	1.76	1.44	0.06	3.20	
	Other	Fatal					
		Serious	0.00	0.00	0.00	0.00	
		Slight	0.41	0.46	0.00	0.86	
2008	Motorcycle	Fatal	0.11	0.00	0.00	0.11	
		Serious					
		Slight	1.77	13.52	0.00	15.01	
	Pedal cycle	Fatal	6.42	14.10	0.94	20.66	
		Serious	4.64	10.96	0.59	15.21	
		Slight					
	Other	Fatal	0.00	0.00	0.00	0.00	
		Serious	4.20	10.08	0.24	13.96	
		Slight	2.13	1.76	0.06	3.86	

This report reviews diesel spillage products and procedures for clean up and reporting of spillage incidents. Accident data involving motorcyclists where spillage was also considered a factor are also reviewed. This literature study reviews existing treatment procedures and a selection of the absorbent products currently available on the market, claimed suitable for treatment of diesel spillages on road surfaces. The review of the products included their absorbent capacity, cost effectiveness, clean-up performance, and potential environmental benefits. Application and clean-up procedures generally followed by the road authorities in the UK and elsewhere were examined. Reporting systems in place for the general public to report spillages and hazardous material spillage management in the UK and USA are also included. The study found that only limited guidelines exist in the UK to deal with spillages, and that these guidelines did not outline any robust procedure or specify any criteria for selecting appropriate product to deal with spillages. Motorcycle accident statistics were also reviewed where spillages were cited as being a contributory factor, and the annual cost of these accidents was assessed. The accident analysis considered STATS19 data for the period from 2005 to 2008, with OTS data also providing illustrations of a variety of accident circumstances that involve road surface contaminants.

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