APPENDIX B
WORKED EXAMPLE

1. Consider a 700 m passing lane (excluding tapers) on a 6% gradient, which is to be extended by 650 m on an average gradient of 4%. The projected traffic growth is 2.5% and the current AADT is 7,000 vpd. The passing lane layout is about 5 km spacings. The downstream terrain is predominantly rolling combined terrain.

2. The reader should note that extending the existing 700 m passing lane by another 650 m is a situation that has been provided for example purposes. Depending on circumstances, after determining the equivalent length of passing lane on a flat gradient (i.e. 1625 m), the reader might have wanted to consider providing a shorter equivalent length of about 1500 m, which should still be adequate, although the 12,000-14,000 vpd traffic volumes are slightly outside of NZTA's Passing and Overtaking Policy.)

Effect of Gradient

3. From surveyed results of SH 58 RP 0/1.07-2.43 Haywards Hill westbound 1.2 km passing lane (excluding tapers), the 7% gradient should provide about a 90 km/hr median free speed in the fast lane and about an 81 km/hr median free speed in the slow lane. From surveyed results of SH 1 RP 574/11.98-10.25 northbound 1.4 km passing lane (excluding tapers) located south of Cambridge, the 0% gradient should provide about a 106 km/hr median free speed in the fast lane and about a 99 km/hr median free speed in the slow lane.

4. From Table A1 within Appendix A, looking at normal maximum and Road Train values, the effect of the 7% gradient is about 40% (i.e. (775 m for a 90 km/hr mean free speed and 1070 m for a 110 km/hr mean free speed in the fast lane. So 1070/775 = 1.38). The speed isn't expected to change much over the 0-3% gradient interval (i.e. 0% effect). Therefore, the first 700 m on 6% gradient is about 900 m on a 0-3% flat gradient (i.e. 700 x 1.3 = 910 m), as the effect of 6% gradient is pro-rated between the factors of 1 for 0-3% and 1.4 for 7% gradient.

5. The second extended section lies between flat 0-3% and mountainous 7% gradient. Pro-rating between the respective factors of 1 and 1.4, the extension is expected to be the equivalent of about 715 m on a flat gradient (i.e. 650 x 1.1 = 715 m). Therefore, the total equivalent length of the extended passing lane (excluding tapers) is estimated to be about 1600 m on a flat gradient (i.e. 910 + 715 = 1625 m).

6. For situations where the first part of the passing lane is steeper, this estimation method is expected to be conservative. At the start of the above-mentioned new extended section, the mean free speed in the slow lane speed is expected to be less than for the mean speed that you would usually expect at the start of a 4% gradient. If in doubt, surveyed speed results over the length of the proposed extended section could be used to estimate the operating speed without a passing lane and then compared with the other estimated speeds in Table A1 within Appendix A.

Effect of AADT

7. Consider the passing lane length factor for an extended 1600 m equivalent length passing lane.

8. The traffic growth is linear over this period so the traffic intervals are assumed to be even intervals of time. At 2.5% growth over 40 years, the traffic volumes would double (i.e. 0.025 x 40 = 100%). So in a 40 year time, the traffic volumes would be 14,000 vpd.

9. Table B1 shows a weighted average passing lane length factor of 1.69 for savings on travel time delays (TT) and vehicle operating costs (VOC). From Table A7.11a) Revised Passing Lane Length Factors for Travel Time Delays and Vehicle Operating Costs within this memo, the passing lane length factor for an equivalent 1600 m on flat gradient at 7,000 vpd is the average of 6,000 vpd and 8,000 vpd, namely 1.59 (i.e. (1.54 + 1.63)/2 = 1.59). At 14,000 vpd, the passing lane length factor is 1.76.

10. Table B2 shows the calculated results for a 1600 m equivalent length passing lane with a weighted average of 1.41 for frustration savings. From Table A7.211(b) Passing Lane Length Factors for Frustration Cost Savings within the memo, the passing lane length factor for the equivalent of 1600 m on flat gradient at 7,000 vpd is 1.38 (i.e. (1.37 + 1.38)/2 = 1.375). At 14,000 vpd, the PL length factor is 1.47.

Table B1. Weighted Average PL Length Factor of TT & VOC Savings for 1600 m (excl tapers)			
AADT (veh/day)	**PL Length Factors**	**Calculation of Weighted Portion**	**Weighted Portion**
7,000	(1.54+1.63)/2=1.59		
8,000	1.63	((1.59+1.63)/2) x 1,000/7,000	0.23
10,000	1.69	((1.63+1.69)/2) x 2,000/7,000	0.47
12,000	1.73	((1.69+1.73)/2) x 2,000/7,000	0.49
14,000	1.76	((1.73+ 1.76)/2) x 2,000/7,000	0.50
			Total 1.69

Table B2. Weighted Average PL Length Factor of Frustration Savings for 1600 m (excl tapers)			
AADT (veh/day)	**Modified Factors**	**Calculation of Weighted Portion**	**Weighted Portion**
7,000	(1.37+1.38)/2=1.38		
8,000	1.38	((1.38+1.38)/2) x 1,000/7,000	0.20
10,000	1.40	((1.38+1.40)/2) x 2,000/7,000	0.40
12,000	1.43	((1.40+1.43)/2) x 2,000/7,000	0.40
14,000	1.47	((1.43+ 1.47)/2) x 2,000/7,000	0.41
			Total 1.41

Passing Lane Length Factors for the Existing Passing Lane

11. Referring to Tables A7.11 (a) & (b) over the range of AADTs from 7000 vpd to 14,000 vpd for about a 900 m equivalent length, the revised passing lane length factors for TT & VOC are the same as for frustration savings. Table B3 shows the calculated results with a weighted average passing lane length factor of 0.58 for both travel time delay and vehicle operating costs savings, as well as frustration cost savings. The equivalent length for a 700 m passing lane on a 6% gradient is about 900 m on a flat gradient (i.e. 1 + ((6-3)/(7-3) x 0.38) = 1.29, 700 x 1.29 = 903 m). So the average passing lane length factors of the equivalent 800 and 1000 m lengths have been used.

Table B3. Weighted Average PL Length Factor for TT & VOC plus Frustration Savings for 900 m (excl tapers)			
AADT (veh/day)	**Modified Factors**	**Calculation of Weighted Portion**	**Weighted Portion**
7,000	(0.7 + 1.0) /2 = 0.85		
8,000	(0.60 + 1.0) /2 = 0.80	((0.85+0.80)/2) x 1,000/7,000	0.12
10,000	(0.38 + 0.82) /2 = 0.60	((0.80+0.60)/2) x 2,000/7,000	0.20
12,000	(0.27 + 0.57) /2 = 0.42	((0.60+0.42)/2) x 2,000/7,000	0.15
14,000	(0.20 + 0.43) /2 = 0.32	((0.42+ 0.32)/2) x 2,000/7,000	0.11

			Total 0.58

Passing Lane Length Factors for the Extended Passing Lane

12. Consider the difference between passing lane length factors for the existing and extended passing lane. The weighted average passing lane length factors of 1.69 (TT & VOC) and 1.41 (frustration) for an equivalent 1600 m PL (on flat gradient) with 5 km spacings compares with an equivalent 900 m PL (on flat gradient) with 5 km spacings with a weighted average passing lane length factor of 0.58 (TT& VOC as well as frustration).

13. Using the EEM graphs for passing lanes at 7,000 vpd with 5 km spacings in rolling combined terrain and the weighted average PL length factors, the difference between remaining with the existing 700 m passing lane on 6% gradient can be calculated using the passing lane length factors. Similarly, benefits for the extended 1350 m PL on mixed gradients of 6% (700 m) and 4% gradient (650 m) with an equivalent 1600 m approx on flat gradient and can be determined using the EEM individual passing lane graphs within Figures A7.7 and A7.8.

Difference between the Current EEM and Revised Passing Lane Length Factors

14. For the extended 1350 m passing lane, using the previous EEM Table A7.11, the passing lane length factor is 1.21 for a 1.4 km passing lane. Therefore, for a 1.4 km passing lane (excluding tapers) over the 7,000-14,000 vpd range, the revised passing lane length factors equate to about a 40% increase (i.e. (1.69-1.21)/1.21 = 0.40) in savings on travel time delays and vehicle operating costs, which are the majority of benefits. For frustration savings, there is about a 17% increase (i.e. 1.41-1.21/1.21 = 0.17) in frustration savings.

15. For the existing 700 m passing lane, using the previous EEM Table A7.11, the passing lane length factor is 0.76 for a 750 m passing lane. So say 0.76 for the existing 700 m. Therefore, for the 700 m passing lane (excluding tapers) over the 7,000-14,000 vpd range, the revised passing lane length factors equate to about a 24% decrease (i.e. (0.76-0.58)/0.76 = 0.24) in savings on travel time and vehicle operating costs, which are the majority of benefits.