

**Whole Life Cost-Benefit Analysis for Median Safety
Barriers**

Task 1 – Relocation of Services

by G L Williams

PPR 276

HA Task Ref No. 3/372/R22

PUBLISHED PROJECT REPORT

TRL Limited



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Task 1 – Relocation of Services**

Version: 2

by G L Williams (TRL Limited)

Prepared for: HA Task Ref No. 3/372/R22; ‘Whole Life Cost-Benefit Analysis for Median Safety Barriers’

Client: Safety Standards and Research Department,
Highways Agency (Mr Danny Ruth)

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CONTENTS

ABSTRACT	1
1. INTRODUCTION	2
1.1 Background	2
1.2 Previous Work	2
1.3 Definitions and abbreviations	2
2. SOURCES OF INFORMATION	3
2.1 The Mouchel Parkman Case Studies – The M25 Sphere	3
2.1.2 Explanation of the Approach to the Costings	6
2.1.3 Contract 1	7
2.1.4 Contract 2	9
2.1.5 Contract 3	11
2.1.6 Contract 4	13
2.1.7 Contract 5	15
2.2 Responses from Highways Agency Maintaining Agents	17
3. DISCUSSION	19
4. CONCLUSIONS	22

List of Annexes

- Annex A: Definitions and Abbreviations
- Annex B: Mouchel Parkman Report
- Annex C: Detailed Costing Sheets
- Annex D: Letter to Highways Agency Maintaining Agents

List of Tables

Table 1: Details of Contracts in the M25 Sphere in which changes to the remedial barrier, drainage and/or lighting have occurred;

Table 2: Incidents in the M25 Sphere involving structural consequences selected for further investigation;

Table 3: Final Account Costs Associated with the M25 Jct 21 to 22 Case Study;

Table 4: Tender Costs Associated with the M20 Jct 2 to 3 Case Study;

Table 5: Final Account Costs Associated with the M1 Jct 1 to 2 (Priority Maintenance) Case Study;

Table 6: Final Account Costs Associated with the M1 Jct 1 to 2 (Crack and Seat Overlay) Case Study;

Table 7: Final Account Costs Associated with the M25 Jct 26 to 27 Case Study;

Table 8: Summary of Safety Fence and Barrier Costs within the Case Studies;

Table 9: Average and Variances in the Cost of Safety Fence and Barrier within the Case Studies.

Table 10: Summary of Ancillary Costs identified within the Case Studies

Table 11: Summary of Ancillary Costs which may be attributable to safety barrier installation within the Case Studies

Table 12: Ancillary Costs identified by Highways Agency Regional representative

List of Figures

Figure 1: The Case Study Area – The M25 Sphere.

Executive Summary

Whole Life Cost-Benefit Analysis for Median Safety Barriers Task 1 – Relocation of Services by G L Williams, TRL Limited

HIGHWAYS AGENCY TASK REFERENCE	: 3/372/R22
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HIGHWAYS AGENCY PROJECT SPONSOR	: Danny Ruth
TRL PROJECT MANAGER	: Gavin Williams

TRL Limited has been commissioned by the Highways Agency to identify, investigate and report on a number of case studies in which a relocation of services has been required within the median.

In order to obtain detailed information relating to such relocation, one area of the Highways Agency's Network, the M25 Sphere, was identified, and details of Works involving the movement and/or replacement of services were collated. From this list of case studies, the following were selected for further analysis:

- Replacement of drainage and safety fence (like-for-like);
- Replacement of drainage and safety fence (Tensioned Corrugated Beam to Open Box Beam);
- Replacement of metal safety fence with concrete barrier, and associated works;
- Crack and seat and overlay of the carriageway and installation of concrete barrier in the verge;
- Replacement of drainage and safety fence (Tensioned Corrugated Beam to Open Box Beam);

In each case, details of the Works completed were collated and the associated costs obtained.

In addition a letter was also distributed to all of the Highways Agency's regional Traffic Operations Departments, their Agents and their Term Maintenance Contractors.

The report concludes that the costs associated with an incident are highly dependant on the impact parameters surrounding the incident, and the costs associated with the individual costs associated with repairs, traffic delay and the severity of the resulting injuries caused by the incident. Each potential hazard should be assessed on a case-by-case basis and each of these factors quantified using a statistical approach, including the implementation of a risk analysis procedure.

ABSTRACT

TRL Limited has been commissioned by the Highways Agency to evaluate and report on the true costs associated with the relocation of services (drainage, communication cables, electrical cables, lighting columns etc.) in the median when replacing steel safety fences with concrete safety barriers.

1. INTRODUCTION

1.1 Background

Early in 1999, there was a series of accidents involving heavy goods vehicles (HGVs) veering to their offside, impacting safety barriers installed in the median, and entering the opposing carriageway. These are referred to as 'crossover accidents' and have caused a number of fatal casualties.

Concern within the Highways Agency about crossover accidents prompted the consideration of replacing normal containment steel safety fences in the median with concrete barriers of a greater level of containment.

TRL Limited has been commissioned by the Highways Agency to investigate three areas of in-service practicality associated with the replacement of metal safety fences with concrete safety barriers in the median:

1. Costs associated with the replacement of steel fences with concrete barriers (and the relocation of services in the median);
2. Costs associated with the structural consequences of breaching a safety barrier;
3. Issues surrounding the provision of temporary and permanent signage in and around concrete median barriers.

This report examines the first of these topics.

1.2 Previous Work

TRL has previously completed three phases to this project, and reports have been produced:

The first phase of the project, TRL unpublished report PR/SE/182/00, examined STATS19 accident data in detail, whilst containing a small amount of information regarding the whole life costs associated with median safety barriers.

Within the second phase, TRL published project report PPR 280, the whole life costing section was significantly expanded, and a whole life costing spreadsheet developed.

Within the third phase, TRL published project report PPR 279, the whole life costing section was expanded further still, incorporating accident rates, risk factors, and revised costing figures.

1.3 Definitions and abbreviations

Definitions and abbreviations used within this report can be located in **Annex A**. In some cases definitions are also included within the main body of the report to aid understanding.

2. SOURCES OF INFORMATION

2.1 The Mouchel Parkman Case Studies – The M25 Sphere

In order to obtain detailed information relating to the relocation of services within the median, one area of the Highways Agency's Network was identified as being of interest. This was the M25 Sphere. This contains a large proportion of the concrete barrier installed in the median of Highways Agency roads, in the form of the Vertical Concrete Barrier (VCB) and Higher Vertical Concrete Barrier (HVCB). This sector also contains lengths of Tensioned Corrugated Beam (TCB), Open Box Beam (OBB), and Wire Rope Safety Fence (WRSF). The M25 Sphere is currently maintained by Mouchel Parkman.

It was hoped that this study area would contain examples of incidents with a wide variety of safety barrier types to enable a full examination of the differing costs associated with service relocation to be examined.



Figure 1: The Case Study Area – The M25 Sphere

2.1.1 Incident Identification

An initial scoping meeting was held between the Highways Agency, TRL and Mouchel Parkman where it was agreed that the following types of Works were of interest to this study:

- Replacement of a safety barrier with one of the same containment;
- Replacement of a metal safety fence with a metal safety fence of greater containment;
- Replacement of a metal safety fence with a concrete barrier of the same containment;
- Replacement of a metal safety fence with a concrete barrier of greater containment;
- The relocation of services;
- Movement of lighting columns;
- The introduction of additional drainage.

From this brief, the following incidents were identified by Mouchel Parkman as being relevant to this project:

Job name	Form of contract		Barrier				Drainage				Lighting			
	Framework / Tender (F / T)	Lane Rental (Y / N)	Original barrier type	Approx length new barrier	New barrier type	Had ex barrier reached end useful life? (Y / N) ##	Type of c/res surface originally	Type of ex drainage	Type replacement drainage	Type of Additional drainage added	Type of ex Lighting in c/res	Type of new lighting in central res	Had ex lighting reached end of useful life? (Y / N)	Type of new lighting in verges
M11 Junct. 6 to 7 N/B Major	T	Y	TCB	6200	1200 OBB 5000 TCB	Y	Soft	Combined FD & carrier	Mix	None	None			
M25 Major Maintenance Jct. 21 to 22	T	Y	OBB	8000	OBB	Y	Soft	Filter Drain	Filter Drain		None			
M25 Junct. 26 to 27 Major	T	Y	TCB	5500	OBB	Y	Soft	Filter Drain	Filter Drain					
M11 Junct. 4 Northbound Hybrid	T	Y	TCB	2700	OBB	Y	Hardened			None	None			
M1 Jct. 1 to 2 Priority Maintenance	T	Y	TCB & OBB		VCB	Y	Soft	Filter Drain				Y		
M1 Junct. 1 to 2 Crack, Seat, Overlay	T	Y	OBB	3350	VCB	N	Hardened	Filter Drain	Filter Drain	None	Reinstate	N	Same	
A20 Swanley by-pass	F	N	TCB	3200	Ex TCB	N	Soft	Channel / Carrier	None	None	None			
M11 Jct. 6 Both Carriageways	T	Y	OBB	3900	OBB?	Y	Soft	Combined FD & carrier	Combined FD & carrier	Replace	Planted double arm **			
A1089 Marshfoot Interchange	F	N	TCB	2800	OBB	Y	Soft	Carrier	Carrier	None	Planted double arm	Y		
A1(M) Junction 1 N & S	F	N	TCB	2150	TCB	Y	Soft	Filter Drain	Filter Drain	None	Flanged double arm	Y		
M20 Junction 2 to 3 Major Maintenance	T	Y	OBB & TCB	7000	OBB	Y	Hardened	Combined FD & carrier	Combined FD & carrier	Combined FD & carrier	Flanged double arm	Y		

Table 1: Details of Contracts in the M25 Sphere in which changes to the remedial barrier, drainage and/or lighting have occurred

From this list, the following five contracts were selected for further analysis:

Job name	Form of contract		Barrier				Drainage				Lighting			
	Framework / Tender (F / T)	Lane Rental (Y / N)	Original barrier type	Approx length new barrier	New barrier type	Had ex barrier reached end useful life? (Y / N) ##	Type of c/res surface originally	Type of ex drainage	Type replacement drainage	Type of Additional drainage added	Type of ex Lighting in c/res	Type of new lighting in central res	Had ex lighting reached end of useful life? (Y / N)	Type of new lighting in verges
M25 Major Maintenance Jct. 21 to 22	T	Y	OBB	8000	OBB	Y	Soft	Filter Drain	Filter Drain		None	None		
M20 Junction 2 to 3 Major Maintenance	T	Y	OBB & TCB	7000	OBB	Y	Hardened	Combined FD & carrier	Combined FD & carrier	Combined FD & carrier	Flanged double arm	Flanged double arm	Y	
M1 Jct. 1 to 2 Priority Maintenance	T	Y	TCB & OBB		VCB	Y	Soft	Filter Drain					Y	
M1 Junct. 1 to 2 Crack, Seat, Overlay	T	Y	OBB	3350	VCB	N	Hardened		Filter Drain	None	Flanged double arm	Reinstate	N	Same
M25 Junct. 26 to 27 Major	T	Y	TCB	5500	OBB	Y	Soft	Filter Drain	Filter Drain					

Table 2: Incidents in the M25 Sphere involving structural consequences selected for further investigation

These particular contracts were selected as it was believed that these would demonstrate the costs associated with a variety of different Works and would include an example in which standard steel safety fencing have been replaced with concrete safety barriers. The contracts would also demonstrate the variety of costs associated with median Works. Complete information sets were also available for these Works.

Details of the incidents and associated costs are contained within the Mouchel Parkman project report, attached to this report as **Annex B**.

2.1.2 Explanation of the Approach to the Costings

Within each of the case studies, the following approach is taken to assess the costs provided from Mouchel Parkman;

1. The costs associated with each case study are first combined into the areas of Work identified within the Highways Agency's Specification for Highway Works.
2. These costs include a provision for 'general preliminaries' which can be partially attributable to the removal/installation of the safety fence in addition to the other area of Works. These are therefore removed from the total cost of the works to give a 'Works value excluding preliminaries'.
3. The ratio of the barrier cost to this Works value excluding preliminaries is then calculated.
4. This ratio is then applied to the general preliminaries cost to ascertain an approximate cost for the general preliminaries resulting from the safety barrier work.
5. This is then added to the cost of the barrier to give a cost of the safety barrier including a proportion of the preliminaries.
6. Costs for the ancillary works within the median only (excluding preliminaries) are then tabulated and calculated per metre.
7. This value is then added to the cost of the safety barrier plus general preliminaries provision to give a value for the total cost of the barrier including both ancillary costs and a provision for preliminaries.

Please note that the contracts are complex as contractors may load their prices in a particular way, and it is also difficult to work out exactly which costs are truly attributable to the safety barrier changes / replacement and those which would have had to have been done anyway or were done as it became cost effective to update something that was nearing end of useful life.

However each of the contracts will now be examined in turn and an assessment of the costs associated with each presented.

2.1.3 Contract 1

Location of Works:	M25, Junction 21 to 22
Contractor:	Amec Lafarge
Start of Works Date:	12 August 2002
Tender Value of Works:	£10,232,942.33
Final Cost of Works:	£13,004,939.40
Changes in:	
Safety Barrier:	8000m of OBB to OBB
Drainage:	Like-for-like replacement of filter drain
Lighting:	No lighting in median before or after Works
Carriageway:	Relay existing flexible surface and harden the median
Additional Works:	Install chambers for cables and bases for future lighting columns

Description of Works

The main works were to:

- Plane out the existing flexible surfacing and relay;
- Renew the existing OBB safety fence with OBB;
- Flush out and repair or renew drainage where necessary;
- Install ducts for electrical works and cable in central reserve for lighting and communications;
- Harden the median;
- Install chambers for cables and bases for future lighting columns in the median.

During the works:

- Only about 10% of the drainage that was going to be replaced was renewed;
- Transverse ducts had to be installed deeper than expected due to a clash with existing services in the central reserve. This resulted in the electrical chambers being deeper than originally planned;
- The restricted width of the central reserve made it difficult to fit everything in and install the works required, e.g. installation of ducts, and the central reserve safety barrier.

Cost of Works (Final Account)

Note that both the tender and final account costs are included in the Mouchel Parkman spreadsheets in **Annex C**. Only the final account costs are presented within the body of the report for this contract.

SfHW Reference	Cost Description	Final Account	Reference Value
100	General Preliminaries	£ 3,920,646.50	(2)
200	Site Clearance	£ 180,529.33	
400	Safety Fencing (median)	£ 815,360.00	(4)
	Safety Fencing (verge)	£ 489,432.00	
500	Drainage and Service Ducts	£ 446,728.27	
600	Earthworks	£ 186,516.35	
700	Pavements	£ 3,690,468.47	
1100	Kerbs and footways	£ 681,188.70	
1200	Traffic Signs and Road markings	£ 99,798.05	
1400	Electrical Work for Road lighting	£ 787,207.74	
1500	Motorway communications	£ 509,656.73	
	Bridges	£ 27,781.56	
1800	Steelwork		
	Remedial Earthworks / landscape and ecology	£ 557,786.04	
	Bonus for early completion	£ 35,000.00	
	Miscellaneous Costs	£ 79,008.24	
	Compensation Events (general)	£ 497,831.42	
	Total	£ 13,004,939.40	(1)
	Length of Scheme	8,000	(3)
	Total Cost of Scheme / m	£ 1,625.62	(1) / (3)
	Works Value excl prelims	£ 9,084,292.90	(1) - (2) = (5)
	Total Cost of Safety Barrier in Median	£ 815,360.00	(4)
	Cost of Safety Barrier / m (excl prelims)	£ 101.92	(4) / (3) = (7)
	Ratio Barrier costs to Works Value (excl prelims)	9.0%	(4) / (5) = (6)
	Value of Prelims attributable to Safety Barrier / m	£ 43.99	[(6) x (2)] / (3) = (8)
	Total cost of Barrier / m including proportion of prelims	£ 145.91	(7) + (8) = (9)
	Ancillary works in the median only		
500	Drainage and Service Ducts	£ 147,420.32	
600	Earthworks	£ 139,887.26	
1100	Kerbs and footways	£ 510,891.52	
1400	Electrical Work for Road lighting	£ 590,405.80	
1500	Communications	£ 382,242.54	
	Total of ancillary works	£ 1,770,847.44	(10)
	Cost ancillary works in the median / m (excl prelims)	£ 221.36	(10) / (3) = (11)
	Total cost barrier + ancillary + proportion of prelims/m	£ 367.27	(9) + (11)

Table 3: Final Account Costs Associated with the M25 Jct 21 to 22 Case Study

2.1.4 Contract 2

Location of Works:	M20, Junction 2 to 3
Contractor:	Hanson
Start of Works Date:	13 August 2005
Tender Value of Works:	£9,122,393.99
Final Cost of Works:	Not yet available
Changes in:	
Safety Barrier:	7000m of TCB/OBB to OBB
Drainage:	Like-for-like replacement of filter drain and carrier
Lighting:	Like-for-like replacement of flanged double arm lighting columns
Carriageway:	Overlay existing concrete carriageway
Additional Works:	None

Description of Works

The main works were to:

- Overlay existing concrete carriageway;
- Flush out and repair or renew existing drainage;
- Upgrade existing TCB / OBB safety fence (most OBB) to OBB.

After the contract had been awarded, Hanson were asked to prepare a costing for changing the tendered form of safety fence (OBB) to concrete safety barrier in line with the newly issued IAN60. The differing elements of cost between the two systems related only to the general preliminaries and safety barrier costs. The following Table shows the differences between the safety barrier costs:

Cost of Works (Tender)

Note that only tender costs are available in the Mouchel Parkman spreadsheets in **Annex C**.

SfHW Reference	Cost Description	Steel Tender (Final Account Values not available)	Concrete Alternative	Reference Value
100	General Preliminaries	£ 1,772,859.72	£ 2,499,379.20	(2)
200	Site Clearance	£ 142,533.64	£ 142,533.64	
300	Fencing, Gates	£ 29,407.00	£ 29,407.00	
400	Safety Fencing (median)	£ 588,100.97	£ 767,120.63	(4)
	Safety Fencing (verge)	£ 398,350.03	£ 398,350.03	
500	Drainage and Service Ducts	£ 701,182.07	£ 701,182.07	
600	Earthworks	£ 125,238.00	£ 125,238.00	
700	Pavements	£ 3,958,709.83	£ 3,958,709.83	
1100	Kerbs and footways	£ 425,328.38	£ 425,328.38	
1200	Traffic Signs and Road markings	£ 95,334.16	£ 95,334.16	
1300	Road Lighting Columns, Brackets and CCTV Masts	£ 187,071.04	£ 187,071.04	
1400	Electrical Work for Road lighting	£ 367,098.78	£ 367,098.78	
1500	Motorway communications	£ 67,868.23	£ 67,868.23	
	Bridges	£ 146,882.40	£ 146,882.40	
1800	Steelwork			
	Remedial Earthworks / landscape and ecology	£ 76,426.85	£ 76,426.85	
	Miscellaneous	£ 40,002.90	£ 40,002.90	
	Total	£ 9,122,393.99	£ 10,027,933.13	(1)
	Length of Scheme	6,395	6,395	(3)
	Total Cost of Scheme / m	£ 1,426.49	£ 1,568.09	(1) / (3)
	Works Value excl prelims	£ 7,349,534.27	£ 7,528,553.93	(1) - (2) = (5)
	Total Cost of Safety Barrier in Median	£ 588,100.97	£ 767,120.63	(4)
	Cost of Safety Barrier / m length (excl prelims)	£ 91.96	£ 119.96	(4) / (3) = (7)
	Ratio Barrier costs to Works Value (excl prelims)	8.0%	10.2%	(4) / (5) = (6)
	Value of Prelims attributable to Safety Barrier /m	£ 22.18	£ 39.82	[(6) x (2)] / (3) = (8)
	Total cost of Barrier / m including proportion of prelims	£ 114.14	£ 159.78	(7) + (8) = (9)
	Ancillary works in the median only			
500	Drainage and Service Ducts	£ 231,390.08		
600	Earthworks	£ 41,328.54		
1100	Kerbs and footways	£ 318,996.28		
1400	Electrical Work for Road lighting	£ 183,549.39		
1500	Communications	£ 33,934.11		
		£ 809,198.40		(10)
	Cost ancillary works in the median / m (excl prelims)	£ 126.54		(10) / (3) = (11)
	Total cost barrier + ancillary + proportion of prelims/m	£ 240.68		(9) + (11)

Table 4: Tender Costs Associated with the M20 Jct 2 to 3 Case Study

2.1.5 Contract 3

Location of Works:	M1, Junction 1 to 2 (Priority Maintenance)
Contractor:	SIAC
Start of Works Date:	September 2001
Tender Value of Works:	£1,537,206.63
Final Cost of Works:	£2,375,167.62
Changes in:	
Safety Barrier:	Replace TCB/OBB with VCB
Drainage:	No changes or Works in this contract
Lighting:	Replacement of lighting columns in the median
Carriageway:	No changes or Works in this contract
Additional Works:	None

Description of Works

The main works were to:

- Construct rigid concrete safety barrier in the central reserve;
- Prepare drainage, cables, earthworks in the central reserve.

This contract was to replace old TCB and OBB in the central reserve with VCB. Also old lighting columns were replaced in the central reserve. The contract suffered from budget changes prior to and during that works that dictated the extent of the work undertaken. Major maintenance work that was required on this section of the M1 was not done in this contract and was completed under the M1 J1 to J2 Crack, Seat and Overlay contract (refer to contract 4).

Compensation events associated with the installation of the VCB were:

- Carry out additional work to the existing chambers and gullies to ensure that they fitted with the VCB;
- Move lighting column ducting.

Cost of Works (Final Account)

Note that both the tender and final account costs are included in the Mouchel Parkman spreadsheets in **Annex C**. Only the final account costs are presented within the body of the report for this contract.

SfHW Reference	Cost Description	Final Account	Reference Value
100	General Preliminaries	£ 664,275.82	(2)
200	Site Clearance	£ 26,722.08	
400	Safety Fencing (median)	£ 907,069.30	(4)
	Safety Fencing (verge)		
500	Drainage and Service Ducts	£ 35,904.20	
600	Earthworks	£ 40,075.03	
1200	Traffic Signs and Road markings	£ 55,779.43	
1300	Road Lighting Columns, Brackets and CCTV Masts	£ 65,932.32	
1400	Electrical Work for Road lighting	£ 111,102.02	
1800	Steelwork	£ 693.22	
	Compensation Events (general)	£ 275,993.84	
	Compensation Events attributable to Safety Barrier	£ 191,620.36	(6)
	Total	£ 2,375,167.62	(1)
	Length of Scheme	3,000	(3)
	Total Cost of Scheme / m	£ 791.72	(1) / (3)
	Works Value excl prelims	£ 1,710,891.80	(1) - (2) = (5)
	Total Cost of Safety Barrier in Median	£ 1,098,689.66	(4) + (6) = (7)
	Cost of Safety Barrier / m (excl prelims)	£ 366.23	(7) / (3) = (9)
	Ratio Barrier costs to Works Value (excl prelims)	64.2%	(7) / (5) = (8)
	Value of Prelims attributable to Safety Barrier / m	£ 142.19	[(8) x (2)] / (3) = (10)
	Total cost of Barrier / m including proportion of Prelims	£ 508.42	(9) + (10) = (11)
	Ancillary works in the median only		
500	Drainage and Service Ducts	£ 35,904.20	
600	Earthworks	£ 40,075.03	
1100	Kerbs and footways	£ -	
1400	Electrical Work for Road lighting	£ 111,102.02	
1500	Communications	£ -	
		£ 187,081.25	(12)
	Cost ancillary works / m (excl prelims)	£ 62.36	(12) / (3) = (13)
	Total cost barrier + ancillary + proportion of prelims/m	£ 570.78	(9) + (13)

Table 5: Final Account Costs Associated with the M1 Jct 1 to 2 (Priority Maintenance) Case Study

2.1.6 Contract 4

Location of Works:	M1, Junction 1 to 2 (Crack and Seat Overlay)
Contractor:	Tarmac Ltd.
Start of Works Date:	12 March 2004
Tender Value of Works:	£5,690,108.48
Final Cost of Works:	£6,158,989.99
Changes in:	
Safety Barrier:	Replace TCB/OBB with VCB
Drainage:	Like-for-like replacement of filter drain
Lighting:	Like-for-like replacement of lighting
Carriageway:	Crack and seat and overlay the existing concrete carriageway
Additional Works:	None

Description of Works

This was a follow up contract to the M1 J1 to J2 Priority Maintenance Scheme (refer to contract 3). Existing drainage was replaced within Area 21 due to it being in poor condition. As part of this major crack and seat project in Area 5, a limited length of VCB was installed in the median; the main length VCB was in the verge. New lighting columns were also placed on the VCB in median.

The main works were to

- Crack and seat and overlay the existing concrete carriageway;
- Install a rigid concrete safety barrier to the verges, with a short length of VCB in the central reserve.

Cost of Works (Final Account)

Note that both the tender and final account costs are included in the Mouchel Parkman spreadsheets in **Annex C**. Only the final account costs are presented within the body of the report for this contract.

SfHW Reference	Cost Description	Final Account	Reference Value
100	General Preliminaries	£ 1,636,816.08	(2)
200	Site Clearance	£ 216,645.23	
400	Safety Fencing (median)	£ 44,294.00	(4)
	Safety Fencing (verge)	£ 885,883.00	
500	Drainage and Service Ducts	£ 252,884.83	
600	Earthworks	£ 46,968.67	
700	Pavements	£ 2,183,421.87	
1100	Kerbs and footways	£ 113,788.13	
1200	Traffic Signs and Road markings	£ 100,201.74	
1300	Road Lighting Columns, Brackets and CCTV Masts	£ 67,453.13	
1400	Electrical Work for Road lighting	£ 48,185.68	
1500	Motorway communications	£ 374,903.46	
	Bridges	£ 47,038.26	
1800	Steelwork	£ 1,014.00	
	Remedial earthworks / landscape and ecology	£ 139,491.91	
	Total	£ 6,158,989.99	(1)
	Length of Scheme	3,350	(3)
	Total Cost of Scheme / m	£ 1,838.50	(1) / (3)
	Works Value excl prelims	£ 4,522,174.32	(1) - (2) = (5)
	Total Cost of Safety Barrier in median	£ 44,294.00	(4)
	Cost of Safety Barrier / m length (excl prelims)	£ 13.22	(4) / (3) = (7)
	Ratio Barrier costs to Works Value (excl prelims)	1.0%	(4) / (5) = (6)
	Value of Prelims attributable to Safety Barrier / m	£ 4.79	[(6) x (2)] / (3) = (8)
	Total cost of Barrier / m including proportion of Prelims	£ 18.01	(7) + (8) = (9)
	Ancillary works in the median only		
500	Drainage and Service Ducts	£ 252,884.03	
600	Earthworks	£ 46,968.67	
1100	Kerbs and footways	£ 113,788.13	
1400	Electrical Work for Road lighting	£ 48,185.68	
1500	Communications	£ 374,903.46	
		£ 836,729.97	(10)
	Cost ancillary works / m (excl prelims)	£ 249.77	(10) / (3) = (11)
	Total cost barrier + ancillary + proportion of prelims/ m	£ 267.78	(9) + (11)

**Table 6: Final Account Costs Associated with the M1 Jct 1 to 2 (Crack and Seat Overlay)
Case Study**

2.1.7 Contract 5

Location of Works:	M25 J26-27
Contractor:	Fitzpatrick
Start of Works Date:	15 July 2003
Tender Value of Works:	£11,164,546.39
Final Cost of Works:	£14,389,700.41
Changes in:	
Safety Barrier:	Replace TCB with OBB
Drainage:	Like-for-like replacement of filter drain
Lighting:	Like-for-like replacement of lighting columns
Carriageway:	Relay the existing flexible pavement
Additional Works:	Upgrade service ducts

Description of Works

The main works were to:

- Overlay the existing concrete carriageway;
- Carry out concrete repairs where necessary to the extent of removing whole bays;
- Plane out and relay the existing flexible pavement;
- Repair or replace existing drainage ;
- Upgrade the safety fence;
- Upgrade the service ducts and cables plus renew lighting columns.

Cost of Works (Final Account)

Note that both the tender and final account costs are included in the Mouchel Parkman spreadsheets in **Annex C**. Only the final account costs are presented within the body of the report for this contract.

SfHW Reference	Cost Description	Final Account	Reference Value
100	General Preliminaries	£ 4,850,589.32	(2)
200	Site Clearance	£ 188,363.28	
300	Fencing, Gates	£ 6,532.25	
400	Safety Fencing (median)	£ 582,056.00	(4)
	Safety Fencing (verge)	£ 465,775.00	
500	Drainage and Service Ducts	£ 1,118,400.81	
600	Earthworks	£ 636,819.75	
700	Pavements	£ 3,533,459.18	
1100	Kerbs and footways	£ 691,742.81	
1200	Traffic Signs and Road markings	£ 115,347.66	
1300	Road Lighting Columns, Brackets and CCTV Masts	£ 156,797.73	
1400	Electrical Work for Road lighting	£ 750,296.08	
1500	Motorway communications	£ 749,798.88	
	Bridges	£ 529,546.03	
1800	Steelwork		
	Remedial Earthworks / landscape and ecology	£ 14,175.63	
	Total	£ 14,389,700.41	(1)
	Length of Scheme	6,200	(3)
	Total Cost of Scheme / m	£ 2,320.92	(1) / (3)
	Works Value excl prelims	£ 9,539,111.09	(1) - (2) = (5)
	Total Cost of Safety Barrier in Median	£ 582,056.00	(4)
	Cost of Safety Barrier / m length (excl prelims)	£ 93.88	(4) / (3) = (7)
	Ratio Barrier costs to Works Value (excl prelims)	6.1%	(4) / (5) = (6)
	Value of Prelims attributable to Safety Barrier / m	£ 47.74	[(6) x (2)] / (3) = (8)
	Total cost of Barrier / m including prop of Prelims	£ 141.62	(7) + (8) = (9)
	Ancillary works in the median only		
500	Drainage and Service Ducts	£ 559,200.40	
600	Earthworks	£ 318,409.87	
1100	Kerbs and footways	£ 622,568.52	
1400	Electrical Work for Road lighting	£ 450,177.64	
1500	Communications	£ 449,879.32	
		£ 2,400,235.75	(10)
	Cost ancillary works / m (excl prelims)	£ 387.13	(10) / (3) = (11)
	Total cost barrier + ancillary + proportion of prelims/m	£ 528.75	(9) + (11)

Table 7: Final Account Costs Associated with the M25 Jct 26 to 27 Case Study

2.2 Responses from Highways Agency Maintaining Agents

In addition to the Mouchel Parkman case studies, the Highways Agency's regional Traffic Operations Departments, their Agents and their Term Maintenance Contractors were also contacted regarding the costs associated with the relocation of services (with particular reference to a change from steel to concrete safety barriers. A copy of the letter sent requesting this information is contained within **Annex D**.

The responses received are detailed below:

2.2.1 Email from Stephen Coe, Highways Agency, Area 2, dated 18-08-05

'Malcolm Wilkinson has passed me your letter dated 2nd August concerning the above. On 1st July we changed our provider from Atkins/RCS to Interroute. Prior to this we had not carried out any schemes with concrete barriers and because of the changeover schemes are a bit thin on the ground at present. However, we are currently developing a scheme for replacement lighting at M5 J16-18 and I have asked Interroute to include concrete barriers over a couple of sections where the steel barriers are close to the end of their life. The current programme is to have the target price by the end of September so I would therefore hope to be able to provide you with some information by this date.'

2.2.2 Subsequent Email from Stephen Coe, Highways Agency, Area 2, dated 09-11-05

'Unfortunately the scheme I mentioned has been put back to next financial year due to ecological issues so the scheme isn't yet designed to the stage where we can supply you with any meaningful costs. The revised timetable for completing the designs/costings is now mid-February 2006...

Unfortunately I am unable to help with the other item either; there are no records of any central reserve bridge pier strikes within Area 2.'

2.2.3 Email from Roger Wantling, Highways Agency, MAC12 Area Team, dated 22-09-05

'With regard to the request for information regarding the concrete step barrier, I am afraid that due to the combination of the works carried out to date there appears to be little information available: However, to try to help, the comments I can make are as follows:-

Costs associated with the relocation of services/street lighting - This has not occurred on the scheme that has already been completed and is not perceived to be a problem on the remaining two schemes that include the concrete step barrier in the 05-06 program. Furthermore, from the information known at this moment in time about the schemes in the forward program (i.e. M1 J32 to J33, M18 J6 to 7 and M62 Balkholme to Gilberdyke) we are likely to have little effect on existing services and the schemes contain no street lighting as far as I am aware. Accordingly, there appears to be no known cost information in relation to this matter.

Costs in relation to drainage - This can be broken into four areas as follows: -

We have considered that a survey of the existing drainage system, prior to the construction of the concrete step barrier above, is essential and on the schemes constructed/designed already the survey has unavoidable costs in the region of £30,000.

Following the drainage survey, if the existing drainage system is in need of repair then it is repaired prior to the implementation of the barrier. The range of costs appears to be from zero when the drainage system is considered serviceable to in the region of £50,000 where extensive repairs are required.

Improvements to the drainage system may also need to be catered for, but this is scheme dependant. The remaining unavoidable cost is for catering for the surface ironwork and can be assumed as typically £35,000, but again this is scheme dependant.

Costs in catering for traffic loops - An allowance for the passage of the traffic loops under the concrete barrier is also required. (i.e. to construct a chamber either side of the barrier with the associated ducting). Again, this is scheme dependant, but it can be assumed that 2 loops per scheme is not unreasonable at a total cost in the region of £2,000.

2.2.4 Email from Paul Chambers to Lesley Ward (both Atkins), Area 10, dated 28-09-05. Received from Barbara McNally, Highways Agency

‘In terms of the costs for moving services we will have more difficulty in providing an answer. Generally if the central reserve is a standard width (whatever that may mean!) then the concrete safety barrier should fit with minimal alterations to the services. Where the median is narrow then the services may have to be buried under the barriers foundation and costs will inevitably rise. It should be noted that a bituminous foundation is acceptable for the barrier and therefore makes the burying of services less of an issue for future maintenance.

We do not have any schemes at a sufficiently developed stage to give a guide on additional costs. We do have a scheme in prep for the M66 which has a narrow central reserve with lighting and drainage wedged in along with the safety barrier. This scheme is currently estimated to cost £8m and is only a safety fence scheme, compare this to some of our main schemes costing some £4- 6m and it would seem that a lot of additional cost has been incorporated.’

3. DISCUSSION

Table 8 summarises the costs associated with the safety barrier installed in the median during the case studies:

	Name of Scheme					
	M25, Jct 21-22	M20, Jct 2-3*	M20, Jct 2-3	M1, Jct 1-2 (Phase 1)	M1, Jct 1-2 (Phase 2)	M25, Jct 26-27
Type of barrier installation	Metal (OBB)	Metal (OBB)	Concrete (VCB) Alternative	Concrete (VCB)	Concrete (VCB)	Metal (OBB)
Total cost of scheme	£13,004,934.40	£9,122,393.99	£10,027,933.13	£2,375,167.62	£6,158,989.99	£14,389,700.41
Length of scheme	8,000	6,395	6,395	3,000	3350	6,200
Total cost of scheme/m	£1,625.62	£1,426.49	£1,568.09	£791.72	£1,838.50	£2,320.92
Cost of barrier/m (exc. Prelims)	£101.92	£91.96	£119.96	£366.32	£13.22	£93.88
%age of barrier costs of total works (excluding Prelims)	9.0%	8.0%	10.2%	64.2%	1.0%	6.1%
Cost of barrier/m (inc. Prelims)	£145.91	£114.14	£159.78	£508.42	£18.01	£141.62
Cost of barrier/m (inc. Prelims and ancillary works)	£367.27	£240.68	Data not available	£570.78	£267.78	£528.75

* Note that these are Tender figures and not final account. For steel systems, the ration of Tender to final account costs is approximately +42%. For concrete systems, this is approximately +7%.

Table 8: Summary of Safety Fence and Barrier Costs within the Case Studies

It is felt that due to the small amount of concrete safety barrier installed in the median during Phase 2 of the M1 works, these results should be disregarded.

The results indicate the following average values for the site specific works examined:

Type of barrier installation	Metal		Concrete	
	Average	Variance	Average	Variance
Cost of barrier/m (exc. Prelims)	£95.92	+6%, -4%	£243.14	±51%
Cost of barrier/m (inc. Prelims)	£133.89	+9%, -15%	£334.10	±52%
Cost of barrier/m (inc. Prelims and ancillary works)	£378.90	+40%, -36%	£570.78	0% *

* Costs only available from one source

Table 9: Average and Variances in the Cost of Safety Fence and Barrier within the Case Studies

Once again, it must be emphasised that the contracts are complex as contractors may load their prices in a particular way, and it is also difficult to work out exactly which costs are truly attributable to the safety barrier changes / replacement and those which would have had to have been done anyway or were done as it became cost effective to update something that was nearing end of useful life.

It should also be emphasised that the installation of safety barrier and the associated relocation of services is very site specific (as stated by the Highways Agency's Regional representatives). Although average values can be calculated, these will only give an indication of associated costs, and will not provide definitive values. Any use of such averages may lead to inaccurate and/or misleading results.

These data show that the initial cost of installing concrete barrier is higher than for those involving steel safety fences. Within the small data set of case studies presented in this report it is estimated that the initial cost associated with concrete safety barriers (excluding other aspects of the installation) is some two and a half times the cost greater than that of a metal system.

The variance in the cost of median safety barrier installations is less variable with metal steel barrier installations.

Once a proportion of preliminary works is included (by taking the safety barrier costs as a percentage of the works excluding the preliminaries), concrete barrier is again, approximately two and a half times the cost of the steel barrier systems.

Once additional median service works are included (such as drainage, earthworks, lighting and communications), this difference reduces to one and a half times more expensive using concrete – however as with all of these figures in which other areas of cost are included, this will depend heavily on the extent of the additional works being undertaken in the median.

It should be emphasised that in the one case study involving the replacement of steel safety fences with concrete barriers, the total cost of the scheme was estimated to be approximately 1,568.09 per metre. As can be seen within the contract 3 description, there was little unrelated work undertaken within this contract and hence, this case study will give a reasonable approximation to the costs resulting from such replacement.

The following Table summarises the ancillary median works costed within each of the case studies.

SfHW Reference	Description of Cost	Name of Scheme					M25, Jct 26-27 TCB to OBB
		M25, Jct 21-22 OBB to OBB	M20, Jct 2-3* OBB & TCB to OBB	M20, Jct 2-3 OBB & TCB to VCB	M1, Jct 1-2 (Phase 1) TCB & OBB to VCB	M1, Jct 1-2 (Phase 2) OBB to VCB	
500	Drainage and Service Ducts	£ 147,420.32	£ 231,390.08	-	£ 35,904.20	£ 252,884.03	£ 559,200.40
600	Earthworks	£ 139,887.26	£ 41,328.54	-	£ 40,075.03	£ 46,968.67	£ 318,409.87
1100	Kerbs and Footways	£ 510,891.52	£ 318,996.28	-	-	£ 113,788.13	£ 622,568.52
1400	Electrical Work for Road Lighting	£ 590,405.80	£ 183,549.39	-	£ 111,102.02	£ 48,185.68	£ 450,177.64
1500	Communications	£ 382,242.54	£ 33,934.11	-	£ -	£ 374,903.46	£ 449,879.32
Total of ancillary works		£ 1,770,847.44	£ 809,198.40	-	£ 187,081.25	£ 836,729.97	£ 2,400,235.75
Cost of ancillary works/m		£ 221.36	£ 126.54	-	£ 62.36	£ 249.77	£ 387.13

Table 10: Summary of Ancillary Costs identified within the Case Studies

In each example it is difficult to ascertain which of these costs can be directly attributed to the safety barrier installation, although the case study summary table (Table 2) may give an indication as to whether the works were needed to be completed in any case. Hence, if such costs are removed from the costing, it could be estimated that the following costs were as a direct result of the safety fence installation:

SfHW Reference	Description of Cost	Name of Scheme					M25, Jct 26-27 TCB to OBB
		M25, Jct 21-22 OBB to OBB	M20, Jct 2-3* OBB & TCB to OBB	M20, Jct 2-3 OBB & TCB to VCB	M1, Jct 1-2 (Phase 1) TCB & OBB to VCB	M1, Jct 1-2 (Phase 2) OBB to VCB	
500	Drainage and Service Ducts			-	£ 35,904.20	£ 252,884.03	
600	Earthworks	£ 139,887.26	£ 41,328.54	-	£ 40,075.03	£ 46,968.67	£ 318,409.87
1100	Kerbs and Footways	£ 510,891.52	£ 318,996.28	-	£ -	£ 113,788.13	£ 622,568.52
1400	Electrical Work for Road Lighting	£ 590,405.80		-	£ 111,102.02	£ 48,185.68	£ 450,177.64
1500	Communications	£ 382,242.54	£ 33,934.11	-	£ -	£ 374,903.46	£ 449,879.32
Total of ancillary works		£ 1,623,427.12	£ 394,258.93	-	£ 187,081.25	£ 836,729.97	£ 1,841,035.35
Cost of ancillary works/m		£ 202.93	£ 61.65	-	£ 62.36	£ 249.77	£ 296.94

Table 11: Summary of Ancillary Costs which may be attributable to safety barrier installation within the Case Studies

The large scatter in the ancillary costs associated with metal and steel safety barrier again highlights the site specific nature of the costs associated with such works, both the barrier costs, and associated ancillary costs.

It should be noted that within the responses from the Highways Agency regional representatives it is stated that for one particular scheme, the following costs have been estimated with regard to the service relocation and/or provision:

SfHW Reference	Description of Cost	
500	Drainage and Service Ducts	£ 30,000 rising to £ 115,000
600	Earthworks	Unknown
1100	Kerbs and Footways	Unknown
1400	Electrical Work for Road Lighting	£ 0.00
1500	Communications	£ 2,000

Table 12: Ancillary Costs identified by Highways Agency Regional representative

4. CONCLUSIONS

In summary, the costs associated with an incident are highly dependant on the impact parameters surrounding the incident, and the costs associated with the individual costs associated with repairs, traffic delay and the severity of the resulting injuries caused by the incident. Each potential hazard should be assessed on a case-by-case basis and each of these factors quantified using a statistical approach, including the implementation of a risk analysis procedure.

ANNEX A – DEFINITIONS AND ABBREVIATIONS

Term or abbreviation	Explanation
• CCTV	Closed Circuit Television
• Central Reserve	The strip of land (may be grassed) between two opposing carriageways
• Concrete Safety Barrier	An installation provided for the protection of users of the highway which is continuously in contact with its supporting foundation.
• Crossover Accident	An accident in which one or more vehicle leaves the carriageway on the offside, and enters the opposing carriageway
• HA	Highways Agency
• HGV	Heavy Goods Vehicle
• Higher Containment	A safety fence or barrier that has been impact tested to and complies with H1, H2 or H3 containment level requirements in BSEN1317, parts 1 and 2 (see Table 2).
• HVCB	Higher vertical concrete barrier - A concrete barrier with a vertical face, 1.2m in height
• Median	See 'central reserve'
• Normal Containment	A safety fence or barrier that has been impact tested to and complies with N1 or N2 containment level requirements in BSEN1317, parts 1 and 2 (see Table 2).
• OBB	Open box beam safety fence
• Safety Barrier	Generic name for a safety fence or a concrete safety barrier
• Safety Fence	An installation provided for the protection of users of the highway consisting of horizontal members mounted on posts
• SfHW	Specification for Highway Works, HA Publication
• STATS19	A reporting system in operation in Great Britain for the collection of information at fatal, serious, and slight accidents; organised by the DTLR.
• TCB	Tensioned corrugated beam safety fence
• VCB	Vertical concrete barrier - A concrete barrier with a vertical traffic face, 0.8m in height
• Vehicle Restraint System	System installed on the road to provide a level of containment for an errant vehicle
• Very High Containment	A safety fence or barrier that has been impact tested to and complies with H4a or H4b containment level requirements in BSEN1317, Parts 1 and 2.
• WRSF	Wire rope safety fence

ANNEX B – MOUCHEL PARKMAN REPORT

Contract: **M25 J21 – J22**
Contractor: Amec Lafarge
Tender Value: £10,232,942.33
Start of Works Date: 12 Aug 02
Final Account Value: £13,004,939.07

The main works were to:

- Plane out the existing flexible surfacing and relay.
- Renew the existing OBB or TCB? safety fence with OBB.
- Flush out and repair or renew drainage where necessary
- Install ducts for electrical works and cable in central reserve for lighting and comms
- Harden the c/res
- Install chambers for cables and bases for future lighting columns in the c/res

During works

- Only about 10% of the drainage that was going to be replaced was renewed.
- Transverse ducts had to be installed deeper than expected due to clash with services in the central reserve. This resulted in the electrical chambers being deeper.
- The restricted width of the central reserve made it difficult to fit everything in and install the works required, e.g. installation of ducts, and the central reserve safety barrier.

Contract: **M20 J2 – J3**
Contractor: Hanson
Tender Value: £9,122,393.74
Start of Works Date: 13 Aug 05
Final Account Value: N/A – contract not settled

The main works were to:

- Overlay existing concrete carriageway
- Flush out and repair or renew existing drainage
- Upgrade existing TCB / OBB safety fence (most OBB) to OBB

After contract had been awarded, Hanson were asked to prepare a costing for changing the tendered form of safety fence () to concrete containment level H1? In line with the newly issued IAN

Contract: **M1 J1 – J2 Priority Maintenance**
Contractor: Siac
Tender Value: £1,537,206.63
Start of Works Date: Oct / Nov 2001
Final Account Value: £2,375,167.62

The main works were to:

- Construct rigid concrete safety barrier in the central reserve
- Prepare drainage, cables, earthworks in the central reserve

This contract was in the main to replace old TCB / OBB in central reserve with VCB. Also old lighting columns replaced in the central reserve. Contract suffered from budget changes prior to and during works, that dictated the extent of the work undertaken. Major maintenance work that was required on this section of the M1 but not done in this contract was completed under the M1 J1 to J2 Crack, Seat and Overlay contract.

Compensation events associated with installation of the VCB were to carry out additional work mainly to the existing chambers and gullies to ensure that they fitted with the VCB and also lighting column ducting that had to be moved such that it could not be installed using a trenching machine.

Contract: **M1 J1 – J2 Crack and Seat**
Contractor: Tarmac
Tender Value: £5,690,108.78
Tender Date: 12 March 04
Final Account Value: £6,158,990.40

This was a follow up contract to the M1 J1 to J2 Priority Maintenance Scheme. Existing drainage was replaced under Area 21 due to it being in poor condition. As part of major crack and seat project in Area 5, limited length of VCB placed in c/res, main length VCB was in verge. New lighting columns placed on VCB in c/res.

The main works were to

- Crack and seat and overlay the existing concrete carriageway
- Install a rigid concrete safety barrier to the verges, with a short length of VCB also being done in the central reserve

Contract: **M25 J26 – J27**
Contractor: Fitzpatrick
Tender Value: £11,645,546.28
Start of Works Date: 15 July 03
Final Account Value: £14,389,700.01

The main works were to

- Overlay the existing concrete carriageway
- Carry out concrete repairs where necessary to the extent of removing whole bays
- Plane out and relay the existing flexible pavement
- Repair or replace existing drainage
- Upgrade safety fence
- Upgrade service ducts and cables plus renew lighting columns