APPENDIX 4.3

Detail Calculation of Ground-borne Noise

Appendix 4.3
Detail Calculation for Ground-borne Noise (Rock Drill)
Ref. No.: GNSR 1
Location: Lai Chi Yuen Tsuen

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	0.536	From site vibration measurement for the Kowloon Southern Link Project	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.13	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	103	$L_v = 20 \times \log (L_{v,rms} / L_{ref})$, $L_{ref} = 10^{-6}$ mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	29.8		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-15	$C_{dist} = - 20 \times \log (R / R_o)$	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping} = - 20 \times \log [(L_{v,rms} (1- e^{-2\pi f \eta R/2C})) / 10^{-6}]$, no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5		[3]
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	$L_p - L_v$ = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**38 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	**ANL - 35 dB(A)**

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report
[2] Federal Transit Administration's manual
[3] Transportation Noise Reference Book
[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05

Appendix 4.3
Detail Calculation for Ground-borne Noise (Rock Drill)
Ref. No.: GNSR 2
Location: Mui Wo Kau Tsuen

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	0.536	From site vibration measurement for the Kowloon Southern Link Project	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.13	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	103	$L_v = 20 \times \log (L_{v,rms} / L_{ref})$, $L_{ref} = 10^{-6}$ mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	539.0		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-40	$C_{dist} = - 20 \times \log (R / R_o)$	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping} = - 20 \times \log [(L_{v,rms} (1- e^{-2\pi f\eta R/2C})) / 10^{-6}]$, no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5		[3]
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	$L_p - L_v$ = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**13 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	**ANL - 35 dB(A)**

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report
[2] Federal Transit Administration's manual
[3] Transportation Noise Reference Book
[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05

Appendix 4.3
Detail Calculation for Ground-borne Noise (Rock Drill)
Ref. No.: GNSR 3
Location: Lung Mei Hang

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	0.536	From site vibration measurement for the Kowloon Southern Link Project	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.13	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	103	$L_v = 20 \times \log (L_{v,rms} / L_{ref})$, $L_{ref} = 10^{-6}$ mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	226.9		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-32	$C_{dist} = - 20 \times \log (R / R_o)$	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping} = - 20 \times \log [(L_{v,rms} (1- e^{-2\pi f \eta R/2C})) / 10^{-6}]$, no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5		[3]
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	$L_p - L_v$ = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**21 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report
[2] Federal Transit Administration's manual
[3] Transportation Noise Reference Book
[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05

Appendix 4.3
Detail Calculation for Ground-borne Noise (Rock Drill)
Ref. No.: GNSR 4
Location: Lung Mei Tsuen

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	0.536	From site vibration measurement for the Kowloon Southern Link Project	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.13	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	103	$L_v = 20 \times \log (L_{v,rms} / L_{ref})$, $L_{ref} = 10^{-6}$ mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	137.2		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-28	$C_{dist} = - 20 \times \log (R / R_o)$	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping} = - 20 \times \log [(L_{v,rms} (1- e^{-2\pi f\eta R/2C})) / 10^{-6}]$, no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5		[3]
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	$L_p - L_v$ = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**25 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report
[2] Federal Transit Administration's manual
[3] Transportation Noise Reference Book
[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05

Appendix 4.3
Detail Calculation for Ground-borne Noise (TBM)
Ref. No.: GNSR 1
Location: Lai Chi Yuen Tsuen

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	2.5	By Exptrapolation, PPV = 28.188 $R^{-1.4103}$	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.63	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	116	L_v = 20 x log ($L_{v,rms}$ / L_{ref}), L_{ref} = 10^{-6} mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	29.8		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-15	C_{dist} = - 20 x log (R / R_o)	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping}$ = - 20 x log [($L_{v,rms}$ (1- $e^{-2\pi f\eta R/2C}$)) / 10^{-6}], no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5	Single Family Residencies	[3] - Figure 16.10
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	L_p - L_v = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**52 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	**ANL - 35 dB(A)**

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report
[2] Federal Transit Administration's manual
[3] Transportation Noise Reference Book
[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05

Appendix 4.3
Detail Calculation for Ground-borne Noise (TBM)
Ref. No.: GNSR 2
Location: Mui Wo Kau Tsuen

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	2.5	By Exptrapolation, PPV = 28.188 $R^{-1.4103}$	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.63	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	116	$L_v = 20 \times \log (L_{v,rms} / L_{ref})$, $L_{ref} = 10^{-6}$ mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	539.0		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-40	$C_{dist} = - 20 \times \log (R / R_o)$	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping} = - 20 \times \log [(L_{v,rms} (1- e^{-2\pi f\eta R/2C})) / 10^{-6}]$, no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5	Single Family Residencies	[3] - Figure 16.10
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	$L_p - L_v$ = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**27 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	**ANL - 35 dB(A)**

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report
[2] Federal Transit Administration's manual
[3] Transportation Noise Reference Book
[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05

Appendix 4.3

Detail Calculation for Ground-borne Noise (TBM)

Ref. No.: GNSR 3

Location: Lung Mei Hang

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	2.5	$PPV = 28.188\ R^{-1.4103}$	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.63	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	116	$L_v = 20 \times \log (L_{v,rms} / L_{ref})$, $L_{ref} = 10^{-6}$ mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	226.9		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-32	$C_{dist} = - 20 \times \log (R / R_o)$	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping} = - 20 \times \log [(L_{v,rms} (1- e^{-2\pi f\eta R/2C})) / 10^{-6}]$, no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5	Single Family Residencies	[3] - Figure 16.10
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	$L_p - L_v$ = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**34 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	**ANL - 35 dB(A)**

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report

[2] Federal Transit Administration's manual

[3] Transportation Noise Reference Book

[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05

Appendix 4.3
Detail Calculation for Ground-borne Noise (TBM)
Ref. No.: GNSR 4
Location: Lung Mei Tsuen

	Description	Data	Remark	Reference
	Reference Distance, R_o (m)	5.5		
Source Strength				
	Peak Particle Velocity, PPV (mm/s) at R_o	2.5	PPV = 28.188 $R^{-1.4103}$	[1] - Section 7 and Appendix 7.1
	Vibration Amplitude, $L_{v,rms}$ (mm/s)	0.63	$L_{v,rms}$ = PPV / Crest Factor, Crest Factor = 4	[2]
a)	Vibration Velocity Level, L_v (VdB)	116	$L_v = 20 \times \log (L_{v,rms} / L_{ref})$, $L_{ref} = 10^{-6}$ mm/s	[1] - Section 7 and Apppendix 7.2.3
	Distance of NSR from the Tunnel Boring Machine, R (m)	137.2		
Attenuation				
b)	Distance Attenuation, C_{dist} (dB)	-28	$C_{dist} = - 20 \times \log (R / R_o)$	[2]
c)	Soil Damping Loss, $C_{damping}$ (dB)	0	$C_{damping} = - 20 \times \log [(L_{v,rms} (1- e^{-2\pi f\eta R/2C})) / 10^{-6}]$, no soil damping was applied as vibration through	[1] - Section 7 and Appendix 7.2.3
d)	Coupling Loss into Building Foundation, $C_{building}$ (dB)	-3.5	Single Family Residencies	[3] - Figure 16.10
e)	Coupling Loss from bed rock to pile	0	Village House without Pile Support	[1] - Ref. F of Appendix 7.2.3
f)	Coupling Loss per Floor, C_{floor} (dB)	0	Residential Units are located at ground floor	[3]
g)	Conversion Factors from Floor Vibration to Noise Levels C_{noise}	-26	$L_p - L_v$ = -10logh _ 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room	[1] - Section 7 and Apppendix 7.1
h)	Conversion from Vibration Level (VdB) to A-weighted Noise (dBA	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): -35 dB; High frequency (60 to 100 Hz): -20 dB	[4]
Predicted Ground-borne Noise Level		**38 dB(A)**	= a) + b) +c) +d) + e) + f) + g) + h)	**ANL - 35 dB(A)**

References:

[1] Kowloon Canton Railway Corporation Kowloon Southern Link Environmental Impact Assessment Report
[2] Federal Transit Administration's manual
[3] Transportation Noise Reference Book
[4] High-speed Ground Transportation Noise and Vibration Impact Assessment, US Department of Transportation, Oct 05