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To: City of Toronto, City Planning
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From: Jamie Kennedy, Hatch
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October 21, 2022

cc: Christina Glass, Hullmark Developments
Jeff Hull, Hullmark Developments

Subject: Assessment of Development Proposal in Proximity to Metrolinx Rail Line
450 Dufferin Street – Proposed Mixed-Use Residential Development

<u>Introduction:</u>

As part of the Zoning By-Law Amendment application (ZBA), HM RK (450 Dufferin) LP (the “Applicant” or “Landowner”) has retained Hatch Ltd. to conduct a ‘Proximity Review’ at 450 Dufferin Street (the “Project” or “Site”) with respect to the Metrolinx Weston Subdivision rail corridor, south of the property.

The purpose of this letter is to review the proposed development against the most recent industry guidelines for new development in proximity to rail infrastructure, identify potential hazards and/or risks, and determine whether any measures are required to mitigate these risks.

<u>Site Context:</u>

The site is located at Mile 2.65 of the Metrolinx Weston Subdivision rail corridor and is bound by Dufferin Street to the east, Alma Avenue to the south, and existing development to the north and west. The Metrolinx rail corridor is approximately 130 metres southwest of the property, as illustrated in Figure 1 below.

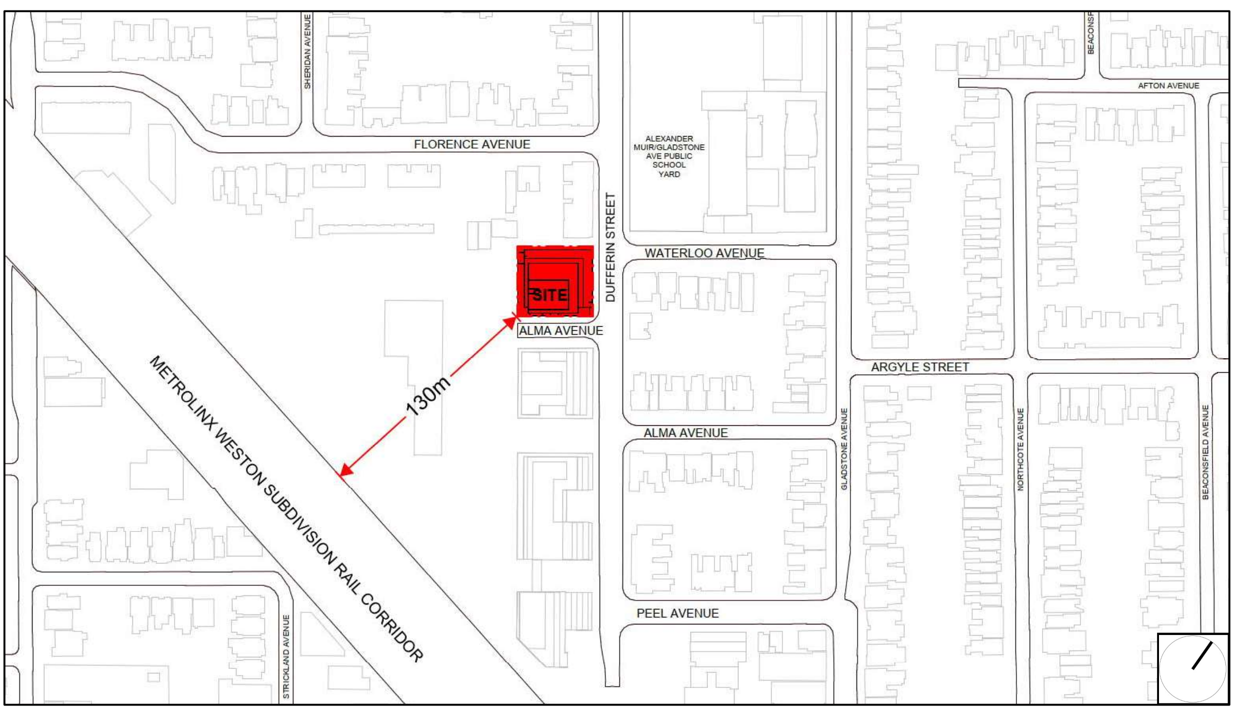


Figure 1: Context Plan

Metrolinx operates daily passenger service on the Kitchener GO Transit line and Milton GO Transit line; service on both lines is expected to increase in the future as part of the GO Regional Express Rail initiative. The Union-Pearson Express (UPX) also operates daily passenger service between Union Station and Toronto Pearson International Airport along this section of track.

Proposed Development

The development at 450 Dufferin Street is proposed as a 15-storey residential development, with retail units at grade. Renderings of the proposed development are illustrated in Figure 2 below.

Figure 2: 450 Dufferin Street Rendering

Metrolinx Weston Subdivision:

The Metrolinx-owned Weston Subdivision rail corridor is located 130m southeast of the site. In the current condition, there are four existing tracks within the corridor which are straight in alignment. As part of the GO Transit expansion plan, Metrolinx will add four additional tracks to the existing rail corridor, resulting in 8 principal main line tracks in the future.

When Metrolinx acquired the rail corridor from Canadian National Railway (CN) and Canadian Pacific Railway (CP), as part of the purchase and sale agreement, both CN Railway and CP Railway maintained operating rights on their respective tracks. Currently the rail corridor is only used for passenger rail service and freight service is unscheduled and infrequent. However, both rail authorities may operate freight traffic at any time.

The Metrolinx track diagram, illustrated in Figure 3 below, depicts the current track alignment near the property, rail corridor speeds, and identifies notable features within the rail corridor including the closest signal bridges, track crossovers, and grade separations.

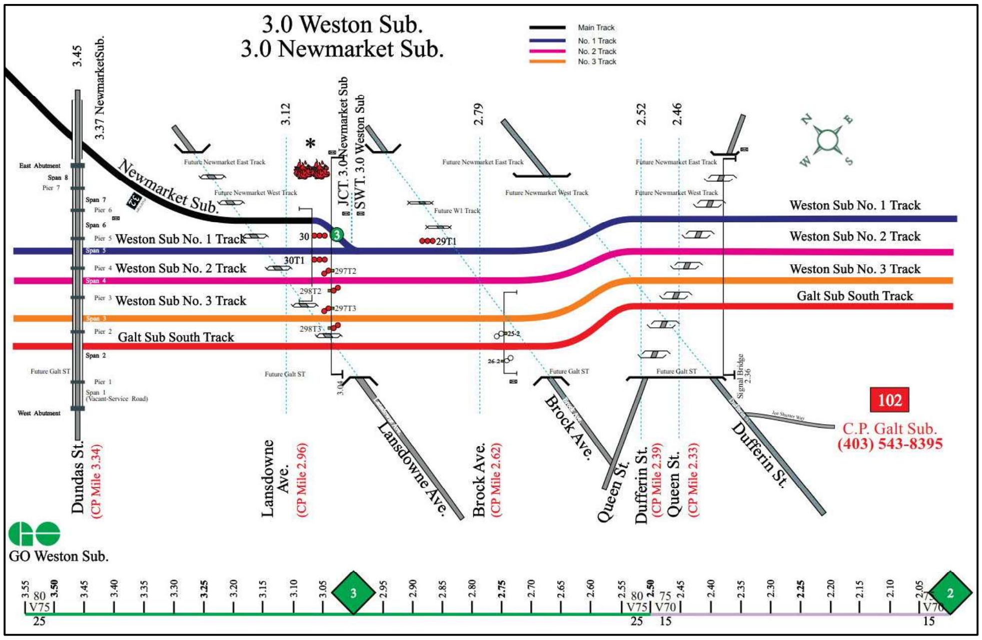


Figure 3: Metrolinx Weston Subdivision Track Diagram

At Mile 2.65, the maximum allowable speeds for passenger trains in the rail corridor is 80mph, and the maximum allowable speed for freight trains is 25mph. Multiple grade separations have been introduced east and west of the property, allowing Metrolinx to operate passenger trains without at-grade interactions, improving the overall risk profile of the rail corridor.

Signal bridges are located further west at Lansdowne Avenue, and further east at King Street and are not anticipated to be affected by the proposed development at 450 Dufferin Street. The track diagram is included in Appendix A – Rail Corridor Details.

Rail Adjacent Development Guidelines:

The 'standard approach' for new developments in proximity to rail corridors, as defined by the Federation of Canadian Municipalities and Railway Association of Canada, is a 30-metre horizontal setback (measured from the rail corridor property line) in combination with a 2.5-metre-high earthen berm. The Metrolinx Adjacent Development Guidelines and the City of Toronto also recommend the same standard measures for new developments adjacent to railways. Additional measures to address noise, vibration, odors, and other risks, are assessed on a site-by-site basis.

Both guidelines also acknowledge that the standard mitigation measures may not be practical or feasible on smaller, urban sites and that alternative mitigation measures may be identified through the Development Viability Assessment.

Specifically, at 450 Dufferin Street the application of a safety barrier is thought to be impractical due to:

a) The existing setback between the rail corridor property line and the development lands.
b) The Landowner does not control the properties between the site and the rail corridor, and thus, is unable to construct a standard safety barrier along the rail corridor property line.
c) The existing buildings between the site and the rail corridor (ie. the intervening land uses) would make the application of a safety barrier on the Landowner's property redundant.

As such, the provision of a safety barrier is not considered for this development as the risk of a train derailment impacting the property is very low.

Notably, as part of the development application, the Landowner will also be asked to enter into an Adjacent Development Agreement with Metrolinx; a standard agreement for new developments within 300 metres of railway facilities. As part of the Adjacent Development Agreement, Metrolinx will also request an environmental easement over the site.

Energy Balance Analysis:

As part of this review, the possibility of a train derailment was considered. Using the methodology outlined in the *AECOM Development of Crash Wall Design Loads from Theoretical Train Impact (or 'AECOM Guidelines'),* an Energy Balance Analysis was conducted to understand the outcome of a train derailment under specific scenarios (or 'Load Cases').

The results of the Energy Balance Analysis indicate that a train travelling at the maximum allowable speed of 80mph would not reach the subject property line under any of the four load cases.

Furthermore, a derailed train would theoretically have to be travelling more than 225mph (nearly 3x the allowable speed) to reach the property line of site, let alone impact the building. This does not account for any structures or barriers that a derailed train would encounter between the rail corridor and the development lands, which would further act to slow the train.

The Energy Balance Analysis indicates that the risk of derailment at the site is acceptably low, as a derailed train would be expected to lose all momentum prior to reaching the property. The supporting calculations are included in Appendix B – Energy Balance Analysis.

Conclusion:

The Federation of Canadian Municipalities (FCM) and Railway Association of Canada (RAC) *Guidelines for New Development in Proximity to Railway Operations* (2013) and Metrolinx's *Adjacent Development Guidelines* include specific recommendations for development adjacent to or in close proximity to principal main line tracks:

1. Setbacks: The recommended setback for new residential development adjacent to principal main line track is 30 metres.
2. Safety Barrier: Safety barriers are required for lands up to 120 metres from the rail corridor.
3. Noise Mitigation: The recommended minimum noise influence area when undertaking noise studies along a principal main line track is *300 metres*.

The results of this Proximity Review indicate the development proposed at 450 Dufferin Street meets the necessary criteria for development within proximity of an active rail corridor. Specifically:

1. The 130-metre setback between the rail corridor property line and the development lands significantly exceeds the standard setback of 30 metres.
2. Derailment protection in the form of a safety barrier is not required and is not planned as the development is greater than 120 metres from the rail corridor property line (in accordance with the Metrolinx Adjacent Development Guidelines, and further supported by the Energy Balance Analysis)
3. A Noise and Vibration Assessment has been commissioned by the Landowner to evaluate transportation-related noise impacts (including rail) on the development and submitted under separate cover.

We hope this letter adequately summarizes the proposed development plans in the context of the rail adjacent development guidelines. Should you have any further questions or comments, please contact the undersigned.

Sincerely,

Jamie Kennedy
Project Manager, Rail Adjacent Development

Andrew Middleton, P. Eng.
Engineer, Structures and Bridges

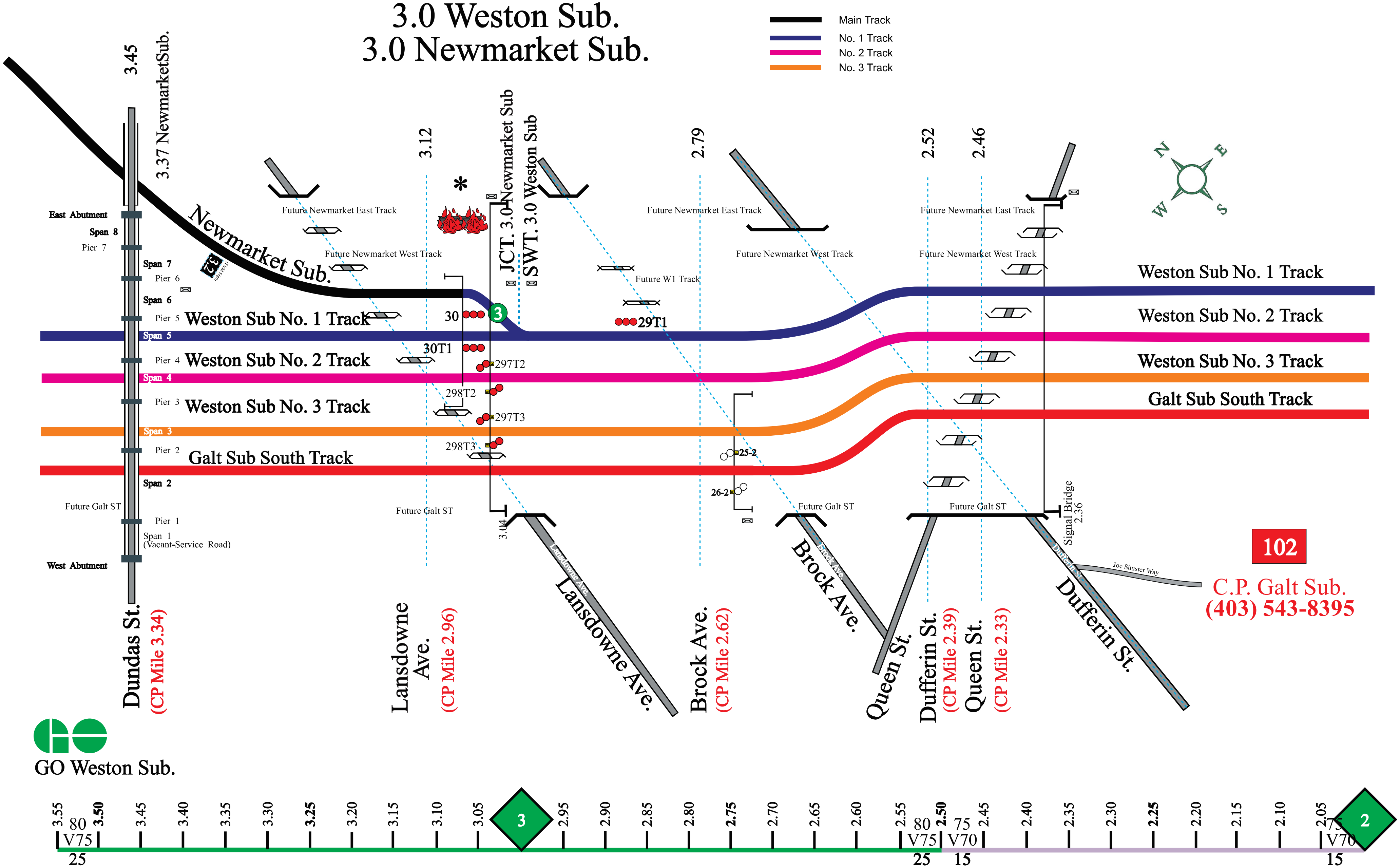
Attachment(s) / Enclosures:

- *Appendix A: Rail Corridor Details*
- *Appendix B: Energy Balance*

Appendix A: Rail Corridor Details

Parkdale

3.0 Weston Sub.
3.0 Newmarket Sub.



Appendix B: Energy Balance Analysis

450 Dufferin Street
Energy Balance Analysis

Equations are referred to the AECOM paper, using the same references in square brackets [EQ #]
Locomotive & Car masses are from the FCM/RAC guidelines

Parameters

	Freight		Passenger	
	Load Case 1	**Load Case 2**	**Load Case 3**	**Load Case 4**
	Glancing Blow	Direct/Single Car Impact	Glancing Blow	Direct/Single Car Impact
No. of Locomotives	1	0	1	0
Mass of Locomotive	200,000	200,000	132,000	200,000
Length (m)	17	17	26	26
No. of Cars	9	1	8	1
Mass of Cars	129,700	129,700	67,120	67,120
Length (m)	17	17	26	26
Total Mass (kg)	1,367,300	129,700	668,960	67,120
Angle of impact (° to wall)	3.5	See Table 1.0	3.5	See Table 1.0
Radians	0.06	See Table 1.1	0.06	See Table 1.1
Speed limits within the corridor:	366	km/h	366	km/h
	101.56	m/s	101.56	m/s
	227.23	mph	227.23	mph

	K.E = 0.5.mass.velocity^2	Glancing Blow	Direct/Single Car Impact	Glancing Blow	Direct/Single Car Impact
Initial Track Speed (km/h)	**Speed of impact (m/s)**	**Maximum Kinetic Energy (MJ) at track speed before derailment**			
112	31.1111	661.71	62.77	323.74	32.48
100	27.7778	527.51	50.04	258.09	25.90
80	22.2222	337.60	32.02	165.18	16.57
72	20.0000	273.46	25.94	133.79	13.42
50	13.8889	131.88	12.51	64.52	6.47
25	6.9444	32.97	3.13	16.13	1.62

Step 1: Calculating Angle of Impact

[EQ 4,4M,5,5M]

Table 1.0

		Freight		Passenger	
		Freight Trains, Metric (4M)	Freight cars, Metric (9M)	Passenger Trains, Metric (5M)	Passenger cars, Metric (10M)
		Taken as 3.5° as suggested by AECOM	**θF = asin(dcL/8.5)**	**Taken as 3.5° as suggested by AECOM**	**θF = asin(dcL/13.0)**
		Glancing Blow	Direct/Single Car Impact	Glancing Blow	Direct/Single Car Impact
Track Number	dcL (m)	**Angle of Impact (Radians)**			
1	130	0.061	#NUM!	0.061	#NUM!
2	0	0.061	0.000	0.061	0.00
3	0	0.061	0.000	0.061	0.0000
4	0	0.061	0.000	0.061	0.0000
		0.061	0.000	0.061	0.0000
		0.061	0.000	0.061	0.0000
		0.061	0.000	0.061	0.0000

Table 1.1

Track Number	dcL (m)	**Angle of Impact (degree equivalent)**			
1	130	3.50	#NUM!	3.50	#NUM!
2	0	3.50	0.00	3.50	0.00
3	0	3.50	0.00	3.50	0.00
4	0	3.50	0.00	3.50	0.00
		3.50	0.00	3.50	0.00
		3.50	0.00	3.50	0.00
		3.50	0.00	3.50	0.00

Step 2: Calculating velocity at impact

EQ [3M, 7M, 8M]

Glancing Blow

EQ [3M]

$$v_G = \sqrt{v_0^2 + 2a\left(\frac{d_{CL}-1.625}{\sin\theta_G}\right)}\ [m/s]$$

Rolling Resistance (R) =	0.25	
Grade (G) =	0	
vo^2 =	-10314.40627	m/s
2a = -9.8*(R+G) =	-4.905	m/s
Experimental (Hirsch et al, 1989)		m/s
Average to account for air resistance an	-4.905	
dcL-1.625	128.375	
sinθG =	0.06104854	

Single Car, Direct Impact

EQ [7M] $$v_A = \frac{2.3\theta_f}{\sqrt{1-\cos\theta_f}}$$ [m/s] for freight cars

EQ [8M] $$v_A = \frac{2.9\theta_f}{\sqrt{1-\cos\theta_f}}$$ [m/s] for passenger cars

Table 2.0

		Freight		Passenger	
		Glancing Blow*	**Direct/Single Car Impact****	**Glancing Blow***	**Direct/Single Car Impact****
Track Number	dcL (m)	**Adjusted Velocity at Impact (m/s)**			
1	130	0.03	#NUM!	0.03	#NUM!
2	0	102.20	#DIV/0!	102.20	#DIV/0!
3	0	102.20	#DIV/0!	102.20	#DIV/0!
4	0	102.20	#DIV/0!	102.20	#DIV/0!
		102.20	#DIV/0!	102.20	#DIV/0!
		102.20	#DIV/0!	102.20	#DIV/0!
		102.20	#DIV/0!	102.20	#DIV/0!

Table 2.1

Track Number	dcL (m)	**Maximum Energy Carried at Impact (MJ) prior to contact with wall**			
1	130	0.00	#NUM!	0.00	#NUM!
2	0	7140.70	#DIV/0!	3493.63	#DIV/0!
3	0	7140.70	#DIV/0!	3493.63	#DIV/0!
4	0	7140.70	#DIV/0!	3493.63	#DIV/0!
		7140.70	#DIV/0!	3493.63	#DIV/0!
		7140.70	#DIV/0!	3493.63	#DIV/0!
		7140.70	#DIV/0!	3493.63	#DIV/0!

Step 3: Calculating Length of Impact

EQ [6M, 11M]

Glancing Blow

[6M] $$l_G = \frac{3.048}{\cos\theta_G}$$

Single Car, Direct Impact

[11M] $$l_A = \frac{.3048}{\sin\theta_f}$$

Two cars in accordion (not used)

$$s = 2\left[\frac{3.25}{2}\sin\theta_f + 0.5\cos\theta_f\right]$$

Table 3.0

		Freight		Passenger	
		Glancing Blow	**Direct/Single Car Impact**	**Glancing Blow**	**Direct/Single Car Impact**
Track Number	dcL (m)	**Length of Action of Impact Force (m)**			
1	130	3.05	#NUM!	3.05	#NUM!
2	0	3.05	#DIV/0!	3.05	#DIV/0!
3	0	3.05	#DIV/0!	3.05	#DIV/0!
4	0	3.05	#DIV/0!	3.05	#DIV/0!
		3.05	#DIV/0!	3.05	#DIV/0!
		3.05	#DIV/0!	3.05	#DIV/0!
		3.05	#DIV/0!	3.05	#DIV/0!

Step 4: Calculating Design Forces

EQ [6M, 11M]

Glancing Blow

$$F_G = \frac{\frac{1}{2}m(v_G \sin\theta_G)^2}{d_G}$$

m = mass of derailed cars (kg)
vG= velocity of impact (step 2)
θG = angle of impact (step 1)
dG = deformation of the consist in the direction of applied force
dG = 3.048sin(θG) in m

Single Car Impact

$$F_A = \frac{\frac{1}{2}m(v_A \cos\theta_f)^2}{d_A}$$

m = mass of derailed cars (kg)
vG= velocity of impact (step 2)
θf = angle of impact (step 1)
dA = deformation of the consist in the direction of applied force
dA = .3048COS(θF) in m

Table 4.0

		Freight		Passenger	
		Glancing Blow	**Direct/Single Car Impact**	**Glancing Blow**	**Direct/Single Car Impact**
Track Number	dcL (m)	**Design Forces (kN)**			
1	130	0.01	#NUM!	0.01	#NUM!
2	0	143021.48	#DIV/0!	69974.14	#DIV/0!
3	0	143021.48	#DIV/0!	69974.14	#DIV/0!
4	0	71510.74	#DIV/0!	69974.14	#DIV/0!
		71510.74	#DIV/0!	69974.14	#DIV/0!
		71510.74	#DIV/0!	69974.14	#DIV/0!
		71510.74	#DIV/0!	69974.14	#DIV/0!

Step 5: Force along the length of the wall

$$F_{II} = F_{\perp} x\ \mu$$

FII = Forces along the length of the wall
F⊥ = Force for each load case
μ = coefficient of friction 0.45 for concrete or steel

Table 5.0

		Freight		Passenger	
		Glancing Blow	**Direct/Single Car Impact**	**Glancing Blow**	**Direct/Single Car Impact**
Track Number	dcL (m)	**Force Along the length of the wall (kN)**			
1	130	0.01	#NUM!	0.00	#NUM!
2	0	64359.67	#DIV/0!	31488.37	#DIV/0!
3	0	64359.67	#DIV/0!	31488.37	#DIV/0!
4	0	32179.83	#DIV/0!	31488.37	#DIV/0!
	0	32179.83	#DIV/0!	31488.37	#DIV/0!
	0	32179.83	#DIV/0!	31488.37	#DIV/0!
	0	32179.83	#DIV/0!	31488.37	#DIV/0!

Calculations beyond this point are not featured in the guidelines by AECOM/AREMA for crash wall designs.
The specification for the total amount of energy absorbed by the wall is useful to guide the engineering of the deflection wall.

Step 6: Energy Absorbed by Crash Wall

Table 6.0

	Numerical value of dG and dA used in Table 4.0	Freight		Passenger	
		Glancing Blow	**Direct/Single Car Impact**	**Glancing Blow**	**Direct/Single Car Impact**
		Deformation in the direction of applied force (m)			
Track Number	dcL (m)	dG = 3.048sin(θG) in m	dA = .3048COS(θF) in m	dG = 3.048sin(θG) in m	dA = .3048COS(θF) in m
1	130	0.3042	#NUM!	0.3042	#NUM!
2	0				0.3048
3	0				
4	0				
	0				
	0				
	0				

Note:
The length of plastic deformation in each directional component as per the angle of attack is considered with respect to the deformation data and absorption energy provided by Bombardier for the passenger cars currently in use (Bi-level IX coach). Bombardier stated that the maximum crumple length at the end of a car is 0.5m, and is designed to absorb 3 MJ of energy.

Deformation Provided by passenger car manufacturer:	20 inches	Equivalent to 3 MJ	at each car end
Assuming a linearly proportional plastic deformation behavior where the energy absorbed is distributed evenly along the designed length of the crumple zone:	0.508 meters for	3	MJ
	5.905511811 MJ/m		

Table 6.1

Track Number	dcL (m)	**Energy Absorbed by plastic deformation, crumple zones (MJ)**			
1	130	1.7966	#NUM!	1.7966	#NUM!
2	0				1.8000
3	0				
4	0				
	0				
	0				
	0				

Notes:

1. Due to lack of more detailed crash test data from locomotive/car manufacturers, we assume that 0.5m of deformation is equivalent to 3 MJ of energy absorption, thus about 6 MJ/m of deformation.

a more direct impact is involved (closer to 90 degree

Table 6.2

		Freight		Passenger	
		Glancing Blow	**Direct/Single Car Impact**	**Glancing Blow**	**Direct/Single Car Impact**
Track Number	dcL (m)	**Energy to be Abosrbed by the wall (MJ)**			
1	130	-1.80	#NUM!	-1.80	#NUM!
2	0			3493.63	#DIV/0!
3	0			349363%	#DIV/0!
4	0			349363%	#DIV/0!
	0			349363%	#DIV/0!
	0			349363%	#DIV/0!
	0			349363%	#DIV/0!

3. The crumpling length is lower in the perpendicular component to the wall as a side impact is less likely to activate the full energy absorption potential of the designed crumple zones.

4. With indeterminency considered, the support structures embeded in the wall design may have better energy absorption characteristics by dissipating energy through designed crumbling, elastic or inelastic deformation or deflection.

Notes

Track Distances as reported by latest survey

min CL	130			
	Location 1	Location 2	Location 3	Location 4
Case 1	Yes	Yes	Yes	Yes
Case 2	No	Yes	Yes	Yes
Case 3	Yes	Yes	Yes	Yes
Case 4	No	Yes	Yes	Yes

8.5 Don't consider if dCL > 8.5 m
13 Don't consider if dCL > 13 m

0	0	0	0	0	0	0