6.0

The Cost of Level Crossings

6.0 Introduction

The true costs of any level crossing are very difficult to establish, primarily because each level crossing is subject to a number of individually differing characteristics and thus standardisation is next to impossible. There is also the obvious issue of contract confidentiality that exists when such jobs are tendered for.

The characteristics can include, but are not necessarily limited to:

- ❑ the road layout
- ❑ side roads and access points
- ❑ pedestrian approaches
- ❑ intensity of traffic; rail, road and pedestrian
- ❑ visibility
- ❑ railway stations where present in close vicinity
- ❑ schools, bus garages, petrol stations et al in vicinity
- ❑ special needs e.g. high proportion of blind people in vicinity.
- ❑ competitive tendering

This dissertation only considers the costs of AHB level crossings. The author believes that ABCL and AOCL level crossings would cost much the same as an AHB within +/- 15% and MCBcctv crossings up to double the AHB costs.

There is strong evidence to suggest that the cost of level crossings has risen to a far greater extent than the inflation rate. Detailed investigations into level crossing costs were carried out as part of the Hixon Inquiry[143] in 1968. Evidence presented to the Inquiry by British Railways indicated a 1968 price range for an AHB as being between £7850 and £28000 per crossing, dependent on the crossing complexity. If one assumes that the mid range cost is that of an 'average' AHB level crossing, the 1998 cost should be circa £183k[144]. Chart 6.A shows the rise in inflation over the period 1968 - 1998, averaging 8.38% per annum. News items within Professional Institutions[145] confirm this

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143 Report of the Public Inquiry into the Accident at Hixon Level Crossing on January 6th, 1968, Page 85, Her Majesty's Stationary Office, Cmnd. 3706. ISBN 10 137060 1.

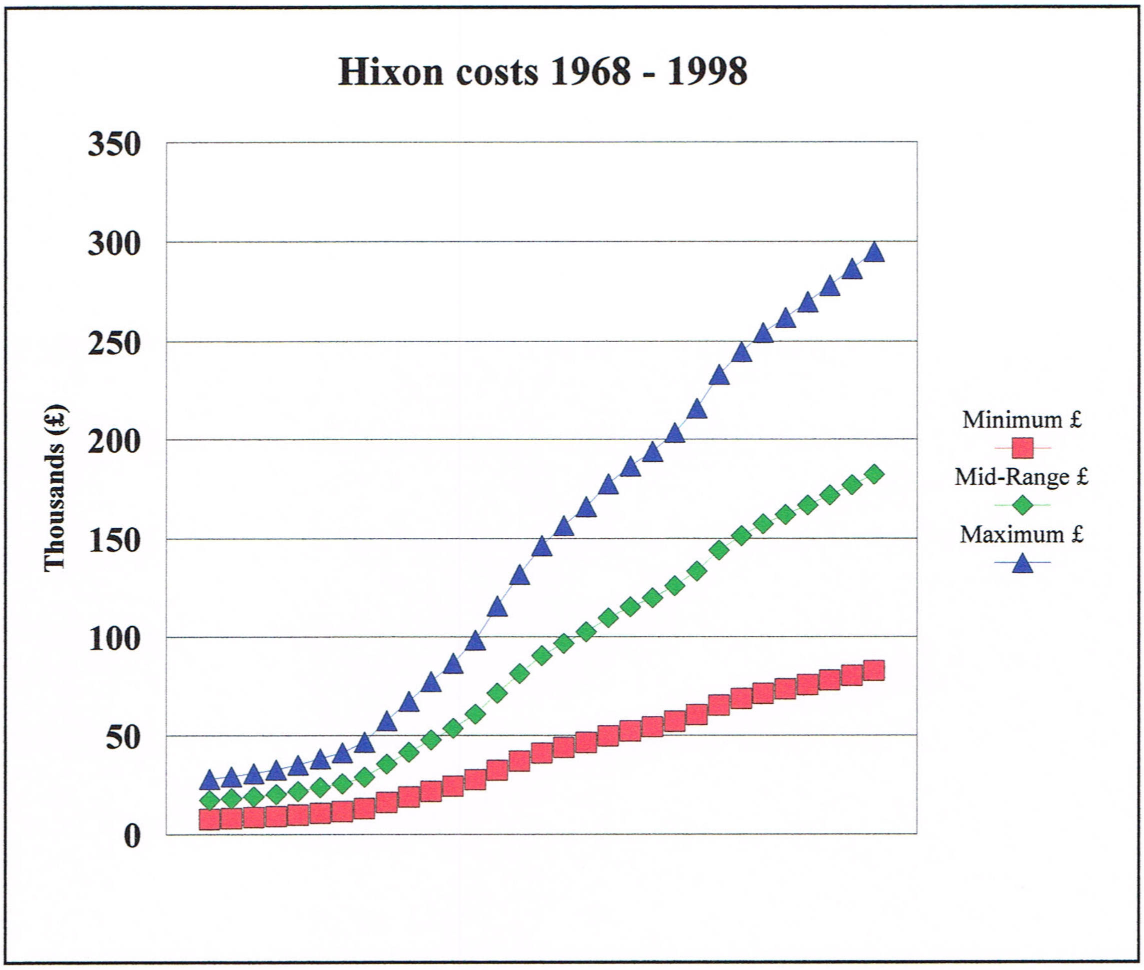
144 Figure 28.1, page 457, Economics, David Begg, Stanley Fischer, Rudiger Dornbusch, 5th Edition, McGraw Hill, 1997, ISBN 0 07 709412 3.

145 News View, Editorial, IRSE News, May 1999, Institution of Railway Signal Engineers.

view with contractors costs increasing to meet performance specifications, directives such as EMC compliance and legislation.

Chart 6.A

Hixon costs at 1998 price levels



However Railtrack representatives advised the author during the West Anglia Route Modernisation feasibility study[146] that the average cost of AHB level crossings on the Great Eastern resignalling scheme(1995/6 prices?) that had just been completed was circa £0.5m per crossing, excluding RT project management costs. For the purpose of

[146] Statement made on typical, average AHB costs incurred by RT on Great Eastern resignalling scheme during discussion between author and Roger Dickinson, Railtrack Signal Engineer, East Anglia Zone, regarding level crossing costs during author's estimating work on West Anglia Route Modernisation Feasibility Study. Substantiated by a confidential 'sight' of a third party estimate for an AHB crossing elsewhere on the RT network. In addition, the author undertook a Level Crossing Development study for RT Scotland and is aware of tender prices quoted. Also, confidential discussion with colleague in the industry on recent estimates prepared for RT; Confirmation of the Contractor's costs (and losses!) on two simple renewal jobs from another source.

this dissertation, the infrastructure owner's project management costs are assumed to be neutral as they would apply equally to bridge construction. This figure was effectively 'confirmed' by a third party estimate for a similar AHB level crossing in another RT Zone shown to the author in confidence, and by professional activity in this field by the author and workplace colleagues. Furthermore, recent discussions with other colleagues have indicated a current estimate price range of £0.5m to £0.75m.

It is assumed then, that a figure of £0.55m represents a fair basis for the current capital cost of completely modernising a typical AHB level crossing at 1998 price levels. It is difficult to establish why the current costs are so much higher than the rate of inflation. It can be presumed that this is related to changes in legislation and the privatisation of the railway network, the result of which involves many more organisations in such work, numerous contractual and safety matters etc.

6.1 AHB Whole life cost build up

There are a number of elements that need consideration in order to build up a true comparative cost of an AHB level crossing in order to compare with a simple bridge at the same location. These elements can be summarised as follows:

- The design life of an AHB compared with that of a bridge
- The capital cost of the level crossing renewals
- The cost of regular level crossing maintenance
- The cost of human life, accidents etc.
- The cost of passenger and train delay, and road user delay

Each of these will be considered in further detail.

With most capital projects, the project concerned would be subject to analysis that considered the rate of return to the infrastructure owner in terms of the cost outlay versus the return on investment. This would normally be achieved by a Rate of Return/Net Present Value exercise. This has been undertaken, but the author believes that, given that level crossings serve no purpose to the railway, they cannot offer a rate of return on the investment; there simply is no advantage to be gained by the infrastructure owner. In effect, the level crossing is a black hole swallowing large quantities of capital outlay, even larger maintenance outlay, added to which one must consider the cost of accidents to the public and the costs of train delays. Whilst this dissertation is considering the railway as the 'aggrieved' party, one must not forget that substantial delays also occur to the motorist and pedestrians held up by level crossing operation. This is also considered.

6.2 General comments

If one accepts that a level crossing does not generate a rate of return on the investment, then the only means of comparing the costs is to project current costs forward to offer a comparison. The biggest difficulty in doing so is to judge what an acceptable rate of inflation is likely to be. Given the life of a bridge can be considered to be 125 years this is a difficult task! The historical data shown in chart 6.A shows an average inflation rate of 8.38% over a thirty year period. The current rate of inflation is probably 3% or thereabouts and some commentators believe it will continue to fall; with some areas of industry, e.g. the computer sector, is currently enjoying deflation.

The author believes that as inflation is such a volatile area of all economies that it is likely to rise again and therefore costs are shown throughout at base cost.

6.3 Design life

The design life of typical, modern, automatic level crossings in the United Kingdom is generally considered to be 25 years. A bridge is generally considered to have a design life of 120 years[147]. An assumption is made that the bridge will survive for 125 years for this exercise; this is a fair assumption given the number of early railway bridges still in use. It will therefore be obvious that a level crossing will have been renewed 5 times in the lifespan of such a bridge and will be due for its 6th replacement at +125 years.

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147 British Standard BS5400

6.4 Initial capital cost of modernisation/renewal

As has already been mentioned the figure of **£0.55m** is considered to be the current average cost of total renewal of a typical AHB level crossing excluding the infrastructure owner's project management costs. This can be broken down into the following areas:

❑ Signalling Design	£44k
❑ Signalling Installation	£72k
❑ Materials	£267k
❑ Testing & Commissioning	£29k
❑ Contractor Project Management	£19k
❑ Civil Engineering	£40k
❑ Power Supplies	£2k
❑ Highway Authority works	£72k
❑ Total	**c.£548k**

6.5 Annual maintenance costs of level crossings

Again, maintenance costs are very difficult to quantify, principally as individual items are not costed in the maintenance regimes. Current RT policy on maintenance is to let a multi-million pound contract covering many miles of infrastructure, covering all disciplines. The 1987 Stott report[148] states that there is evidence to support a figure of 7% of the original installation cost per annum based on a review of level crossing subsidy claims made by the BRB. The earlier 1978 report on Level Crossing Protection[149] put the figure at 5%. Since then privatisation has become the norm and the author believes that costs have probably risen, although the figure of 7% annual maintenance is assumed; Similar costs for level crossing maintenance were quoted by German Federal railways in a 1986 safety report[150].

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148 Automatic Open Level Crossings A Review of Safety, paragraph 4, page 37, Prof. P.F. Stott, HMSO, 1987, ISBN 0 11 550831 7.

149 Level Crossing Protection, page 6, Report by officers of the Department of Transport and of the British Railways Board, HMSO, 1978, ISBN not known.

150 Translation of German Federal Railways safety presentation; details unknown

6.6 Costs of accidents at level crossings

The cost of accidents on level crossings can be calculated by considering the number of annual fatalities and serious injuries multiplied by a 'cost of life' figure and then divided by the number of crossings. Data for such an exercise exists in the Annual Report on Railway Safety by HMRI[151]. Accident data from this source has been considered in relation to automatic level crossings in England Scotland and Wales over the period 1988-1998. Table 6.A shows the numbers of fatalities, injuries and the number of automatic level crossings (AHB, ABCL, AOCL & AOCR) for each year. There were no staff fatalities during this period. The author makes no distinction between the value of public or staff life; the cost of dealing with a fatality or treating a major injury does not reduce if staff are involved. The table though excludes trespassers and vandals killed or injured.

Table 6.A

Fatalities and injuries at automatic level crossings, 1988-1998

Year ending 31/3	Fatalities	Injuries Public	Injuries Staff	Total Crossings
1988	4	10	2	602
1989	2	11	3	625
1990	5	14	2	631
1991	7	15	2	630
1992	6	61	5	636
1993	5	17	8	663
1994	5	17	6	657
1995	2	14	4	649
1996	5	14	4	639
1997	1	16	2	640
1998	2	11	0	644
Total	44	197	38	7016
Average (rounded up)	4	19	4	638

151 Railway Safety, HM Chief Inspecting Officer's Annual Report on the safety record of the Railways of Great Britain, all editions, 1997/98 - 1988/89.

Railtrack's 'Valuation of life' figure is £2.65m per fatality involving a train. This is sub-divided into 10 major injuries being equal to a fatality and, similarly' 200 minor injuries being equal to a fatality[152]; other railway, non-train fatalities are considered to be around the £900k mark; a road fatality is considered to be £950k. It is assumed that all injuries are major.

Therefore:

- the annual cost of fatalities is equal to **4 x 2.65m** **= £10.6m**: the annual fatality cost per crossing is equal to **10.6m ÷ 638 = £16614**
- the annual cost of injuries is equal to **23 x (2.65m ÷ 10) = £6.095m** the annual major injury cost per crossing is equal to **6.095m ÷ 638 = £9553**
- therefore an annual accident costing of fatality plus injuries of **£26167** per crossing is assumed for this exercise. This is an economic cost to the nation.

In addition, and next to impossible to predict is the cost of damage to the infrastructure and rolling stock. No consideration is given to this figure, but it should be borne in mind that serious accidents such as Hixon and Lockington will cost many millions of pounds to clear up and investigate. Such costs are likely to be 'weighted' by traffic type and frequency.

6.7 Costs of delays

6.7.1 Road delays

The delay to the road user has no direct bearing on the railway's costs, however, it is a real cost in terms of the economic performance of the country and should not be ignored lightly. Stott[153] considered this problem as a standard level crossing cost and devised a traffic flow based on table 6.B. The author recorded closure times and the numbers of cars delayed at the level crossings shown in Appendix H. By taking averages of the

152 Modern Railways, page 543, August 1998. Modern Railways, page 438/9 July 1998.

153 Automatic Open Level Crossings A Review of Safety, paragraph 4, page 37, Prof. P.F. Stott, HMSO, 1987, ISBN 0 11 550831 7.

closure times, cars delayed and % traffic flows based on Stott's table, a picture of an 'average' number of cars delayed can be built up.

To arrive at a figure for this, a number of assumptions must be made so as to produce figures for an average level crossing:

The Value of Time to those people in the cars held up:

- ❑ The value of time[154]:
    - assume **£5** per hour, non-working person
    - assume **£12** per hour, working person
    - assume **80%** of delayed users are non-working, **20%** working

therefore VoT£ = (5 x 0.8) + (12 x 0.2) per hour = **£6.40**
or **£0.107** per minute being an average value of time for the delayed road user

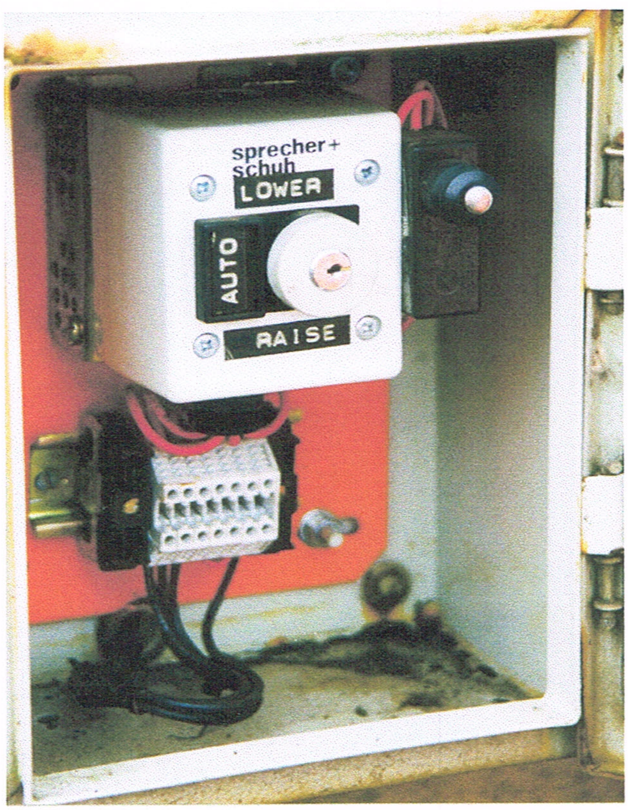

Figure 6.1
Killagan AHB LC, NIR;
Typical Local Control Unit. The LCU allows the operators to operate the LC manually on site during failures or maintenance. This particular example is operated by a key. If it is not in auto the key cannot be removed and the door cannot be locked. Note also the microswitch to the right of 'lower' that indicates the door open or closed so that the supervising signalman is aware of any activity at the LC.

154 Department of Transport Highway Economic Note 2.

Figure 6.2

Boston West Street MCG LC;

Typical 1990's rural train, Class 150, No. 150.216, 2 car DMU on rural service in Lincolnshire.

- assume level crossing closed to road for **60 seconds** per closure period in an operating period of 18.5 hours (0530 - 2300hrs); two track rural railway with two trains per hour, per direction; therefore **74** crossing closures per day assuming closed for single trains on each occasion; giving **74** minutes per 24 hour period.
  (average closure period from Appendix H).

- average traffic flow based on cars recorded by the author delayed by level crossing closures during the period 0700 - 1900 and that 'assumed' level crossing is on a moderately used 'B' class road (average closure period from Appendix H). An 'A' class trunk road will have substantially higher figures; a 'C' class or unclassified road, substantially lower figures.

- average number of cars delayed is **2.64** per LC closure
  thus **195** cars per day (2.64 x 74)

- ❑ assume each delayed car has **1.5** occupants

Therefore the daily cost of delay to road users is:

Closure period x £6.40p per hour x number of cars x 1.5 occupants

74.00 x £0.107p x 195 x 1.5 = **£2316 per day**

Thus the annual cost = **£845340**; This is an economic cost to the nation.

6.7.2 Rail delays

When an automatic level crossing fails, it requires the operators to caution all trains passing over the failed level crossing and to get an operating official to site to control the level crossing manually; this leads to a delay to the timetabled operation of the train as it has to slow down to a speed where it can stop short of any obstruction on the level crossing and then, having confirmed it is clear, re-accelerate back to line speed. A review of AHB failures on Northern Ireland Railways[155] automatic level crossings revealed an average failure period of **189** minutes per failure.

NIR, a rural network, have an annual average AHB failure rate of **1.78** failures per level crossing, with the vast majority of level crossings being under ten years old. It is therefore assumed that similar level crossings on rural parts of RT would have similar failure statistics, although large numbers of RT level crossings are more elderly, therefore a figure of **2** failures per annum is assumed. In the current Railtrack track access regime, such delays result in penalty payments ranging from **£25** to **£75** per minute delay. Discussions with NIR signalmen indicate an average delay of **5** minutes per train until an operating official is on site and **3** minutes per train thereafter. Similar RT figures are assumed.

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[155] Northern Ireland Safety Strategy Review, Halcrow-Transmark & A.D. Little, 1999, J. Tilly, Author of Signalling and LC sections.

Table 6.B

Stott assumptions of hourly traffic, from Stott Report page 34.

'Author recorded %' refers to a 12 hour study carried out at

Ramsey Road AHB LC in Whittlesea, Cambridgeshire.

Hour beginning	% of daily traffic	Author recorded %	Hour beginning	% of daily traffic	Author recorded %
0700	5	11.78	1600	9	5.00
0800	7	6.43	1700	8	8.57
0900	6	3.21	1800	5	5.00
1000	7	6.07	1900	5	-
1100	7	5.36	2000	5	-
1200	6	6.43	2100	4	-
1300	6	1.07	2200	3	-
1400	7	3.93	2300	2	-
1500	8	18.21	2400 - 0600	0	-

Therefore the following assumptions are made:

two track rural railway with two trains per hour, per direction

2 trains delayed 5 minutes each

10.4 trains delayed 3 minutes each

Accordingly the total delay per level crossing failure is **41.2** minutes.

Assume a figure of £35 per minute track access penalty[156] (lower end of scale, rural railway):

thus train delay cost is 35 x 41.2 = **£1442** per failure

giving an annual failure cost of

£1442 x 2 = **£2884.** This is a financial cost to the railway, per crossing.

The second aspect of the delay is the Value of Time to those passengers on the trains held up.

- ❑ The value of time:

[156] Confidential RT source; delay costs for rural Lincolnshire £30-£40 per minute; thus £35 assumed.

- As stated above; **£6.40** per hour or **£0.107** per minute being an average value of time for the delayed road user

Assume a typical two car DMU (Sprinter Class 150) train with a seating capacity of 146 seats with say, an average occupancy of 35% over the daily service. Thus **51** passengers are delayed.

51 x £0.107 x 41.2 x 2.00 = **£450** per annum

thus the total train delay cost figure is £2884 + £450 = **£3334** per annum

Added to this one must, take into account the delay cost to road users affected by failures; Using the same figures as shown in Section 6.7.1 above this aggregates to:

(delay time x cars per minute x no of occupants) x (delay time x cost per minute)

hence

(82.4 x 2.64 x 1.5) x (82.4 x 0.107) = **£2878** per annum

giving a total failure cost of **£6212** per annum. The track access penalty cost is a financial cost to the railway; the delay costs are economic costs to the nation.

6.8 Whole life costs

From the information above, a picture of the whole life costs can be built up, assuming a 125 year lifespan. Maintenance costs form an ongoing annual expenditure. Accident and delay costs similarly, but it has been assumed that they stay at an average level as shown. However, with increasing traffic on the roads, and potentially, railways, it must be accepted that delay costs will rise. This is not related to inflation which is not considered for the present calculation. The costs are seperated into two sections; those that are financial costs to the railway and those that are economic costs to the nation. Table 6.C follows with details of Net Present Value tests.

Table 6.C

Level Crossing whole life costs over 125 years

	Base Cost
Railway Financial Costs	
Modernisation of level crossing @ 0, 25, 50, 75 & 100 years. Base price £0.55M (See note below)	£2.75M
Cumulative maintenance costs @ 7% p.a. base £38500 p.a.	£4.81M
Cumulative railway delay costs base £ 2884 p.a.	£360.5k
Total railway costs for 125 years	**£7.92M**
Economic Costs to Nation	
Cumulative fatality/injury costs, base £26167 p.a.	£3.27M
Cumulative rail delay costs; rail passenger and road user, base £3328 p.a.	£416k
Cumulative road user delay costs; base £845340 p.a.	£106M
Total Economic (non-railway) costs	**£109.69M**
Note: At 125 years renewal will be required for both level crossing and bridge.	

6.8.1 NPV

Four Net Present Value tests over a 125 year period have been carried out on the above figures as follows:

- ❑ LC1: Pure rail costs - at 10% commercial rate of interest
  - Renewal every 25 years at £550k
  - Annual maintenance costs at £38.5k p.a.
  - Annual access penalty charge at £2884 p.a.
- Result: **-£1.06M** Railway Financial Cost

- ❑ LC2: Road/Rail delay costs, failures - at 6% government rate of interest
  - Annual failure delay to passenger (rail) and road users at £3328 p.a.
- ■ Result: **-£58.75k** Economic Cost to Nation

- ❑ LC3: Road delay costs, normal LC operation - at 6% government rate of interest
  - Annual delay to road users at £845340 p.a.
- ■ Result: **-£14.9M** Economic Cost to Nation

- ❑ LC4: Accident, Fatality/Injury costs, failures - at 6% government rate of interest
  - Annual accident costs at £26167 p.a.
- ■ Result: **-£462k** Economic Cost to Nation

It can be argued that the costs to the nation are passed on in the form of higher charges to customers, however this can only be considered for those commercial organisations who are delayed etc. Such an argument cannot be applied to non-working housewives, for instance.

The NPV test offers the benefit of a comparision that allows an organisation to compare the cost of a project against the future value of money that could be invested. Thus it can be determined if a project is of a greater value to the organisation than an equivelant cash investment.

Possession costs and the infrastructure owner's project management costs are assumed to be neutral; both level crossing and bridges will require possessions, probably more for the LC works as a result of the testing of the signalling component of the project. Figures 6.3 and 6.4, following, show typical LC layouts from the highway point of view.

6.8.2 Conclusion

The view that level crossings are cheap can be laid to rest.

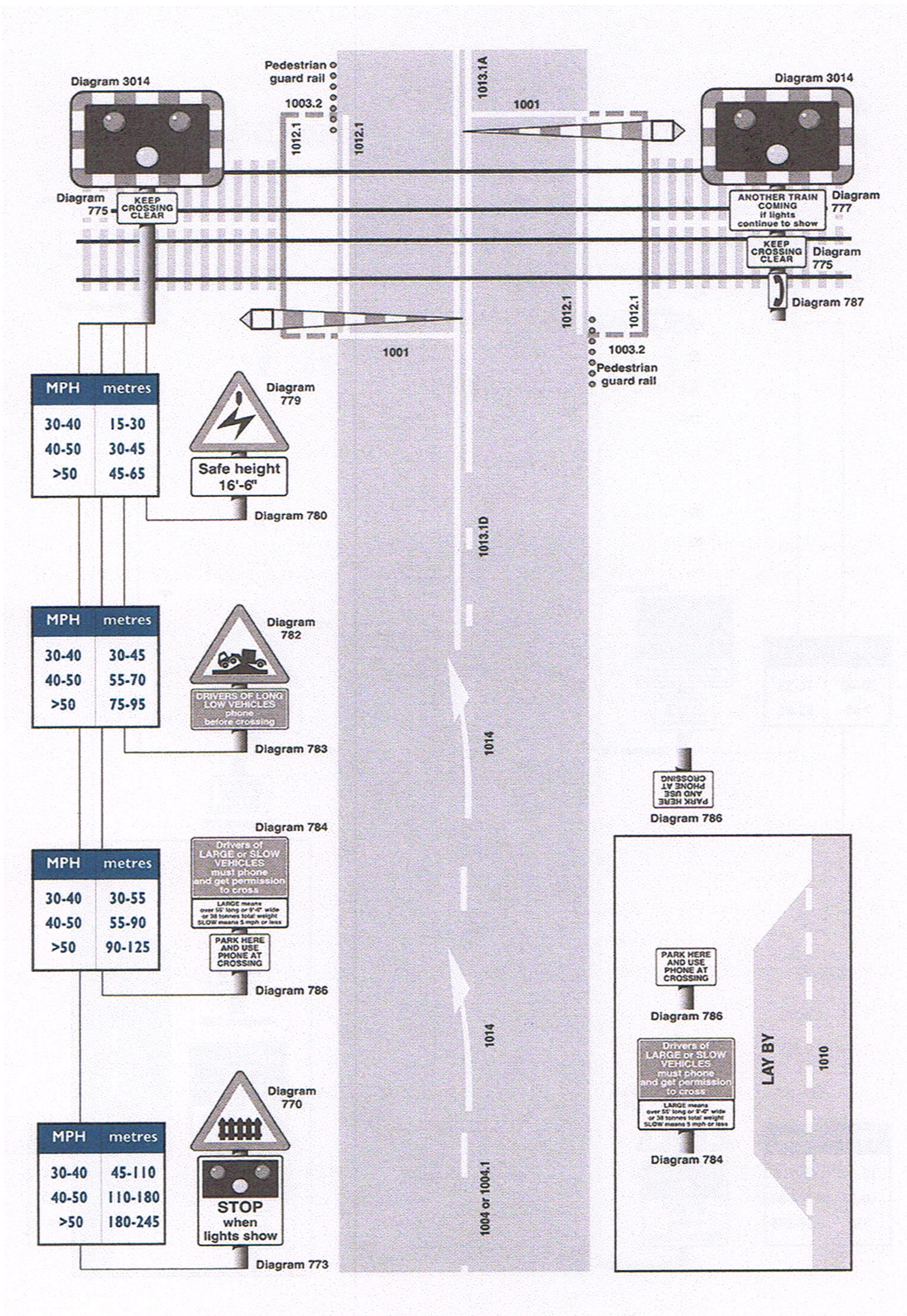

Figure 6.3

Typical layout, and arrangement of approach signs to an AHB or ABCL LC with additional risks.

(from page 56, Railway Safety Principles & Guidance)

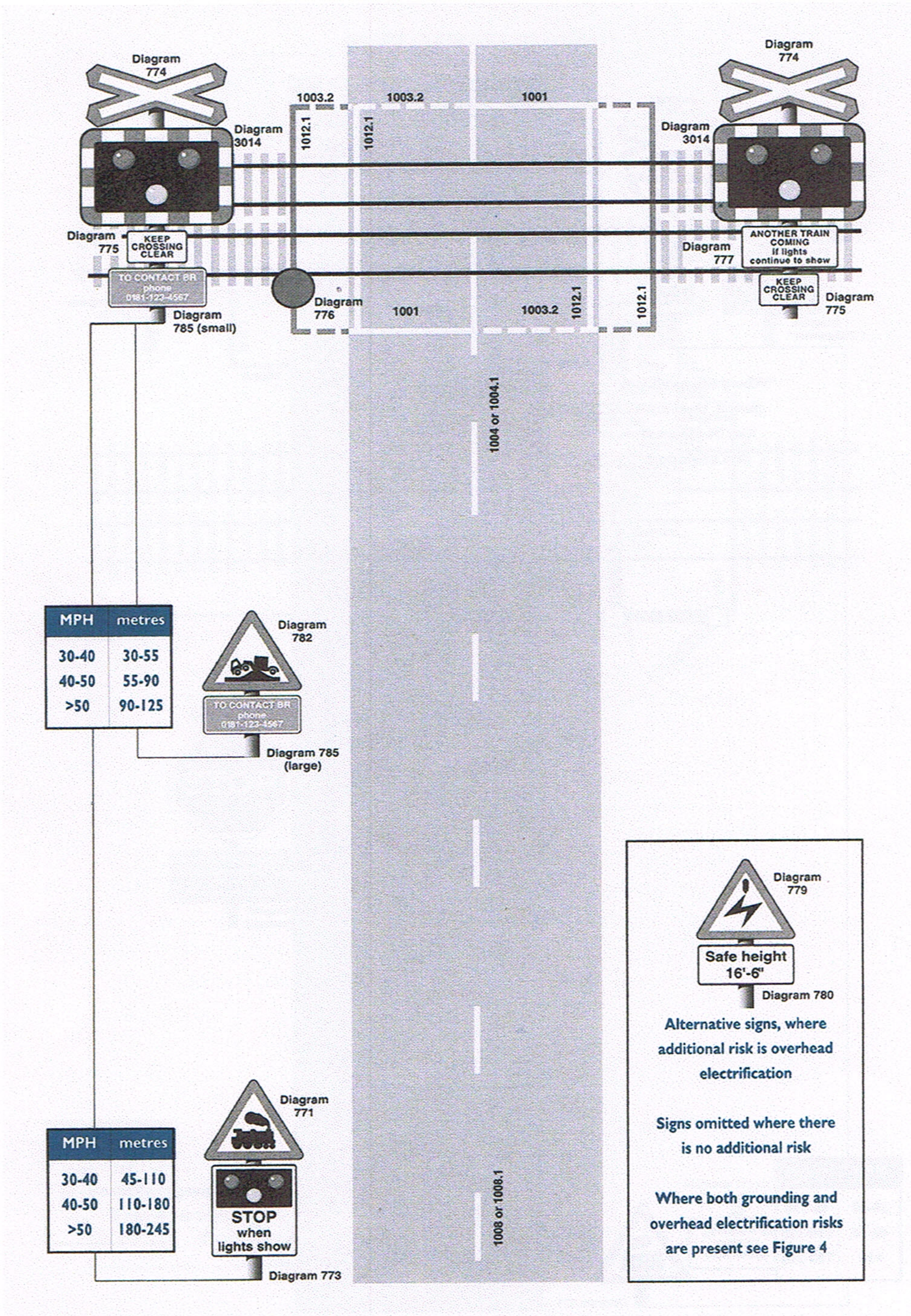

Figure 6.4

Typical layout, and arrangement of approach signs to an AOCL LC with additional risks.

(from page 57, Railway Safety Principles & Guidance)

6.9 Reference Detail

Railway Safety, HM Chief Inspecting Officer's Annual Report on the safety record of the Railways of Great Britain;

1997/98, Chapter 6, HSE/HMRI, 1998, ISBN 0 7176 1655 X;

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