

Table 4-18 Construction activity noise management level exceedances, out of hours, sensitive residential receivers by NCA, dB(A)

NCA	Construction Management Level		Maximum predicted exceedance of construction management level (dB(A))																										
			S01	S02	S03 _a	S03 _b	S03 _c	S04	S05	S06	S07	S08	S09	S10 _a	S10 _b	S10 _c	S11 _a	S11 _b	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22
NCA1	OOHW Day	50	1	4	0	0	0	13	5	0	13	14	0	0	0	0	0	0	8	0	0	6	2	12	12	9	4	0	0
	OOHW Evening	44	7	-	-	-	-	-	11	-	-	-	-	0	0	0	3	0	-	-	5	-	-	18	18	-	10	6	-
	OOHW Night	38	-	-	-	-	-	-	17	-	-	-	-	-	-	-	9	4	-	-	11	-	-	24	24	-	-	12	-
NCA2	OOHW Day	54	22	25	0	4	6	34	26	0	34	35	0	0	0	2	0	0	29	14	13	27	23	33	33	30	25	21	0
	OOHW Evening	48	28	-	-	-	-	-	32	-	-	-	-	0	6	8	0	0	-	-	19	-	-	39	39	-	31	27	-
	OOHW Night	40	-	-	-	-	-	-	40	-	-	-	-	-	-	-	8	3	-	-	27	-	-	47	47	-	-	35	-
NCA3	OOHW Day	42	14	17	0	18	15	26	18	0	26	27	3	0	14	11	6	1	21	17	16	19	15	25	25	22	17	13	0
	OOHW Evening	42	14	-	-	-	-	-	18	-	-	-	-	0	14	11	6	1	-	-	16	-	-	25	25	-	17	13	-
	OOHW Night	35	-	-	-	-	-	-	25	-	-	-	-	-	-	-	13	8	-	-	23	-	-	32	32	-	-	20	-
NCA4	OOHW Day	51	48	51	0	11	58	60	52	0	60	61	0	0	7	54	0	0	53	21	20	51	47	57	57	54	49	45	0
	OOHW Evening	49	50	-	-	-	-	-	54	-	-	-	-	0	9	56	1	0	-	-	22	-	-	59	59	-	51	47	-
	OOHW Night	40	-	-	-	-	-	-	63	-	-	-	-	-	-	-	10	5	-	-	31	-	-	68	68	-	-	56	-
NCA5	OOHW Day	60	29	32	0	12	2	41	33	0	41	42	0	0	8	0	0	0	36	13	12	34	30	40	40	37	32	28	0
	OOHW Evening	56	33	-	-	-	-	-	37	-	-	-	-	0	12	2	0	0	-	-	16	-	-	44	44	-	36	32	-
	OOHW Night	46	-	-	-	-	-	-	47	-	-	-	-	-	-	-	3	0	-	-	26	-	-	54	54	-	-	42	-
NCA6	OOHW Day	38	31	34	11	21	37	43	35	3	43	44	17	7	17	33	20	15	38	27	26	36	32	42	42	39	34	30	7
	OOHW Evening	40	29	-	-	-	-	-	33	-	-	-	-	5	15	31	18	13	-	-	24	-	-	40	40	-	32	28	-
	OOHW Night	35	-	-	-	-	-	-	38	-	-	-	-	-	-	-	23	18	-	-	29	-	-	45	45	-	-	33	-
NCA7	OOHW Day	44	6	9	6	8	5	18	10	0	18	19	12	2	4	1	15	10	13	5	4	11	7	17	17	14	9	5	2
	OOHW Evening	41	9	-	-	-	-	-	13	-	-	-	-	5	7	4	18	13	-	-	7	-	-	20	20	-	12	8	-
	OOHW Night	39	-	-	-	-	-	-	15	-	-	-	-	-	-	-	20	15	-	-	9	-	-	22	22	-	-	10	-
NCA8	OOHW Day	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	OOHW Evening	53	0	-	-	-	-	-	0	-	-	-	-	0	0	0	0	0	-	-	0	-	-	0	0	-	0	0	-
	OOHW Night	38	-	-	-	-	-	-	2	-	-	-	-	-	-	-	13	8	-	-	2	-	-	9	9	-	-	0	-
NCA9	OOHW Day	39	13	16	17	0	0	25	17	8	25	26	22	13	0	0	26	21	20	13	12	18	14	24	24	21	16	12	13
	OOHW Evening	37	15	-	-	-	-	-	19	-	-	-	-	15	0	0	28	23	-	-	14	-	-	26	26	-	18	14	-

NCA	Construction Management Level		Maximum predicted exceedance of construction management level (dB(A))																										
			S01	S02	S03 _a	S03 _b	S03 _c	S04	S05	S06	S07	S08	S09	S10 _a	S10 _b	S10 _c	S11 _a	S11 _b	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22
	OOHW Night	35	-	-	-	-	-	-	21	-	-	-	-	-	-	-	30	25	-	-	16	-	-	28	28	-	-	16	-
NCA10																													
	OOHW Day	43	13	16	0	0	0	25	17	12	25	26	5	0	0	0	7	2	20	11	10	18	14	24	24	21	16	12	0
	OOHW Evening	40	16	-	-	-	-	-	20	-	-	-	-	0	0	0	10	5	-	-	13	-	-	27	27	-	19	15	-
	OOHW Night	35	-	-	-	-	-	-	25	-	-	-	-	-	-	-	15	10	-	-	18	-	-	32	32	-	-	20	-
NCA11	OOHW Day	55	0	0	0	0	0	6	0	0	6	7	0	0	0	0	3	0	1	0	0	0	0	5	5	2	0	0	0
	OOHW Evening	47	2	-	-	-	-	-	6	-	-	-	-	0	0	0	11	6	-	-	3	-	-	13	13	-	5	1	-
	OOHW Night	38	-	-	-	-	-	-	15	-	-	-	-	-	-	-	20	15	-	-	12	-	-	22	22	-	-	10	-
NCA12	OOHW Day	41	14	17	0	0	0	26	18	10	26	27	5	0	0	0	7	2	21	7	6	19	15	25	25	22	17	13	0
	OOHW Evening	41	14	-	-	-	-	-	18	-	-	-	-	0	0	0	7	2	-	-	6	-	-	25	25	-	17	13	-
	OOHW Night	35	-	-	-	-	-	-	24	-	-	-	-	-	-	-	13	8	-	-	12	-	-	31	31	-	-	19	-
NCA13	OOHW Day	61	26	29	0	0	0	38	30	16	38	39	0	0	0	0	0	0	33	7	6	31	27	37	37	34	29	25	0
	OOHW Evening	54	33	-	-	-	-	-	37	-	-	-	-	0	0	0	0	0	-	-	13	-	-	44	44	-	36	32	-
	OOHW Night	38	-	-	-	-	-	-	53	-	-	-	-	-	-	-	14	9	-	-	29	-	-	60	60	-	-	48	-
NCA14	OOHW Day	43	15	18	19	0	0	27	19	0	27	28	25	15	0	0	28	23	22	6	5	20	16	26	26	23	18	14	15
	OOHW Evening	42	16	-	-	-	-	-	20	-	-	-	-	16	0	0	29	24	-	-	6	-	-	27	27	-	19	15	-
	OOHW Night	40	-	-	-	-	-	-	22	-	-	-	-	-	-	-	31	26	-	-	8	-	-	29	29	-	-	17	-

Table 4-19 Number of construction noise management level exceedances, out of hours, sensitive residential receivers by NCA

NCA	Construction Management Level		Number of residential receivers - construction noise management level exceedances per NCA and activity																											
			S0_1	S0_2	S0_3a	S0_3b	S0_3c	S0_4	S0_5	S0_6	S0_7	S0_8	S0_9	S1_0a	S1_0b	S1_0c	S1_1a	S1_1b	S1_2	S1_3	S1_4	S1_5	S1_6	S1_7	S1_8	S1_9	S2_0	S2_1	S2_2	
NCA1	OOHW Day	50	1	15	0	0	0	154	19	0	154	184	0	0	0	0	0	27	0	0	19	6	107	107	38	15	0	0		
	OOHW Evening	44	20	-	-	-	-	-	77	-	-	-	-	0	0	0	3	0	-	-	19	-	-	197	197	-	55	19	-	
	OOHW Night	38	-	-	-	-	-	-	197	-	-	-	-	-	-	-	171	7	-	-	182	-	-	197	197	-	-	107	-	
NCA2	OOHW Day	54	89	126	0	10	26	235	140	0	235	254	0	0	0	4	0	0	163	24	17	146	102	211	211	178	124	77	0	
	OOHW Evening	48	157	-	-	-	-	-	199	-	-	-	-	0	16	49	0	0	-	-	76	-	-	303	303	-	186	146	-	
	OOHW Night	40	-	-	-	-	-	-	305	-	-	-	-	-	-	-	209	12	-	-	271	-	-	308	308	-	-	254	-	
NCA3	OOHW Day	42	261	379	0	411	473	587	432	0	587	592	73	0	202	272	371	10	548	382	330	487	291	585	585	566	381	224	0	
	OOHW Evening	42	261	-	-	-	-	-	432	-	-	-	-	0	202	272	371	10	-	-	330	-	-	585	585	-	381	224	-	
	OOHW Night	35	-	-	-	-	-	-	585	-	-	-	-	-	-	-	570	457	-	-	567	-	-	594	594	-	-	520	-	
NCA4	OOHW Day	51	133	169	0	26	88	225	172	0	225	247	0	0	8	43	0	0	181	79	65	176	149	206	206	185	170	117	0	
	OOHW Evening	49	155	-	-	-	-	-	177	-	-	-	-	0	13	64	1	0	-	-	96	-	-	247	247	-	176	149	-	
	OOHW Night	40	-	-	-	-	-	-	254	-	-	-	-	-	-	-	225	78	-	-	217	-	-	257	257	-	-	194	-	
NCA5	OOHW Day	60	44	65	0	31	3	117	67	0	117	122	0	0	12	0	0	0	88	13	11	75	51	112	112	93	65	40	0	
	OOHW Evening	56	67	-	-	-	-	-	93	-	-	-	-	0	31	2	0	0	-	-	24	-	-	137	137	-	88	65	-	
	OOHW Night	46	-	-	-	-	-	-	168	-	-	-	-	-	-	-	60	0	-	-	76	-	-	222	222	-	-	122	-	
NCA6	OOHW Day	38	278	320	214	249	250	331	323	10	331	331	309	92	166	201	321	290	328	281	270	325	301	331	331	329	319	258	94	
	OOHW Evening	40	243	-	-	-	-	-	314	-	-	-	-	40	145	167	315	252	-	-	228	-	-	330	330	-	301	232	-	
	OOHW Night	35	-	-	-	-	-	-	328	-	-	-	-	-	-	-	329	315	-	-	306	-	-	331	331	-	-	314	-	
NCA7	OOHW Day	44	12	65	31	88	80	173	115	0	173	173	142	2	8	1	168	93	172	112	71	151	23	173	173	172	65	9	2	
	OOHW Evening	41	65	-	-	-	-	-	172	-	-	-	-	22	59	40	171	166	-	-	155	-	-	173	173	-	165	39	-	
	OOHW Night	39	-	-	-	-	-	-	172	-	-	-	-	-	-	-	172	168	-	-	172	-	-	173	173	-	-	115	-	
NCA8	OOHW Day	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	OOHW Evening	53	0	-	-	-	-	-	0	-	-	-	-	0	0	0	0	0	-	-	0	-	-	0	0	-	0	0	-	
	OOHW Night	38	-	-	-	-	-	-	16	-	-	-	-	-	-	-	104	102	-	-	17	-	-	104	104	-	-	0	-	
NCA9	OOHW Day	39	177	207	215	0	0	215	209	199	215	215	215	206	0	0	215	215	215	204	201	212	200	215	215	215	207	153	206	

NCA	Construction Management Level		Number of residential receivers - construction noise management level exceedances per NCA and activity																											
			S0_1	S0_2	S0_3a	S0_3b	S0_3c	S0_4	S0_5	S0_6	S0_7	S0_8	S0_9	S1_0a	S1_0b	S1_0c	S1_1a	S1_1b	S1_2	S1_3	S1_4	S1_5	S1_6	S1_7	S1_8	S1_9	S2_0	S2_1	S2_2	
	OOHW Evening	37	206	-	-	-	-	-	214	-	-	-	-	212	0	0	215	215	-	-	205	-	-	215	215	-	212	200	-	
	OOHW Night	35	-	-	-	-	-	-	215	-	-	-	-	-	-	-	215	215	-	-	208	-	-	215	215	-	-	207	-	
NCA10	OOHW Day	43	65	83	0	0	0	93	89	90	93	93	34	0	0	0	41	13	93	80	78	90	72	93	93	93	83	60	0	
	OOHW Evening	40	83	-	-	-	-	-	93	-	-	-	-	0	0	0	58	35	-	-	86	-	-	93	93	-	91	80	-	
	OOHW Night	35	-	-	-	-	-	-	93	-	-	-	-	-	-	-	87	58	-	-	91	-	-	93	93	-	-	93	-	
NCA11	OOHW Day	55	0	0	0	0	0	13	0	0	13	16	0	0	0	0	7	0	2	0	0	0	0	10	10	4	0	0	0	
	OOHW Evening	47	4	-	-	-	-	-	13	-	-	-	-	0	0	0	17	17	-	-	7	-	-	17	17	-	10	2	-	
	OOHW Night	38	-	-	-	-	-	-	17	-	-	-	-	-	-	-	17	17	-	-	17	-	-	17	17	-	-	17	-	
NCA12	OOHW Day	41	54	100	0	0	0	196	116	99	196	200	36	0	0	0	116	3	169	31	26	137	68	191	191	181	102	40	0	
	OOHW Evening	41	54	-	-	-	-	-	116	-	-	-	-	0	0	0	116	3	-	-	26	-	-	191	191	-	102	40	-	
	OOHW Night	35	-	-	-	-	-	-	189	-	-	-	-	-	-	-	198	155	-	-	123	-	-	206	206	-	-	137	-	
NCA13	OOHW Day	61	10	15	0	0	0	24	16	12	24	26	0	0	0	0	0	0	18	6	4	16	11	22	22	18	15	10	0	
	OOHW Evening	54	18	-	-	-	-	-	22	-	-	-	-	0	0	0	0	0	-	-	12	-	-	59	59	-	22	17	-	
	OOHW Night	38	-	-	-	-	-	-	141	-	-	-	-	-	-	-	133	93	-	-	139	-	-	151	151	-	-	109	-	
NCA14	OOHW Day	43	2	2	2	0	0	2	2	0	2	2	2	2	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	
	OOHW Evening	42	2	-	-	-	-	-	2	-	-	-	-	2	0	0	2	2	-	-	2	-	-	2	2	-	2	2	-	
	OOHW Night	40	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2	2	-	-	2	-	-	2	2	-	-	2	-	

Table 4-20 Potential construction noise impacts, residential receivers, OOHW

NCA	Potential impact
1	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 13 dB(A) at up to 184 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), vegetation clearing (S4), utility relocations (S5), soil stripping (S7), bulk earthworks (S8), property adjustment work (S12), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19) and landscaping (S20). OOHW daytime levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (Jesmond Early Learning Centre and Jesmond Neighbourhood Centre) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW daytime levels are predicted to exceed the noise management noise level at 1 commercial/industrial receiver in the Jesmond commercial precinct in this NCA, however noise management levels only apply when the commercial properties are in use. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 17 dB(A) at up to 197 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), major compound A operations (S11a), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 23 dB(A) at up to 197 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
2	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 34 dB(A) at up to 254 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound B (S3b), establishment of site compound C (S3c), vegetation clearing (S4), utility relocations (S5), soil stripping (S7), bulk earthworks (S8), compound C operations (S10c), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21). OOHW daytime levels are predicted to exceed the noise management level at 9 sensitive non-residential receivers (buildings in Jesmond Community Preschool, Callahan College and Jesmond Neighbourhood Centre) in this NCA, however noise management levels only apply when the relevant non-residential receiver properties are in use. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 38 dB(A) at up to 303 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound B operations (S10b), compound C operations (S10c), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are predicted to exceed the noise management level at 8 sensitive non-residential receivers (buildings in Jesmond Community Preschool, Callahan College and Jesmond Neighbourhood Centre) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 46 dB(A) at up to 308 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are predicted to exceed the noise management level at 8 sensitive non-residential receivers (buildings in Jesmond Community Preschool, Callahan College and Jesmond Neighbourhood Centre) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
3	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 27 dB(A) at up to 592 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound B (S3b), establishment of site compound C (S3c), vegetation clearing (S4), utility relocations (S5), soil stripping (S7), bulk earthworks (S8), hard rock earthworks (S9), compound B operations (S10b), compound C operations (S10c), major compound A operations (S11a), major compound B operations (S11b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21). OOHW daytime levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (buildings in Jesmond Public School and Callahan College) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 25 dB(A) at up to 585 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound B operations (S10b), compound C operations (S10c), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (buildings in Jesmond Public School and Callahan College) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 32 dB(A) at up to 594 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (buildings in Jesmond Public School and Callahan College) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
4	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 60 dB(A) at up to 247 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound B (S3b), establishment of site compound C (S3c), vegetation clearing (S4), utility relocations (S5), soil stripping (S7), bulk earthworks (S8), compound B operations (S10b), compound C operations (S10c), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21). OOHW daytime levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW daytime levels are predicted to exceed the noise management level at 21 commercial/industrial receivers (buildings in Executive Villas Jesmond, Jesmond commercial precinct and Bluegum Apartments) in this NCA, however noise management levels only apply when the commercial/industrial properties are in use. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 59 dB(A) at up to 247 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound B operations (S10b), compound C operations (S10c), major compound A operations (S11a), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are predicted to exceed the noise management level at 17 commercial/industrial receivers (buildings in Executive Villas Jesmond, Jesmond commercial precinct and Bluegum Apartments) in this NCA, however noise management levels only apply when the commercial/industrial properties are in use. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 68 dB(A) at up to 257 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are predicted to exceed the noise management level at 17 commercial/industrial receivers (buildings in Executive Villas Jesmond, Jesmond commercial precinct and Bluegum Apartments) in this NCA, however noise management levels only apply when the commercial/industrial properties are in use.

NCA	Potential impact
5	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 41 dB(A) at up to 122 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound B (S3b), establishment of site compound C (S3c), vegetation clearing (S4), utility relocations (S5), soil stripping (S7), bulk earthworks (S8), compound B operations (S10b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21). OOHW daytime levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (Jesmond Park Uniting Church and St Margaret's Anglican Church) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 43 dB(A) at up to 137 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound B operations (S10b), compound C operations (S10c), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (Jesmond Park Uniting Church and St Margaret's Anglican Church) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 53 dB(A) at up to 222 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (Jesmond Park Uniting Church and St Margaret's Anglican Church) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
6	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 44 dB(A) at up to 331 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound A (S3a), establishment of site compound B (S3b), establishment of site compound C (S3c), vegetation clearing (S4), utility relocations (S5), demolition (S6), soil stripping (S7), bulk earthworks (S8), hard rock earthworks (S9), compound A operations (S10a), compound B operations (S10b), compound C operations (S10c), major compound A operations (S11a), major compound B operations (S11b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21) and (S22). OOHW daytime levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 40 dB(A) at up to 330 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound A operations (S10a), compound B operations (S10b), compound C operations (S10c), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 45 dB(A) at up to 331 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
7	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 18 dB(A) at up to 173 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound A (S3a), establishment of site compound B (S3b), establishment of site compound C (S3c), vegetation clearing (S4), utility relocations (S5), soil stripping (S7), bulk earthworks (S8), hard rock earthworks (S9), compound A operations (S10a), compound B operations (S10b), compound C operations (S10c), major compound A operations (S11a), major compound B operations (S11b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21) and (S22). OOHW daytime levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 19 dB(A) at up to 173 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound A operations (S10a), compound B operations (S10b), compound C operations (S10c), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 21 dB(A) at up to 173 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
8	No exceedances of construction noise management levels are predicted for noise sensitive residential receivers during the day and evening OOHW work periods. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 13 dB(A) at up to 104 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17) and road tie-ins (S18). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
9	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 25 dB(A) at up to 215 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound A (S3a), vegetation clearing (S4), utility relocations (S5), demolition (S6), soil stripping (S7), bulk earthworks (S8), hard rock earthworks (S9), compound A operations (S10a), major compound A operations (S11a), major compound B operations (S11b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21) and (S22). OOHW daytime levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 27 dB(A) at up to 215 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound A operations (S10a), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 29 dB(A) at up to 215 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
10	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 26 dB(A) at up to 93 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), vegetation clearing (S4), utility relocations (S5), demolition (S6), soil stripping (S7), bulk earthworks (S8), hard rock earthworks (S9), major compound A operations (S11a), major compound B operations (S11b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21). OOHW daytime levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 27 dB(A) at up to 93 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 32 dB(A) at up to 93 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
11	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 6 dB(A) at up to 16 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including vegetation clearing (S4), soil stripping (S7), bulk earthworks (S8), major compound A operations (S11a), property adjustment work (S12), pavement and median construction (S17), road tie-ins (S18) and street light installation (S19). OOHW daytime levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 12 dB(A) at up to 17 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 21 dB(A) at up to 17 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
12	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 26 dB(A) at up to 200 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), vegetation clearing (S4), utility relocations (S5), demolition (S6), soil stripping (S7), bulk earthworks (S8), hard rock earthworks (S9), major compound A operations (S11a), major compound B operations (S11b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21). OOHW daytime levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (buildings in New Lambton Heights Infants School) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 24 dB(A) at up to 191 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (buildings in New Lambton Heights Infants School) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 30 dB(A) at up to 206 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are predicted to exceed the noise management level at 2 sensitive non-residential receivers (buildings in New Lambton Heights Infants School) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

NCA	Potential impact
13	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 38 dB(A) at up to 26 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), vegetation clearing (S4), utility relocations (S5), demolition (S6), soil stripping (S7), bulk earthworks (S8), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21). OOHW daytime levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW daytime levels are predicted to exceed the noise management levels at one commercial/industrial receiver (a music teaching and recording business located in a private residence at 136 Lookout Road) in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 43 dB(A) at up to 59 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW evening levels are predicted to exceed the noise management levels at one commercial/industrial receiver (a music teaching and recording business located in a private residence at 136 Lookout Road) in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 59 dB(A) at up to 151 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are not predicted to exceed the noise management levels at any sensitive non-residential receivers in this NCA. OOHW night levels are predicted to exceed the noise management levels at one commercial/industrial receiver (a music teaching and recording business located in a private residence at 136 Lookout Road) in this NCA.

NCA	Potential impact
14	For activities undertaken during the OOHW daytime period, noise management levels would be exceeded by up to 28 dB(A) at up to 2 sensitive residential receivers. OOHW daytime impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), installation of erosion and sediment controls (S2), establishment of site compound A (S3a), vegetation clearing (S4), utility relocations (S5), soil stripping (S7), bulk earthworks (S8), hard rock earthworks (S9), compound A operations (S10a), major compound A operations (S11a), major compound B operations (S11b), property adjustment work (S12), mine remediation work (S13), bridge construction (S14), drainage work (S15), structural work (S16), pavement and median construction (S17), road tie-ins (S18), street light installation (S19), landscaping (S20) and finishing work (S21) and (S22). OOHW daytime levels are predicted to exceed the noise management noise level at 14 sensitive non-residential receivers (health facilities in the John Hunter Hospital precinct) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW daytime levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW evening period, noise management levels would be exceeded by up to 29 dB(A) at up to 2 sensitive residential receivers. OOHW evening impacts are predicted for a number of construction activities including establishment of fencing and traffic management (S1), utility relocations (S5), compound A operations (S10a), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18), landscaping (S20) and finishing work (S21). OOHW evening levels are predicted to exceed the noise management level at 13 sensitive non-residential receivers (health facilities in the John Hunter Hospital precinct) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW evening levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA. For activities undertaken during the OOHW night period, noise management levels would be exceeded by up to 31 dB(A) at up to 2 sensitive residential receivers. OOHW night impacts are predicted for a number of construction activities including utility relocations (S5), major compound A operations (S11a), major compound B operations (S11b), bridge construction (S14), pavement and median construction (S17), road tie-ins (S18) and finishing work (S21). OOHW night levels are predicted to exceed the noise management level at 13 sensitive non-residential receivers (health facilities in the John Hunter Hospital precinct) in this NCA, however noise management levels only apply when the relevant sensitive non-residential receiver properties are in use. OOHW night levels are not predicted to exceed the noise management levels at any commercial/industrial receivers in this NCA.

4.4.5 Construction noise assessment – construction compounds

Standard construction hours

Operation of construction compounds A, B and C during standard construction hours are predicted to exceed the daytime NMLs at nearby sensitive residential receivers. The highly affected level is predicted to be exceeded due to the operation of compound C. Numbers of impacted sensitive residential receivers and maximum level of exceedance for standard construction hours is presented Table 4-21.

Table 4-21 Predicted construction compound impacts, standard construction hours, sensitive residential receivers

Construction assessment scenario	Number of potentially impacted sensitive residential receivers		Highest exceedance of construction criterion, dB(A)	
	Highly affected level	Standard hours	Highly affected level	Standard hours
Compound A operations (S10a)	0	78	0	10
Compound B operations (S10b)	0	154	0	12
Compound C operations (S10c)	5	186	30	49
Major compound A operations (S11a)	0	626	0	23
Major compound B operations (S11b)	0	425	0	18

Compound B operations (S10) are predicted to exceed construction management levels for sensitive non-residential receivers including Jesmond Uniting Church and St Margaret's Anglican Church within NCA5.

Construction noise management levels would be exceeded at 14 sensitive non-residential receivers within NCA14 (health facilities within the hospital precinct) during major compound operations (S11) at Compound A.

Construction noise management levels would be exceeded at five commercial/industrial receivers (Executive Villas Jesmond) in NCA4 due to the operations of Compound C (S10c).

Extended construction hours

Operation of construction compounds A, B and C during extended construction hours are predicted to exceed the relevant criteria at nearby sensitive residential receivers. Numbers of impacted sensitive residential receivers and maximum level of exceedance for extended construction hours is presented Table 4-22.

Table 4-22 Predicted construction compound impacts, extended construction hours, sensitive residential receivers

Construction assessment scenario	Number of potentially impacted sensitive residential receivers				Highest exceedance of construction criterion, dB(A)			
	Weekday 6am - 7am	Weekday 6pm - 7pm	Saturday 7am - 8am	Saturday 1pm - 5pm	Weekday 6am - 7am	Weekday 6pm - 7pm	Saturday 7am - 8am	Saturday 1pm - 5pm
Compound A operations (S10a)	232	203	294	359	16	13	14	17
Compound B operations (S10b)	313	266	344	510	13	12	16	18
Compound C operations (S10c)	412	322	430	635	51	50	54	54

Construction assessment scenario	Number of potentially impacted sensitive residential receivers				Highest exceedance of construction criterion, dB(A)			
	Weekday 6am - 7am	Weekday 6pm - 7pm	Saturday 7am - 8am	Saturday 1pm - 5pm	Weekday 6am - 7am	Weekday 6pm - 7pm	Saturday 7am - 8am	Saturday 1pm - 5pm
Major compound A operations (S11a)	1146	957	1085	1305	29	26	27	30
Major compound B operations (S11b)	568	534	609	698	24	21	22	25

Construction noise management levels would be exceeded at Jesmond Park Uniting Church and St Margret's Anglican Church during extended construction hours when these properties are in use due to the operations of Compound B (S10b).

Construction noise management levels would be exceeded at up to 14 sensitive non-residential receivers within NCA14 (health facilities within the hospital precinct) during compound operations (S10a) and major compound operations (S11) at Compound A.

Construction noise management levels would be exceeded at five commercial/industrial receivers (Executive Villas Jesmond) in NCA4 due to the operations of Compound C (S10c).

Out of hours

Operation of construction compounds A, B and C during out of hours periods are predicted to exceed the relevant criteria at nearby sensitive residential receivers. Numbers of impacted sensitive residential receivers and maximum level of exceedance for standard hours is presented Table 4-23. Night time impacts have not been assessed for standard compound operations (S10), however night time operations may occur for major compound operations (S11) at compounds A and B.

Table 4-23 Predicted construction compound impacts, out of hours work, sensitive residential receivers

Construction assessment scenario	Number of potentially impacted sensitive residential receivers			Highest exceedance of construction criterion , dB(A)		
	day	evening	night	day	evening	night
Compound A operations (S10a)	302	276	0	15	16	0
Compound B operations (S10b)	396	466	0	17	15	0
Compound C operations (S10c)	521	594	0	54	56	0
Major compound A operations (S11a)	1241	1269	2492	28	29	31
Major compound B operations (S11b)	626	700	1679	23	24	26

Construction noise management levels would be exceeded at Jesmond Park Uniting Church and St Margret's Anglican Church during out of hours periods when these properties are in use due to the operations of Compound B (S10b).

Construction noise management levels would be exceeded at up to 14 sensitive non-residential receivers within NCA14 (health facilities within the hospital precinct) during compound operations (S10a) and major compound operations (S11) at Compound A.

Construction noise management levels would be exceeded at five commercial/industrial receivers (Executive Villas Jesmond) in NCA4 due to the operations of Compound C (S10c).

Summary of potential impacts

Noise impacts are predicted for sensitive residential, sensitive non-residential and commercial/industrial receivers due to the operation of construction compounds. Therefore the noise and vibration mitigation measures detailed in Section 4.9 will be implemented where feasible and reasonable and all potentially impacted receivers should be informed of the nature of the work, expected noise levels, duration of work and a method of contact.

Roads and Maritime has carried out ongoing consultation with NSW Health Infrastructure and Hunter New England Local Health District during all stages of development of the project. This has included potential impacts during construction. Further consultation will be carried out during detailed design and construction to minimise and manage potential adverse impacts associated with construction compounds on the John Hunter Hospital precinct.

4.4.6 Summary of noise impacts from construction activities

Based on the results discussed in Sections 4.4.2 to 4.4.5 the main findings of the construction noise assessment are:

- In relation to the noise catchment areas:
 - All noise catchments areas that are located next to the construction footprint are affected by construction noise levels.
 - NCA4, NCA5 (located on Newcastle Road) and NCA13 (located on Lookout Road), are the most impacted based on predicted noise levels.
 - NCA3 (located north of Newcastle Road) and NCA6 (located west of the project) are the most impacted based on number of receivers that could experience noise levels above the noise management level.
 - The John Hunter Hospital precinct (NCA14) would experience high levels of external construction noise that could exceed the internal noise criteria due to it being located near the construction footprint.
 - Commercial receivers next to the construction footprint located within NCA1 and NCA4 have the potential to be impacted by construction noise above the noise management level.
 - Residential and non-residential sensitive receivers nearest to construction activities within NCA2, NCA4, NCA5, NCA6, NCA13 and NCA14 could experience noise levels above the highly affected noise management level.
- In relation to construction activities:
 - Activities that encompass the entire project area, such as vegetation clearing (S4), bulk earthworks (S8) and pavement and median construction (S17) are likely to affect the most receivers.
 - Activities such as bulk earthworks (S8), general compound operations (S10), major compound operations (S11) and bridge construction (S14) have the potential to impact nearby receivers for longer periods of time.
 - Most construction activities near the John Hunter Hospital precinct have the potential to result in high levels of external construction noise that could exceed the internal noise criteria.
- In relation to working hours:
 - Construction activities carried out during standard construction hours are predicted to exceed the noise management level in NCAs next to the construction footprint.

- Construction activities carried out during the proposed extended construction hours adopted for the project increase the level of impact at residential sensitive receivers due to activities being carried out early in the morning and during the evening period.
- Construction activities during out of hours are predicted to exceed the noise management level in all NCAs.
- Construction activities during standard construction hours have the potential to exceed the noise management level at non-residential sensitive receivers including educational, child care and hospital facilities. Construction noise management levels are applicable as an internal level only when the facilities are in use. As a guide, an external trigger has been adopted, assuming a 10 dB reduction from external to internal noise levels (in accordance with *Interim Construction Noise Guideline* (DECC 2009)).
- Construction activities during standard construction hours have the potential to exceed the noise management level at formal and informal recreational areas including bushland areas, parks and sporting facilities when these areas are in use.
- Construction activities during extended construction hours are not anticipated to generate noise impacts at childcare facilities or schools as the construction management levels apply only when the facility is in use. Impacts may still occur at community centres, places of worship, health facilities and recreational areas where these receiver locations are in use during the extended construction hours.

The noise and vibration mitigation measures detailed in Section 4.9 are to be implemented where feasible and reasonable and all potentially impacted receivers should be informed of the nature of the work, expected noise levels, duration of work and a method of contact.

4.5 Sleep disturbance impacts

The *Interim Construction Noise Guideline* (DECC, 2009) states that ‘where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works’.

Typically, $L_{A1(1\text{minute})}$ or, $L_{A\text{max}}$ noise levels are around 5 dB to 10 dB greater than the $L_{Aeq(15\text{minute})}$ noise levels. Typically, a standard window will provide a 10 dB reduction when partially open and a 20 dB reduction when closed. To be conservative, it is assumed that windows would be kept partially open during night-time construction activities.

The *Environmental Criteria for Road Traffic Noise* (OEH, 1999) acknowledges that based on the current level of understanding no absolute noise level criteria have been established that correlate to an acceptable level of sleep disturbance. However, the RNP provides guidance suggesting that maximum internal noise levels below 50 dB(A) to 55 dB(A) are unlikely to cause awakening reactions and one or two events per night, with maximum internal noise levels of 65 dB(A) to 70 dB(A) (inside dwellings) are not likely to significantly affect health and wellbeing.

There is the potential for sleep disturbance impacts, with consideration to the RNP sleep disturbance levels, if construction activities occur during the night-time period. Construction scenarios with the potential for sleep disturbance impacts in each potentially impacted NCA are presented in Table 4-24.

Table 4-24 Construction scenario potential sleep disturbance per NCA

Scenario	NCA1	NCA2	NCA3	NCA4	NCA5	NCA6	NCA10	NCA12	NCA13	NCA14
S1		X		X	X	X			X	X
S2		X		X	X	X			X	X
S3										X
S4					X					
S5				X		X				
S6	X	X	X	X	X	X	X	X	X	X
S7		X		X	X	X			X	X
S8									X	
S9	X	X	X	X	X	X	X	X	X	X
S10	X	X	X	X	X	X	X	X	X	X
S11										X
S12										X
S13					X					
S14				X		X				
S15										X
S16										X
S17	X	X		X	X	X			X	X
S18		X		X	X	X			X	
S19		X		X	X				X	
S20		X		X	X	X			X	X
S21		X		X	X	X			X	X
S22	X	X	X	X	X	X	X	X	X	X

Given the high potential for sleep disturbance impacts, construction activities likely to generate the highest levels of noise be scheduled to occur at the beginning of the shift (before 11:00 pm) to minimise the potential for sleep disturbance. All workers should be briefed on the need to minimise noise as a result of their activities.

The noise and vibration mitigation measures detailed in Section 4.9 are to be implemented to manage potential sleep disturbance impacts during construction.

4.6 Construction traffic impacts

4.6.1 Construction traffic noise during standard construction hours

The application notes² for the *Road Noise Policy* state that 'for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of, or exceeds, the relevant day or night noise assessment criterion.' This is also considered to be applicable for construction noise therefore if road traffic noise increases from construction is within 2 dB(A) of current levels then the objectives of the *Road Noise Policy* are achieved.

A significant increase in traffic volumes would be needed in order to increase road traffic noise by 2 dB(A) (a doubling in traffic corresponds to about a 3 dB(A) increase).

Construction would generate heavy vehicle movements associated with the transportation of construction machinery, equipment and materials to the site. Light vehicle movements would be associated with employees and smaller deliveries. Predicted volumes of construction traffic generated by the project (Table 4-25) are small when compared to existing road traffic volumes and are therefore unlikely to noticeably increase noise in the local area.

²<http://www.environment.nsw.gov.au/noise/roadnoiseappnotes.htm> 12 December 2012

Vehicle movements, deliveries routes and workforce site access are to be via major roads where possible to minimise the potential for adverse traffic noise impacts. The specific details of these routes and vehicle volumes are in the early stages of development, therefore to evaluate the potential for noise increase due to construction traffic, the full number of average daily construction traffic movements has been assumed for each route, while volumes on Kookaburra Circuit are based on preliminary haulage requirements. Assumed construction traffic volumes and predicted noise increases using the CoRTN algorithm are presented in Table 4-25.

Table 4-25 Predicted increase in noise due to construction traffic

Road	Existing (2014) 24 hour traffic volumes (average weekday)	Existing (2014/15) daytime traffic volumes (average weekday)	Existing heavy vehicle percentage	Construction generated light vehicles (average per day)	Construction generated heavy vehicles (average per day)	Predicted relative increase in total traffic noise (dB)
Lookout Road, south of McCaffrey Drive	47,200	42,578	1.5%	200	355	0.4
Lookout Road, north of McCaffrey Drive	49,400	43,907	1.0%	200	355	0.3
McCaffrey Drive, west of Lookout Road	18,600	16,913	0.4%	200	355	0.8
Kookaburra Circuit (John Hunter Hospital access)	15,300	13,693	0.4%	200	144	0.6
Croudace Street, north of Elder Street	41,800	36,264	1.4%	200	355	0.4
Newcastle Road, east of Newcastle Inner City Bypass	60,200	53,493	1.6%	200	355	0.2
Newcastle Road, west of Newcastle Inner City Bypass	44,300	39,674	1.6%	200	355	0.3

Noise increases due to construction traffic on the haulage routes is predicted to be less than 1 dB on all proposed roads.

Construction traffic and heavy vehicles within the project area have been included in the assessment of construction noise impacts presented in Section 4.4. While noise impact from construction traffic on public roads is predicted to be negligible, adverse noise impacts are possible from traffic within the construction boundary including at site access locations. Therefore the noise and vibration mitigation measures detailed in Section 4.9 are to be implemented to manage potential construction traffic impacts.

4.6.2 Construction traffic noise outside standard construction hours

Traffic noise on public roads is assessed using the time periods detailed in the *Road Noise Policy*, which are day (7 am to 10 pm) and night (10 pm to 7 am). These time periods differ from weekday standard construction hours (7 am to 6 pm) and proposed weekday extended construction hours (6 am to 7 pm). To assess the potential for construction traffic impacts during the night time road traffic noise assessment period the following assumptions have been made:

- Half of daily light vehicle movements during the night time period to represent workers arriving to site prior to 7 am.
- 15% of daily heavy vehicle movements prior to 7 am. This considers an even split throughout the day of 7.7% of daily heavy vehicles per hour (extended construction hours) plus an allowance for additional morning deliveries.

Assumed construction traffic volumes and predicted noise increases using the CoRTN algorithm are presented in Table 4-26.

Table 4-26 Predicted increase in noise due to construction traffic

Road	Existing (2014/15) night traffic volumes (average weekday)	Existing heavy vehicle percentage	Construction generated light vehicles (average per day)	Construction generated heavy vehicles (average per day)	Predicted relative increase in total traffic noise (dB)
Lookout Road, south of McCaffrey Drive	4622	1.5%	100	53	0.5
Lookout Road, north of McCaffrey Drive	5493	1.0%	100	53	0.4
McCaffrey Drive, west of Lookout Road	1687	0.4%	100	53	1.3
Kookaburra Circuit (John Hunter Hospital access)	1607	0.4%	100	22	0.9
Croudace Street, north of Elder Street	5536	1.4%	100	53	0.4
Newcastle Road, east of Newcastle Inner City Bypass	6707	1.6%	100	53	0.3
Newcastle Road, west of Newcastle Inner City Bypass	4626	1.6%	100	53	0.4

Noise increases due to construction traffic on the haulage routes is predicted to be less than 1.3 dB during the night time period on all proposed roads.

For works carried out outside standard construction hours, construction traffic and heavy vehicles within the project area have been included in the assessment of construction noise impacts presented in Section 4.4. While out of hours noise impact from construction traffic on public roads is predicted to be negligible, adverse noise impacts are possible from traffic within the construction boundary including at site access locations. Therefore the noise and vibration mitigation measures detailed in Section 4.9 are to be implemented to manage potential construction traffic impacts.

4.7 Construction vibration assessment

4.7.1 Construction vibration criteria

Human comfort

Vibration has been assessed based on the criteria provided in AVTG (DEC 2006). *British Standard (BS) 6472 – 1992, Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* is recognised by the AVTG (DEC 2006) as the preferred standard for assessing 'human comfort criteria'.

The AVTG discusses three main types of vibration: continuous, intermittent and impulsive. These are further described in Table 4-27.

Table 4-27 Types of vibration (AVTG, DEC 2006)

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to three distinct vibration events in an assessment period, eg occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990) (Section 4.8).	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

For impulsive and continuous vibration there is low probability of disturbance to a receptor within a building provided the vibration levels are below the preferred values in Table 4-28.

Table 4-28 Preferred and maximum weighted values for continuous and impulsive vibration (AVTG, DEC 2006)

Location	Assessment period ¹	rms acceleration (m/s ²) ³		peak velocity (mm/s) ⁴	
		preferred	maximum	preferred	maximum
Continuous vibration					
Critical areas ²	Day or night-time	0.0050	0.010	0.14	0.28
Residences	Daytime	0.010	0.020	0.28	0.56
	Night-time	0.0070	0.014	0.20	0.40
Offices, schools, educational institutions and places of worship"	Day or night-time	0.020	0.040	0.56	1.1
Workshops	Day or night-time	0.040	0.080	1.1	2.2
Impulsive vibration					
Critical areas ²	Day or night-time	0.0050	0.010	0.14	0.28
Residences	Daytime	0.30	0.60	8.6	17.0
	Night-time	0.10	0.20	2.8	5.6
Offices, schools, educational institutions workshops and places of worship"	Day or night-time	0.64	1.28	18.0	36.0

Note:

1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am

2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria. Stipulation of such criteria is outside the scope of this policy, and other guidance documents (eg relevant standards) should be referred to. Source: BS 6472–1992
3. Values derived from z-axis critical frequency range 4–8 Hz. Where required, a more detailed analysis can be conducted as per BS 6472–1992.
4. Values given for the most critical frequency range >8 Hz assuming sinusoidal motion. Where required, a more detailed analysis can be conducted as per AS 2670.2–1990. Sufficient justification should accompany the use of a peak velocity approach if used in an assessment.

Typically, construction activities generate ground vibration of an intermittent nature. Intermittent vibration is assessed using the vibration dose value (VDV). Acceptable values of vibration dose are presented in Table 4-29 for receivers.

While the assessment of response to vibration in *BS 6472-1:1992* is based on vibration dose value and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak value, since this parameter is likely to be more routinely measured to monitor potential building damage.

Table 4-29 Human comfort intermittent vibration limits, mms-1.75 (BS 6472-1992)

Location	Daytime ¹		Night time ¹	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas ²	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Note:

1. Daytime is 7:00 to 22:00 and night time is 22:00 to 7:00.
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be need to assess intermittent values against the continuous or impulsive criteria for critical areas. These locations for the project are provided in Table 2.2 and 2.3.

Humans are capable of detecting vibration at levels well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in *BS 5228.2 – 2009, Code of Practice for noise and vibration on construction and open sites – Part 2: Vibration*, as shown in Table 4-30.

Table 4-30 Guidance on effects of vibration levels for human comfort (BS 5228.2 – 2009)

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

Structural damage

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Cosmetic damage criteria are provided in *British Standard BS 7385.2 – 1993 Evaluation and measurement for vibration in buildings* (Table 4-31) and *German Standard DIN 4150-3: 1999-02 Structural Vibration – Part 3: Effects of vibration on structures* (Table 4-32). This assessment has applied the DIN 4150-3: 1999 criteria (Table 4-32) as they are more stringent.

Table 4-31 BS 7385.2 – 1993 Transient vibration guideline values for cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominate pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4Hz and above	
2	Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4Hz increasing to 20 mm/s at 15Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above.

Table 4-32 DIN 4150-3: 1999 Guideline values for short-term vibration on structures

Line	Type of structure	Guideline values for velocity, (mm/s)		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz ¹
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy.	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (eg listed buildings under preservation order).	3	3 to 8	8 to 10

Note 1: At frequencies above 100 Hz, the values given in this column may be used as a minimum value.

Vibration due to construction processes also has the potential to affect services such as buried pipes. German Standard DIN 4150.3:1999 also provides guidance on safe vibration levels for buried pipe work. DIN 4150.3:1999 details the limits for short-term vibration, as presented in Table 4-33. The levels apply on the wall of the pipe.

Table 4-33 Guidance values for short-term vibration on buried pipes

Pipe material	Guideline values for velocity measured on the pipe (mm/s)
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, metal (with or without flange)	80
Masonry, plastic	50

Sensitive or vulnerable equipment, activities or processes often has the potential to be adversely impacted by vibration at levels well below the limit of perceptibility for humans. Often, sensitive equipment will have a rated vibration set by the manufacturer which should be used to form a recommended criterion. As the specific equipment at buildings within the John Hunter Hospital precinct are not known, initial guidance is necessary. BS5228.2 – 2009 presents guidance for a number of sensitive equipment cases which are shown in Table 4-34. PPV limits have been approximated from the Root Mean Square (RMS) limits assuming sinusoidal vibration. For continuous vibration, the guidance limits are typically set to 40% of the limits of intermittent vibration.

Table 4-34 Guidance on effects of vibration levels for sensitive equipment (BS 5228.2 – 2009) – RMS vibration velocity and PPV

Facility, equipment or use (class)	RMS vibration velocity (mm/s)	PPV (mm/s)
A: Bench Microscopes at up to 400x magnification optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators. Microelectronics manufacturing equipment – inspection, probe test and other manufacturing support equipment.	0.05	0.07
B: Micro surgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400x; optical equipment on isolation tables. Microelectronics manufacturing equipment – aligners, steppers, and other critical equipment for photolithography with line widths of 3 µm or more	0.025	0.035
C: Electron microscopes at up to 30000x magnification; microtomes; magnetic resonance imagers. Microelectronics manufacturing equipment – aligners, steppers, and other critical equipment for photolithography with line widths of 1 µm.	0.012	0.017
D: Electron microscopes at greater than 30000x magnification; mass spectrometers; cell implant equipment. Microelectronics manufacturing equipment – aligners, steppers, and other critical equipment for photolithography with line widths of 0.5 µm; includes electron-beam systems.	0.006	0.008
E: Microelectronics manufacturing equipment - aligners, steppers, and other critical equipment for photolithography with line widths of 0.25 µm; includes electron-beam systems, un-isolated laser and optical research systems.	0.003	0.004

4.7.2 Potential impacts of individual equipment

Energy from equipment is transmitted into the ground and transformed into vibration, which attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- The efficiency of the energy transfer mechanism of the equipment (ie impulsive; reciprocating, rolling or rotating equipment).
- The frequency content.
- The impact medium stiffness.
- The type of wave (surface or body).
- The ground type and topography.

Vibration impacts focus on potential structural damage in close proximity to construction activities. Furthermore, it is possible that receivers may perceive construction vibration at times. The level of annoyance, however, will depend on individuals.

Due to complicated ground conditions and other variables associated with construction vibration, an exact vibration assessment result is generally not expected from available prediction methods. Rather, regular monitoring of vibration levels at receivers is required to quantify the vibration effect. This is particularly the case with activities such as pile driving and operation of heavy vibratory compaction plant, where avoidance of damage or other disruption is critical. During construction, monitoring will be carried out as detailed in Section 4.9.

Table 4-35 outlines typical vibration levels for different plant activities sourced from the *Environmental Noise Management Manual* (ENMM) (2001), British Standard *BS 5228.1 Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration* and the *Construction Noise Strategy* (Transport for NSW 2012).

Table 4-35 Typical vibration levels - construction equipment

Item	Peak Particle Velocity at 10 m (mm/s)
Roller	5 - 6
15 tonne roller	7 - 8
Loader breaking kerbs	6 - 8
7 tonne compactor	5 - 7
Pavement Breaker	4.5 - 6
Dozer	2.5 - 4
Backhoe	1
Piling	12 - 30
Excavators, Scrapers, Graders etc.	2.5 ¹
Piling (bored) ²	7.4

Note 1: Based on levels derived at 8 m from: Tyan, A. E. *Ground Vibrations. Damaging effects to Buildings*. Road Research Board 1973

Note 2: based on levels derived from BS5228-2. Bored piling through stones or other obstruction.

As stated in the ENMM (2001), it can be assumed that the vibration level is inversely proportional to distance. Field variations show that the distance relationship generally varies between $d^{-0.8}$ and $d^{-1.6}$, rather than d^{-1} . On that basis, maximum vibration levels were estimated at each receiver using a factor of $d^{-0.8}$ which provides a measure of conservatism.

Based on the vibration levels stated in Table 4-35 and the list of construction equipment detailed in section 4.3.5 the maximum potential vibration impacts of the sources associated with the project at various distances are shown in Table 4-36.

Table 4-36 Estimated vibration levels at distance from activity

Vibration source	Distance to Source (m)/PPV (mm/s)			
	10	20	50	100
Roller	6.0	3.4	1.7	1.0
15 tonne vibratory roller	8.0	4.6	2.2	1.3
Loader breaking kerbs	7.0	4.0	1.9	1.1
7 tonne compactor	6.0	3.4	1.7	1.0
Pavement breaker	6.0	3.4	1.7	1.0
Dozer	4.0	2.3	1.1	0.6
Backhoe	1.0	0.6	0.3	0.2
Jackhammer	0.5	0.3	0.1	0.1
Excavator	2.1	1.2	0.6	0.3
Piling (bored/CFA)	7.4	4.3	2.1	1.2

Safe working buffer distances to comply with the human comfort, cosmetic damage, standard dwelling and heritage building structural damage criteria were calculated for typical intermittent vibration values and are listed in Table 4-37. This table is based on advice given in BS7385: 1993 – *Evaluation and measurement of vibration in buildings*. At this stage, specifics of vibration sensitive equipment in the hospital precinct are unknown, therefore buffer distances have only been provided for Class A and B equipment. As there are no anticipated sources of continuous or impulsive vibration, assessment for human comfort impacts has been carried out for intermittent vibration only.

Vibration may be amplified in multi-level buildings through the structure to the upper floors. A doubling of the buffer distances provided in Table 4-37 would provide a conservative allowance for this possible effect in multi-level buildings.

Table 4-37 Vibration estimated safe working buffer distances

Activity	Human comfort BS 5228-2 criteria ¹ (1.0 mm/s)	Structural damage		Sensitive equipment ²	
		Heritage structure DIN 4150-3 criteria (3.0 mm/s)	Standard dwellings DIN 4150-3 criteria (5.0 mm/s)	Class A (0.07 mm/s)	Class B (0.035 mm/s)
Roller	90 m	24 m	13 m	410 m	730 m
15 tonne vibratory roller	140 m	35 m	18 m	520 m	930 m
Loader breaking kerbs	120 m	30 m	16 m	470 m	830 m
7 tonne compactor	90 m	24 m	13 m	410 m	730 m
Pavement Breaker	90 m	24 m	13 m	410 m	730 m
Dozer	60 m	15 m	8 m	300 m	520 m
Backhoe	10 m	3 m	2 m	100 m	170 m
Jackhammer	4 m	2 m	1 m	60 m	100 m
Excavator	25 m	7 m	4 m	160 m	290 m
Piling (bored/CFA)	120 m	35 m	17 m	490 m	870 m

Notes: 1) based on levels derived from BS5228-2. Bored piling through stones or other obstruction.

2) As stated in the RTA's Environmental Noise Management Manual, it can be assumed that the vibration level is inversely proportional to distance. Field variations show that the distance relationship generally varies between $d^{0.8}$ and $d^{1.6}$, rather than d^{-1} . For prediction of approximate safe working distance for sensitive equipment the mid-value of $d^{-1.2}$ has been used as a guide.

4.7.3 Structural damage

Where desktop estimates or pre-construction monitoring indicates that vibration levels from construction activities will exceed the target levels, a property condition survey of all potentially affected structures may be carried out to enable post-construction verification that construction activities did not cause existing structural damage.

A property condition survey report should include as a minimum:

- A visual inspection of all buildings and structures (all internal and external walls, ground level floors and external pavements, all connections of other structures above ground level and their connection at ground level and any exposed foundations).
- Photographs of all cracks and/or defects observed.

- A record of the location of all cracks and/or defects observed, and measurements of the crack width/defect size.

The noise and vibration mitigation measures detailed in Section 4.9 are to be implemented to manage potential construction vibration impacts.

Based on the safe working distances shown in Table 4-37, the potential impacts from construction vibration for each noise catchment area is discussed in Table 4-38.

General construction activities

With consideration to structural damage vibration impacts for general construction activities, the expected magnitude of ground vibrations should not be sufficient to cause damage if the equipment operates at distances greater than 18 metres from standard residential buildings or structures of similar construction. Heritage buildings and structures may be impacted up to 35 metres from the work.

The noise and vibration mitigation measures detailed in Section 4.9 are to be implemented to manage potential construction vibration impacts.

Piling

Vibration impacts due to piling activities have the potential to exceed structural vibration values for standard dwellings at distances from the activity of 17 metres for bored piling. Heritage buildings and structures may be impacted up to 35 metres for bored piling.

In the event that these buffer distances are not practical, other methods may be investigated such as press-in hydraulic piling or jacked-in piling. These methods generally exhibit much lower vibration levels compared to impact, vibratory and bored piling.

4.7.4 Human comfort

With consideration to human comfort vibration impacts, where rolling and compacting activities occur within 140 metres of nearby receivers including residences, schools and places of worship, there is the potential that vibration levels could be intrusive for some activities. Where reasonable and feasible, buffer distances are to be implemented as per values shown in Table 4-37 for the corresponding activities.

Piling activities may cause adverse reaction from sensitive residential receivers up to 120 metres from the activity where bored piling is used. Press-in hydraulic piles or jacked-in piles may also provide alternatives with negligible vibration levels by comparison.

The noise and vibration mitigation measures detailed in Section 4.9 are to be implemented to manage potential construction vibration impacts.

Based on the safe working distances shown in Table 4-37, the potential impacts from construction vibration for each noise catchment area is discussed in Table 4-38.

Table 4-38 Potential construction vibration impacts

NCA	Potential impacts
1	The nearest receivers are located about 130 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used near this area. While considered unlikely, some receivers may perceive construction vibration above the human comfort level however, the predicted levels would not exceed the structural damage criteria. There are no listed heritage buildings near the construction footprint in this noise catchment area.
2	The nearest receivers are located about 18 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used in or near this area. Receivers in this area would experience vibration levels above the human comfort level. Subject to the type and size of equipment used during construction, predicted vibration levels would exceed the structural damage criteria. There are no listed heritage buildings near the construction footprint in this noise catchment area.
3	The nearest receivers are located about 115 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used near this area. While considered unlikely, some receivers may perceive construction vibration above the human comfort level however, the predicted levels would not exceed the structural damage criteria. The nearest listed heritage building is located about 115 metres from construction activities. The predicted levels of vibration at this distance would not exceed the structural damage criteria.
4	The nearest receivers are located within about 10 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used in or near this area. Receivers in this area would experience vibration levels above the human comfort level. Subject to the type and size of equipment used during construction, predicted vibration levels would exceed the structural damage criteria at buildings closest to the work. There are no listed heritage buildings near the construction footprint in this noise catchment area.
5	The nearest receivers are located within about 10 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used in or near this area. Receivers in this area would experience vibration levels above the human comfort level. Subject to the type and size of equipment used during construction, predicted vibration levels may exceed the structural damage criteria at buildings closest to the work. There are no listed heritage buildings near the construction footprint in this noise catchment area, with the nearest being over 400 metres away. The predicted levels of vibration at this distance would not exceed the structural damage criteria.

NCA	Potential impacts
6	The nearest sensitive receivers (residential) are located about 30 metres from construction activities, however there are other structures (eg sheds) closer. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used in or near this area. Receivers in this area would experience vibration levels above the human comfort level. Subject to the type and size of equipment used during construction, predicted vibration levels would exceed the structural damage criteria at structures (eg sheds) closest to the work. There are no listed heritage buildings near the construction footprint in this noise catchment area.
7	The nearest receivers are located about 450 metres from construction activities. These receivers are unlikely to experience any vibration from construction. There are no listed heritage buildings near the construction footprint in this noise catchment area.
8	The nearest receivers are located more than 900 metres from construction activities. These receivers are unlikely to experience any vibration from construction. There are no listed heritage buildings near the construction footprint in this noise catchment area.
9	The nearest receivers are located about 200 metres from construction activities. These receivers are unlikely to experience any vibration from construction. There are no listed heritage buildings near the construction footprint in this noise catchment area.
10	The nearest receivers are located about 280 metres from construction activities. These receivers are unlikely to experience any vibration from construction. There are no listed heritage buildings near the construction footprint in this noise catchment area.
11	The nearest receivers are located about 350 metres from construction activities. These receivers are unlikely to experience any vibration from construction. There are no listed heritage buildings near the construction footprint in this noise catchment area.
12	The nearest receivers are located about 60 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used in or near this area. Receivers in this area would experience vibration levels above the human comfort level however, the predicted levels would not exceed the structural damage criteria. There are no listed heritage buildings near the construction footprint in this noise catchment area.

NCA	Potential impacts
13	The nearest receivers are located within about 10 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers, pavement breakers and pile drivers would be used in or near this area. Receivers in this area would experience vibration levels above the human comfort level. Subject to the type and size of equipment used during construction, predicted vibration levels would exceed the structural damage criteria at buildings closest to the work. There are no listed heritage buildings near the construction footprint in this noise catchment area.
14	The nearest receivers are located about 25 metres from construction activities. It is possible that heavy equipment including rollers, compactors, dozers and pile drivers would be used in or near this area. Receivers in this area would experience vibration levels above the human comfort level however, the predicted levels would not exceed the structural damage criteria. Sensitive equipment located at the hospital precinct has the potential to be impacted by vibration generating activities that are carried out within distances of up to 930 metres. Greater buffer distances may be required for other types of sensitive equipment. The nearest locations housing sensitive equipment within the hospital precinct are Hunter Medical Research Institute (160 metres), pathology building (50 metres), neonatal intensive care unit (150 metres) and imaging department (200 metres). Further investigation of ground conditions and existing vibration isolation of sensitive equipment will be required however, appropriate assessment has been carried out to identify the potential impacts and to identify appropriate management and mitigation measures (Section 4.9). However, it is noted that recent large scale construction activities for the extension of the hospital carpark were carried out with no vibration issues being reported. Further the assessment has adopted the more stringent residential building criteria and it is possible that most structures in the John Hunter Hospital precinct would be able to withstand higher vibration levels associated with commercial buildings. The nearest listed heritage building is located about 260 metres from construction activities. The predicted levels of vibration at this distance would not exceed the structural damage criteria. Roads and Maritime has carried out ongoing consultation with NSW Health Infrastructure and Hunter New England Local Health District during all stages of development of the project. This has included potential impacts during construction. Further consultation will be carried out during detailed design and construction to minimise and manage potential adverse impacts associated with construction vibration on the operations of the John Hunter Hospital precinct.

4.7.5 Sensitive equipment

Comparing the predicted vibration levels with guidance limits for sensitive equipment and uses indicates that vibration from construction activities has the potential to exceed the guidance values for Class A equipment at distances up to 520 metres and Class B equipment at distances of up to 930 metres. By comparison, the nearest known sensitive equipment locations within the hospital precinct are located about 50 metres from construction activities. As these guidance limits may be quite restrictive for nearby construction activities, site investigations would typically be carried out to determine the existing ambient vibration levels at the equipment locations which may indicate safe and stable operations at levels higher than the limits presented in Table 4-37. Additionally, preliminary trials with monitoring next to the sensitive items would allow the specific site conditions to be established. The results of these trials would typically assist to set the limitations of construction activities and guide suitable work methods.

4.8 Construction blasting assessment

Blasting may be required during construction. The need for blasting will be determined during detailed design or by the construction contractor before or during construction. Geotechnical investigation carried out for the project has identified that some of the rock strata in cuts 3 and 4 located near the hospital precinct (Figure 1-3), are at the upper limit of being able to be excavated with techniques other than blasting. Further the use of techniques other than blasting (such as rock breaking and ripping by large dozers) would result in increased duration to complete the excavation as well as generating high levels of construction noise. Therefore, depending on the actual ground conditions encountered, there is potential that the use of blasting may result in a comparative reduction of impacts to receivers. Receivers potentially impacts are located in the John Hunter Hospital precinct (NCA14) and to the west of the project in NCA6 and NCA9.

Due to the potential for exceedance of both overpressure blasting criteria and vibration limits for sensitive equipment at the hospital precinct, further investigation and assessment with reference to site specific conditions is required. A detailed assessment of blast design would be carried out by a suitably qualified and licenced contractor incorporating refined site/ground conditions. This would also include consultation with NSW Health Infrastructure and Hunter New England Local Health District to identify the applicable criteria category for each building at the site and if required, test blasting at each proposed blast location to determine site specific ground conditions and to assist with development of a blasting management plan.

4.8.1 Blasting noise and vibration criteria

Typically, when dealing with potential blasting noise (overpressure) and vibration, OEH guidance refers to Australian and New Zealand Environment Council (ANZEC) Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (1990). This guideline recommends noise and vibration limits for human comfort for residential dwellings (Table 4-39).

Table 4-39 Recommended ANZEC 1990 Blasting limits for residential dwellings (human comfort)

Airblast Overpressure	Ground Vibration
115 dB(lin) peak	5 mm/s PPV
The level of 115 dB may be exceeded on up to 5% of the total number of blasts over a period of 12 months, but never over 120 dB(lin) peak.	The level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months, but never over 10 mm/s.

In addition to these limits, the impulsive vibration criteria from the AVTG is applicable for human comfort and impacts on other sensitive land uses including the nearby hospital precinct. These criteria are detailed in Table 4-28 and Table 4-34.

Guide values to limit cosmetic and minor building structural damage are also provided in AS 2187.2 – 2006 *Explosives – Storage and use Part 2: Use of explosives* with reference to British Standard, BS 7385-2 – 1993 *Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration*. These limits are shown in Table 4-40).

Table 4-40 Transient vibration guide values for cosmetic damage (BS 7385-2)

Line	Type of building	PPV in frequency of predominant pulse	
		4 Hz to 15 Hz	15Hz and above
1	Reinforced or framed structures. Industry and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structure. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15Hz increasing to 50 mm/s at 40 Hz and above

Note 1: values referred to are at the base of a building

Note 2: for line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

Requirements for building vibration may not be sufficient to cover high rise buildings, buildings with long span floors, specialist structures including hospitals or those with sensitive equipment. These cases require special consideration which may include measurement on the structure itself with particular attention given to suspended floors. Further consideration will also be required in relation to underground services including pipes and cables. This analysis will be carried out before or during construction if it is determined that blasting is required.

For heritage structures this assessment has adopted the DIN 4150-3: 1999 criteria (Table 4-32) for 'line 3' structures.

4.8.2 Potential blasting impacts

Air blast overpressure and ground vibration were estimated using distance relationship calculations, with reference to AS 2187.2 – 2006. The standard recommends a site constant in the range of 10 to 100 for the purpose of assessing air blast overpressure – a Ka value of 100 was applied as a conservative assessment. For ground vibration, the standard suggests a site constant of 1140 and site exponent of 1.6 for average conditions, however the resulting vibration predictions are a median value with 50% probability of exceedance and actual vibration levels may vary from 40 percent to 400 percent of the predictions.

To present a preliminary assessment scenario for noise and vibration impacts, blasting was considered to occur at the proposed pavement location nearest to the receivers (in NCA6, NCA9 and NCA14) near cuts 3 and 4. As blast size Maximum Instantaneous Charge (MIC) is unknown at this stage, the equations were used to identify possible MIC values based on the receiver distance and blast overpressure and vibration criteria levels. Overpressure predictions are presented in Table 4-41 and ground vibration predictions are presented in Table 4-42.

Table 4-41 Predicted blast overpressure, dB(Lin)

Receiver	Receiver type	Nearest potential blast location	Distance to nearest blast location (m)	Predicted Blast Overpressure dB(Lin) site constant K(air) = 100 MIC (kg)				
				0.5	1.0	2.0	5.0	10.0
R2068_RES	Residential	Cut 4	215	123	126	130	133	136
R2198_RES	Residential	Cut 4	250	122	124	128	131	134
R2245_RES	Residential	Cut 4	300	119	122	126	129	132
R2269_RES	Residential	Cut 4	510	113	115	119	122	125
R2377_RES	Residential	Cut 4	300	119	122	126	129	132
R2418_HTH	Hunter Medical Research Institute	Cut 3	280	120	123	127	130	133
R2429_HTH	Hunter Medical Research Institute	Cut 3	230	123	125	129	132	135
R2430_HTH	Yallarwah Place	Cut 3	150	128	131	135	138	141
R2431_HTH	John Hunter Hospital SSU	Cut 3	110	132	135	139	142	144
R2432_RES	Yallarwah Place	Cut 3	172	126	129	133	136	139
R2433_RES	Yallarwah Place	Cut 3	200	124	127	131	134	137
R2434_RES	Residential	Cut 3	300	119	122	126	129	132
R2440_HTH	Forensic Medicine	Cut 3	55	141	144	147	150	153
R2441_HTH	Forensic Medicine	Cut 3	70	138	140	144	147	150
R2449_RES	Residential	Cut 3	310	119	122	126	128	131
R2468_HTH	John Hunter Hospital, main building	Cut 3	170	126	129	133	136	139
R2475_HTH	John Hunter Hospital, main building	Cut 3	90	134	137	141	144	147
R2480_HTH	Newcastle Private Hospital	Cut 3	700	109	111	115	118	121
R2482_HTH	Newcastle Private Hospital	Cut 3	740	108	111	115	118	120
R2489_HTH	Newcastle Private Hospital	Cut 3	690	109	112	115	118	121
R2498_HTH	Newcastle Private Hospital	Cut 3	650	109	112	116	119	122
R2505_HTH	John Hunter Hospital	Cut 3	350	117	120	124	127	130
R2507_HTH	Newcastle Private Specialist Centre	Cut 3	605	110	113	117	120	123
R2515_RES	Residential	Cut 3	425	115	118	122	125	127
R2537_HTH	Rankin Park Unit	Cut 3	560	111	114	118	121	124
R2542_HTH	Hunter Prosthetics & Orthotics Service	Cut 3	505	113	116	119	122	125
R2550_HTH	Byrne House	Cut 3	495	113	116	120	123	126
R2561_RES	Ronald McDonald House	Cut 3	450	114	117	121	124	127

Receiver	Receiver type	Nearest potential blast location	Distance to nearest blast location (m)	Predicted Blast Overpressure dB(Lin) site constant K(air) = 100				
				MIC (kg) 0.5	1.0	2.0	5.0	10.0
R2570_HTH	Area Administration Building	Cut 3	570	111	114	118	121	124
R2596_RES	Residential	Cut 3	690	109	112	115	118	121
R2644_RES	Residential	Cut 3	505	113	116	119	122	125

Table 4-42 Predicted blast ground vibration PPV, mm/s

Receiver	Receiver type	Nearest potential blast location	Distance to nearest blast location (m)	Predicted Blast Ground Vibration PPV (mm/s) site constant K(ground) = 1140				
				MIC (kg) 0.5	1.0	2.0	5.0	10.0
R2068_RES	Residential	Cut 4	215	0.12	0.21	0.37	0.77	1.33
R2198_RES	Residential	Cut 4	250	0.10	0.17	0.29	0.60	1.05
R2245_RES	Residential	Cut 4	300	0.07	0.12	0.22	0.45	0.78
R2269_RES	Residential	Cut 4	510	0.03	0.05	0.09	0.19	0.33
R2377_RES	Residential	Cut 4	300	0.07	0.12	0.22	0.45	0.78
R2418_HTH	Hunter Medical Research Institute	Cut 3	280	0.08	0.14	0.24	0.50	0.87
R2429_HTH	Hunter Medical Research Institute	Cut 3	230	0.11	0.19	0.33	0.69	1.20
R2430_HTH	Yallarwah Place	Cut 3	150	0.22	0.38	0.65	1.36	2.37
R2431_HTH	John Hunter Hospital SSU	Cut 3	110	0.35	0.62	1.08	2.24	3.90
R2432_RES	Yallarwah Place	Cut 3	172	0.17	0.30	0.53	1.09	1.91
R2433_RES	Yallarwah Place	Cut 3	200	0.14	0.24	0.41	0.86	1.50
R2434_RES	Residential	Cut 3	300	0.07	0.12	0.22	0.45	0.78
R2440_HTH	Forensic Medicine	Cut 3	55	1.08	1.87	3.26	6.78	11.81
R2441_HTH	Forensic Medicine	Cut 3	70	0.73	1.27	2.22	4.61	8.03
R2449_RES	Residential	Cut 3	310	0.07	0.12	0.20	0.43	0.74
R2468_HTH	John Hunter Hospital, main building	Cut 3	170	0.18	0.31	0.54	1.12	1.94
R2475_HTH	John Hunter Hospital, main building	Cut 3	90	0.49	0.85	1.48	3.09	5.37
R2480_HTH	Newcastle Private Hospital	Cut 3	700	0.02	0.03	0.06	0.12	0.20
R2482_HTH	Newcastle Private Hospital	Cut 3	740	0.02	0.03	0.05	0.11	0.18
R2489_HTH	Newcastle Private Hospital	Cut 3	690	0.02	0.03	0.06	0.12	0.21
R2498_HTH	Newcastle Private Hospital	Cut 3	650	0.02	0.04	0.06	0.13	0.23

Receiver	Receiver type	Nearest potential blast location	Distance to nearest blast location (m)	Predicted Blast Ground Vibration PPV (mm/s) site constant K(ground) = 1140				
				MIC (kg) 0.5	1.0	2.0	5.0	10.0
R2505_HTH	John Hunter Hospital	Cut 3	350	0.06	0.10	0.17	0.35	0.61
R2507_HTH	Newcastle Private Specialist Centre	Cut 3	605	0.02	0.04	0.07	0.15	0.25
R2515_RES	Residential	Cut 3	425	0.04	0.07	0.12	0.26	0.45
R2537_HTH	Rankin Park Unit	Cut 3	560	0.03	0.05	0.08	0.17	0.29
R2542_HTH	Hunter Prosthetics & Orthotics Service	Cut 3	505	0.03	0.05	0.09	0.20	0.34
R2550_HTH	Byrne House	Cut 3	495	0.03	0.06	0.10	0.20	0.35
R2561_RES	Ronald McDonald House	Cut 3	450	0.04	0.06	0.11	0.23	0.41
R2570_HTH	Area Administration Building	Cut 3	570	0.03	0.04	0.08	0.16	0.28
R2596_RES	Residential	Cut 3	690	0.02	0.03	0.06	0.12	0.21
R2644_RES	Residential	Cut 3	505	0.03	0.05	0.09	0.20	0.34

Blasting impacts at sensitive residential receivers

The predictions summarised in Table 4-41 indicate that for MIC size of as little as 0.5 kg or greater have the potential to exceed the overpressure criteria of 115 dB(Lin) at nearby sensitive residential receivers if a conservative blast constant is used in the calculations. These predictions are based on a range of assumed site constants and therefore provide a guide only.

The ground vibration predictions presented in Table 4-42 show that for a 10 kg MIC, ground vibration levels at nearby sensitive residential receivers are generally not predicted to exceed the 5 mm/s ANZEC blasting criteria, however are likely to be perceptible at distances of up to 1 kilometre. These predictions are based on a range of assumed site constants and therefore provide a guide only.

Blasting impacts at the John Hunter Hospital precinct

It is considered the most likely limiting factor for blasting near the hospital precinct will be the sensitive equipment located in various parts of the hospital precinct. While there would be potential constraints associated with air blast overpressure and human comfort/building structural damage criteria these have not been assessed at this stage. These criteria would require further investigation should blasting be considered during detailed design or construction.

The adopted vibration criteria for blasting with respect to sensitive equipment are significantly more stringent than the ANZEC limits. These values are presented in Table 4-28 and Table 4-34 for five categories of sensitive spaces with criteria that ranges from 0.07 mm/s to 0.004 mm/s. Buildings within the hospital precinct are included in Table 4-42 and show that the criterion for 'category A' sensitive equipment has potential to be exceeded within 700 metres of a blast for a 0.5 kg MIC.

To estimate the maximum charge size that would be permissible with relation to the hospital precinct, the average parameters (site constant $K_G=1140$) from AS2187.2-2006 Appendix J were used. These predictions are a median value with 50% probability of exceedance and as stated in the standard, actual vibration levels may vary from 40 percent to 400 percent of the predictions.

The results are presented in Figure 4-1 and show the five sensitive equipment category criteria curves which can be used to find a MIC that corresponds to a given distance. For instance, a 1 kg MIC is likely to exceed the 0.07 mm/s criterion for 'category A' equipment at distances less than 400 metres from the blast. The criterion of 0.004 mm/s for 'category E' equipment may still be exceeded at distances of up to 3 km for the same 1 kg MIC size.

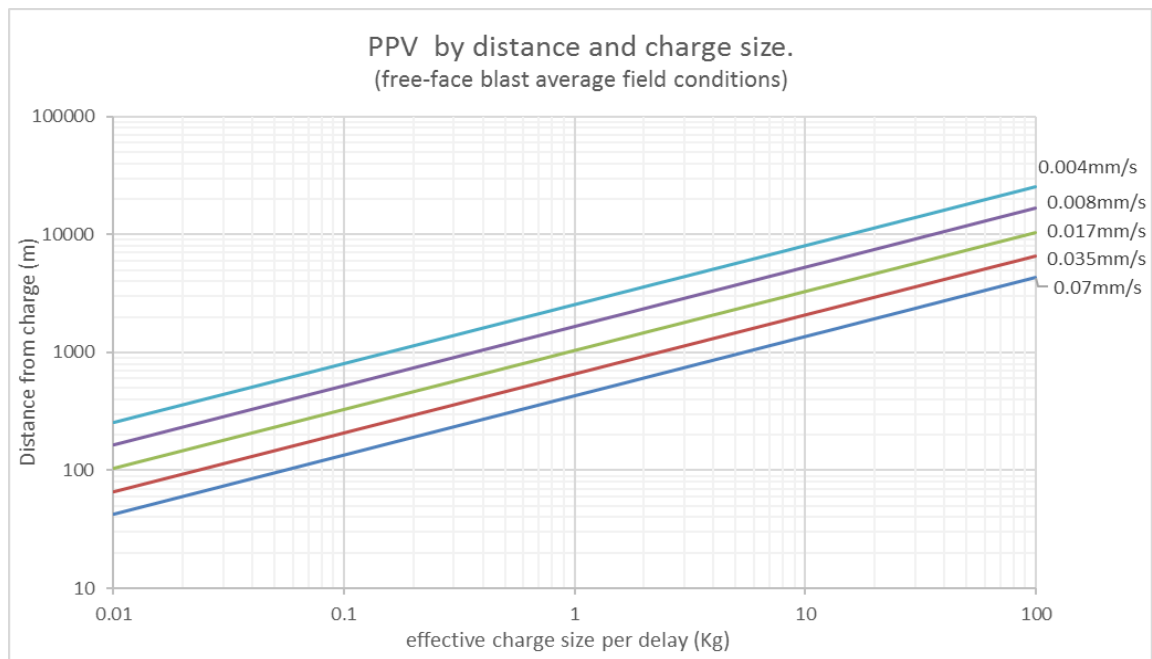


Figure 4-1 Blasting vibration –Sensitive equipment criteria (PPV) by distance and charge size

Due to the potential for exceedance of both overpressure blasting criteria and vibration limits for sensitive equipment at the hospital precinct, further investigation and assessment with reference to site specific conditions is required to ensure potential impacts are appropriately managed. A detailed assessment of blast design would be carried out by a suitably qualified and licenced contractor incorporating refined site/ground conditions. This would also include consultation with NSW Health Infrastructure and Hunter New England Local Health District to identify the applicable criteria category for each building at the site and if required, test blasting at each proposed blast location to determine site specific ground conditions and to assist with development of a blasting management plan.

4.9 Construction noise, blasting and vibration mitigation measures

The ICNG and ENMM provide a summary of potential noise mitigation measures that may be applicable to the project. The construction noise and vibration mitigation measures presented in Table 4-43 are to be implemented where reasonable and feasible to reduce the potential noise, blasting and vibration impact on the surrounding residents.

Table 4-43 Construction noise, blasting and vibration mitigation measures

Impact	Environmental safeguards	Responsibility	Timing
Vibration impacts (sensitive equipment)	Consultation with NSW Health and Hunter New England Local Health District will be carried out to identify the specific construction vibration limits for all sensitive equipment and facilities within the hospital precinct. Appropriate buffer distances will then be established.	Roads and Maritime and Construction contractor	Detailed design, pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
Construction noise and vibration management	A construction noise and vibration management plan (CNVMP) will be prepared as part of the construction environmental management plan (CEMP). The plan will include, but not be limited to: • A map indicating the locations of receivers. • A risk assessment to determine potential risk for activities likely to affect receivers (for activities carried out during standard construction hours, during the proposed extended construction hours and outside the proposed extended working hours). • Management measures to avoid noise and vibration impacts during construction activities including identification of appropriate work practices and equipment selection and use. • A process for community notifications regarding construction activities. • A process for scheduling of high noise and/or vibration generating activities during less sensitive noise periods as far as is possible. • A process for implementation of respite periods, where required, in accordance with ICNG for noise and vibration generating activities with impulsive, tonal or low frequency characteristics. • A process for assessing the performance of the implemented management measures. • A process for documenting and resolving issues and complaints. • A program of noise and vibration monitoring for sensitive receivers. • A process for updating the plan when activities affecting construction noise and vibration change. • Identify in inductions and where required toolbox talks where noise and vibration management is required.	Construction contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
	An out of hours work procedure (for work outside the proposed extended construction hours) will be developed and would include the following: • Contact the local community potentially affected by the proposed work and inform them by letter of the proposed work, location, type of work, days and dates of work and hours involved. The contact will be made before the start of work. • A suitable advertisement will be placed within local papers including a reference to night-time noise impacts. • A 24-hour community liaison phone number and permanent site contact will be provided so that complaints can be received and addressed in a timely manner. • Measures to investigate and respond to any valid noise complaints.	Construction contractor	Pre-construction and construction
Construction vibration impacts	Building condition surveys will be conducted at receivers (as required) within 18 metres of proposed vibration generating activities. (buildings and other structures).	Construction contractor	Pre-construction
	Notification of the proposed construction activities by letterbox drop will be carried out for all occupied buildings within 18 metres of vibration generating activities.	Construction contractor	Pre-construction and construction
	Where construction work is located within 18 metres of any buildings vibration monitoring will be carried out at the beginning of the given construction activity. Where measurements indicate building damage criteria are exceeded, vibration generating activities are to immediately halt and alternative low-vibration work practices will be investigated and implemented.	Construction contractor	Construction
	A documented review will be carried out to determine if alternative methods can be implemented, where construction activity involving vibration intensive plant occurs: • Within 18 metres of buildings • Within the sensitive equipment buffer distances • Or if any monitoring indicates levels are excessive.	Construction contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
Construction vibration impacts - John Hunter Hospital precinct	Construction buffer distances and potential additional mitigation measures identified during detailed design will be implemented in relation to sensitive equipment, standard buildings and heritage buildings in the John Hunter Hospital precinct.	Construction contractor	Construction
Construction noise impacts	Where practical, equipment will be selected to minimise noise emissions. Equipment will be fitted with appropriate silencers and be in good working order. Machines found to produce excessive noise compared to normal industry expectations will be removed from the site or stood down until repairs or modifications can be made.	Construction contractor	Construction
	Where reasonable and feasible, measures will be taken to shield residential receivers from noise such as: • The layout of the construction compound so that primary noise sources are at a maximum distance from residences, with solid structures (sheds, containers, etc.) placed between residences and noise sources (and as close to the noise sources as is practical). • Enclosures to shield fixed noise sources such as pumps, compressors, fans, screens (where practicable). • Taking advantage of site topography when situating plant.	Construction contractor	Construction
Construction noise and vibration complaints handling	In the event of a valid noise complaint, monitoring will be carried out and reported as soon as possible. If exceedances are detected, the situation will be reviewed to attempt to identify reduce the impact to acceptable levels, where practicable.	Construction contractor	Construction
Blasting overpressure and ground vibration impacts	If blasting is to be carried out, a detailed blasting assessment will be carried out in consultation with NSW Health Infrastructure and Hunter New England Local Health District. The assessment will be prepared with reference to the human comfort, sensitive equipment and structural damage criteria for all receivers including residential receivers and receivers located in the John Hunter Hospital precinct. The assessment will be carried out by a suitably qualified and experienced blast consultant / contractor and determine the allowable blast sizes based on site specific conditions and may include carrying out test blasts (or equivalent method). The assessment will identify all relevant requirements to be incorporated into a blasting management plan for the construction phase to ensure the relevant criteria can be met.	Roads and Maritime and Construction contractor	Detailed design, pre-construction and construction

5. Conclusion

5.1 Operational noise and vibration

5.1.1 Road traffic noise levels

The operational noise assessment identified that many receivers next to existing major roads such as Newcastle Road, Lookout Road and Croudace Street are subject to existing high levels of traffic noise. Many of these receivers are expected to experience noise reductions due to the project which will incorporate potentially quieter road pavements for sections of Newcastle Road and Lookout Road at interchanges with the bypass. Noise reductions are also anticipated due to reduced traffic on Croudace Street, Lookout Road (north of the southern interchange) McCaffrey Drive and Newcastle Road (east of the northern interchange). The assessment considered 3041 receiver locations within the study area to the requirements of the NCG and NMG and identified the following:

- The controlling criterion from the NCG is predicted to be exceeded at 760 assessed sensitive receivers during the day time period and 591 assessed receivers during the night time period. However, most of these are due to noise from existing roads not part of the project and therefore not all would qualify for consideration for mitigation. Of these sensitive receivers, 21 exceed the controlling criterion due to the project.
- The cumulative limit from the NMG is exceeded at 37 sensitive receivers, however noise levels are also predicted to decrease at some sensitive receivers next to Lookout Road (north of the southern interchange) and on Newcastle Road (east of the northern interchange) as a result of the project.
- No sensitive residential receivers are predicted to trigger the relative increase criteria.
- Seven sensitive receivers exceed both the controlling criterion and the cumulative limit.
- In total 50 sensitive receivers qualify for consideration for mitigation.

The project is predicted to exceed the NCG criteria at the following sensitive non-residential receivers:

- R1511_WOR, Jesmond Uniting Church
- R1514_WOR, St Margaret's Anglican Church
- R2418_HTH, Hunter Medical Research Institute
- R2429_HTH, Hunter Medical Research Institute
- R2430_HTH, Yallarwah Place
- R2431_HTH, John Hunter Hospital SSU
- R2440_HTH, Forensic Medicine
- R2441_HTH, Forensic Medicine
- R2468_HTH, John Hunter Hospital, main building

Additional detailed noise assessment (including internal and external noise monitoring (if required)) will be required during detailed design at these receivers to identify which spaces within these structures are sensitive locations with regards to the traffic noise criteria and to determine the transmission loss through the relevant building facades.

The current maximum noise levels exceed the $L_{Aeq(1hr)}$ noise levels by more than 15 dB(A) and are above 65 dB(A) during the night time for:

- More than 90 per cent of 15-minute periods at receivers near Lookout Road, Cardiff Road, McCaffrey Drive and Blue Gum Road during the night time period.
- 50 to 70 per cent of 15-minute periods at Janet Street and Crest Road.
- 20 to 50 per cent of 15 minute periods at Myall Street, Roberts Circuit, Grandview Street, Birchgrove Street and Marshall Street.
- 0 to 15 per cent of 15-minute periods at Kookaburra Circuit, Minimbah Close, Sygna Close, Shereline Avenue, Yallarwah Cottage, Cambridge Drive and Kingsway Avenue.

The project, incorporating the new and redeveloped sections, is likely to reduce the number of maximum noise level events for some residential receivers, particularly along Lookout Road (north of the southern interchange) and Croudace Street to the north of the project.

Conversely, there are expected to be receivers near the project that will be exposed to more frequent maximum noise events due to the location of the project, particularly in relation heavy vehicle engine (compression) braking by northbound bypass heavy vehicle traffic descending from the southern interchange.

Locations with low numbers of maximum night time noise events near to the project are considered to be representative of receivers that are potentially affected by the project. On this basis, the upper range of the maximum noise levels have the potential and the number of L_{Amax} events greater than 65 dB(A) and 15 dB(A) above $L_{Aeq(1hr)}$ have the potential to increase to about 34 events per night.

Local road traffic is not expected to change as a result of the project therefore mitigation measures are not required in relation to local traffic noise.

Based on this noise assessment 50 sensitive receivers qualify for consideration of noise mitigation. Most of these receivers are situated around the northern interchange at Newcastle Road and qualify for consideration for mitigation due to an exceedance of the cumulative limit. Other receivers are located to the west of the project including receivers in the area of Birchgrove Drive, Minimbah Close and Bellinger Close which are away from existing major roads. Receivers in the John Hunter Hospital precinct and isolated receivers near the southern interchange also qualify for consideration of mitigation measures.

5.1.2 Operational noise mitigation

The NMG recommends noise mitigation in the following order of preference: quieter pavement surfaces, noise mounds, noise barriers (noise walls) and at-property treatments.

Existing noise barriers are noted to be present along the existing inner city bypass north of Newcastle Road, however in some cases further mitigation is warranted for nearby receivers.

A review of the predicted noise levels and exceedances shows that the application of more than one noise mitigation treatment type would be required. The NMG states that noise barriers should be considered where there are four or more closely spaced receivers. As most of the receivers are relatively closely spaced, noise barriers should be considered as a potential mitigation option.

As a possible noise mitigation scenario, five barrier locations were considered.

1. Replacement or upgrade of the existing noise barrier next to the eastern side of the existing Newcastle Inner City Bypass north of Newcastle Road. This barrier extends along the southbound off-ramp from the bypass and along Newcastle road and consists of four segments, (a, b, c and d). This noise barrier was not considered feasible or reasonable for a range of reasons. These receivers would be subject to consideration for at-property treatments.
2. This barrier on the western side of the proposed main carriageway extends from the northbound off-ramp to the bridge over Newcastle Road and addresses noise west of the project at receivers near Birchgrove Drive. This noise barrier was considered feasible and reasonable.
3. Due to the significant volumes of traffic on the northbound off-ramp from the project to Newcastle Road, this barrier compliments Barrier 3 and also provides attenuation for receivers near Minimbah Close and Bellinger Close. This noise barrier was considered feasible and reasonable.
4. A barrier was considered to provide noise amelioration for the hospital receivers most affected by noise from the project, however due to the terrain a barrier of significant height would be required to provide reasonable benefit. This noise barrier was not considered feasible or reasonable for a range of reasons. These receivers would be subject to consideration for at-property treatments.

Implementation of two noise barriers successfully mitigates project noise levels at 13 of 50 receivers resulting in 37 receivers that qualify for consideration of further or alternative mitigation options. Post construction noise monitoring will be carried out to confirm predicted noise levels and verify required mitigation measures.

All noise mitigation options including but not limited to the use of barriers, quieter pavements and at-property treatments would be re-evaluated at the detailed design stage.

5.1.3 Operational vibration

There are no expected operational vibration impacts associated with the project and no mitigation measures have been recommended.

5.2 Construction noise and vibration

Standard construction hours are 7am to 6pm Monday to Friday, 8am to 1pm on Saturdays and no work on Sundays or public holidays. Extended construction hours for normal construction activities of 6am to 7pm Monday to Friday and 7am to 5pm Saturday are proposed to enable a reduced construction duration and minimise potential impacts on nearby receivers. Work outside the proposed extended construction hours may be required at times for certain activities that are either time sensitive or which have the potential to be disruptive if carried out during standard or extended construction hours.

5.2.1 Construction noise

The key findings of the construction noise assessment are:

- Construction activities carried out during standard construction hours are predicted to exceed the noise affected construction noise management level in NCAs next to the work.
- Only the closest receivers to the work are predicted to exceed the highly affected noise management level.

- Construction activities outside standard construction hours (day, evening and night) are predicted to exceed the noise affected construction noise management level in all NCAs.
- Construction activities during standard construction hours have the potential to exceed the noise management level at non-residential sensitive receivers including educational facilities, child care facilities and hospital precinct receivers. Construction noise management levels are applicable as an internal level only when the facilities are in use. As a guide, an external trigger has been adopted, assuming a 10 dB reduction from external to internal noise levels³ and an internal noise management level for these receivers.
- Construction activities during standard construction hours have the potential to exceed the noise management level at recreational areas when these areas are in use, particularly during clearing, earthworks and other activities that may occur near to these receivers. Noise management levels in these areas are applied as external noise criteria.

The key findings of the construction noise assessment with reference to work during the proposed extended construction hours for the project are:

- Construction activities carried out during the proposed extended construction hours adopted for the project increase the level of impact at residential sensitive receivers due to activities being carried out early in the morning and during the evening period.
- Construction activities during extended construction hours are not anticipated to generate noise impacts at childcare facilities or schools as the construction management levels apply only when the facility is in use. Impacts may still occur at community centres, places of worship, health facilities and recreational areas where these receiver locations are in use during the extended construction periods.

Mitigation measures for construction noise have been provided (section 4.9) based on the anticipated construction requirements of the project. The final staging and construction methodology for the project would be determined by the construction contractor and may change. The mitigation measures include the preparation of a comprehensive Construction Noise and Vibration Management Plan (CNVMP) as part of the Construction Environmental Management Plan (CEMP) for the project. This will include consideration of alternative construction methods, conduct of noise monitoring at sensitive receivers and a community consultation program.

5.2.2 Construction vibration

The key findings of the construction vibration assessment for the project are:

- Where desktop estimates or pre-construction monitoring indicates that vibration levels from construction activities will exceed the structural damage levels, a property condition survey of all potentially affected structures will be carried out to enable post-construction verification that construction activities did not cause existing structural damage.
- With consideration to structural damage vibration impacts for general construction activities, the expected magnitude of ground vibrations should not be sufficient to cause damage if the equipment operates at distances greater than 18 metres from standard residential buildings or structures of similar construction. Heritage buildings and structures may be impacted up to 35 metres from the work.
- Vibration impacts due to piling activities have the potential to exceed structural vibration values for standard dwellings at distances from the activity of 17 metres for bored piling.

³ The ICNG (DECCW 2009) states that a "conservative estimate of the difference between internal and external noise levels is 10 dB for buildings other than residences".

Heritage buildings and structures may be impacted up to 35 metres for bored piling. In the event that these buffer distances are not practical, other methods may be investigated such as press-in hydraulic piling or jacked-in piling. These methods generally exhibit much lower vibration levels compared to impact, vibratory and bored piling.

- With consideration to human comfort vibration impacts, where rolling and compacting activities occur within 140 metres of receivers including residences, schools and places of worship, there is the potential that vibration levels could be intrusive for some activities. Where reasonable and feasible, buffer distances are to be implemented as per values shown in Table 4-37 for the corresponding activities. Piling activities may cause adverse reaction from residential receivers up to 120 metres from the activity where bored piling is used. Press-in hydraulic piles or jacked-in piles may also provide alternatives with negligible vibration levels by comparison.

Noise and vibration mitigation measures detailed in Section 4.9 will be implemented where feasible and reasonable and all potentially impacted receivers will be informed of the nature of the work, expected noise and vibration levels, duration of work and a method of contact.

5.2.3 Blasting overpressure and vibration

Blasting may be required during construction. The need for blasting will be determined during detailed design or by the construction contractor before or during construction. Geotechnical investigation carried out for the project has identified that some of the rock strata in cuts 3 and 4 located near the hospital precinct, are at the upper limit of being able to be excavated with techniques other than blasting. Further the use of techniques other than blasting (such as rock breaking and ripping by large dozers) would result in increased duration to complete the excavation as well as generating high levels of construction noise. Therefore, depending on the actual ground conditions encountered, there is potential that the use of blasting may result in a comparative reduction of impacts to receivers. Receivers potentially impacts are located in the John Hunter Hospital precinct (NCA14) and to the west of the project in NCA6 and NCA9.

Due to the potential for exceedance of both overpressure blasting criteria and vibration limits for sensitive equipment at the hospital precinct, further investigation and assessment with reference to site specific conditions is required. A detailed assessment of blast design would be carried out by a suitably qualified and licenced contractor incorporating refined site/ground conditions. This would also include consultation with NSW Health Infrastructure and Hunter New England Local Health District to identify the applicable criteria category for each building at the site and if required, test blasting at each proposed blast location to determine site specific ground conditions and to assist with development of a blasting management plan.

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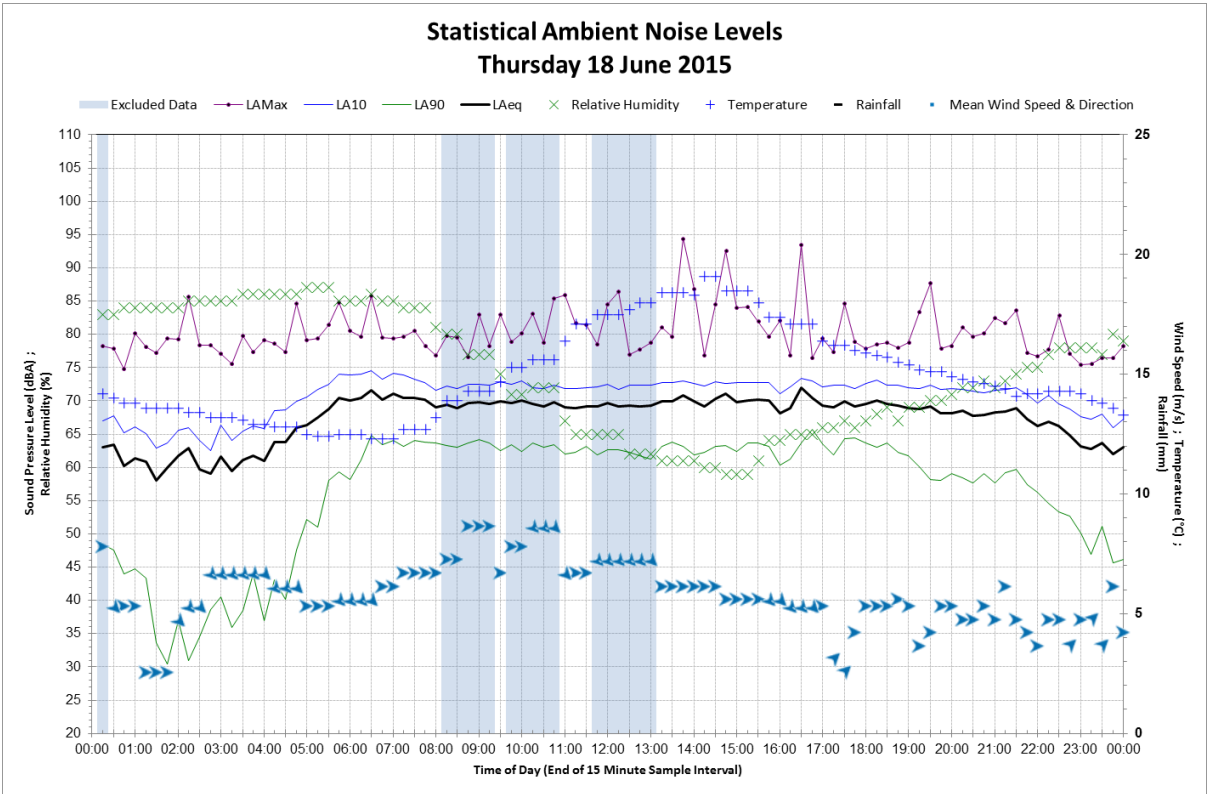
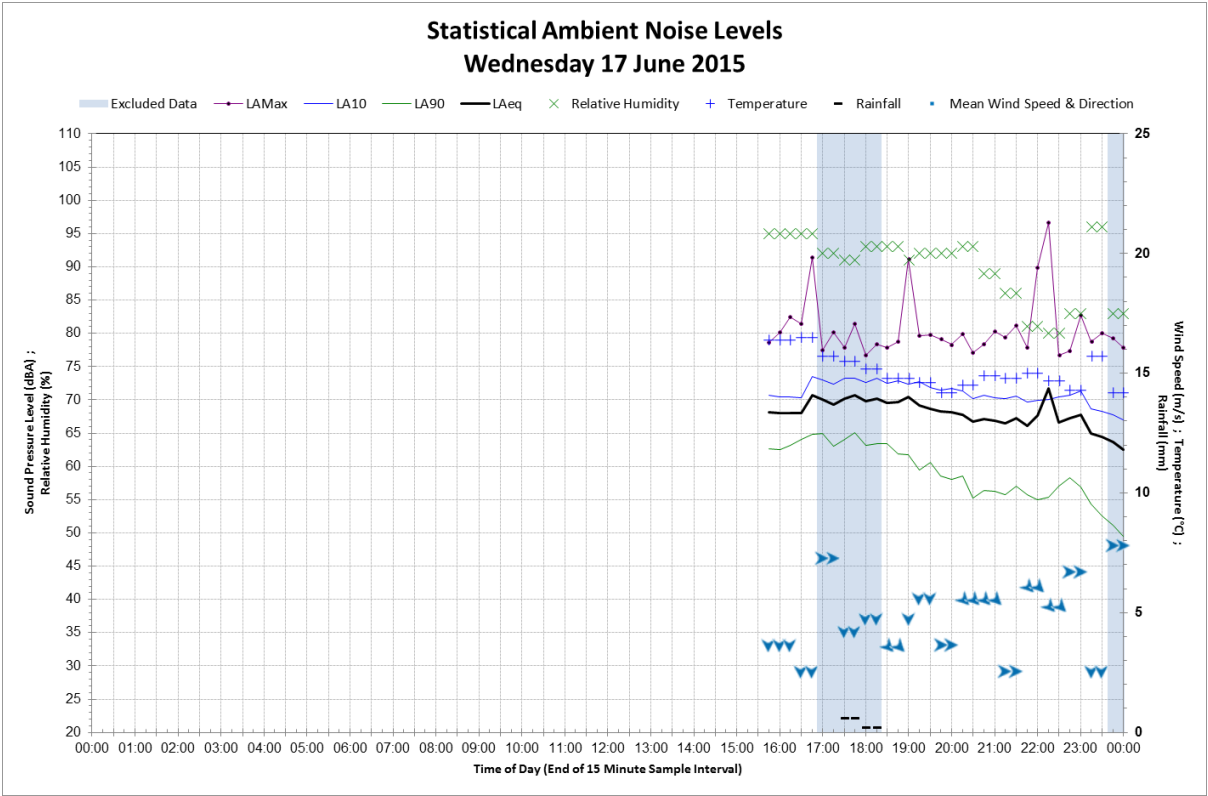
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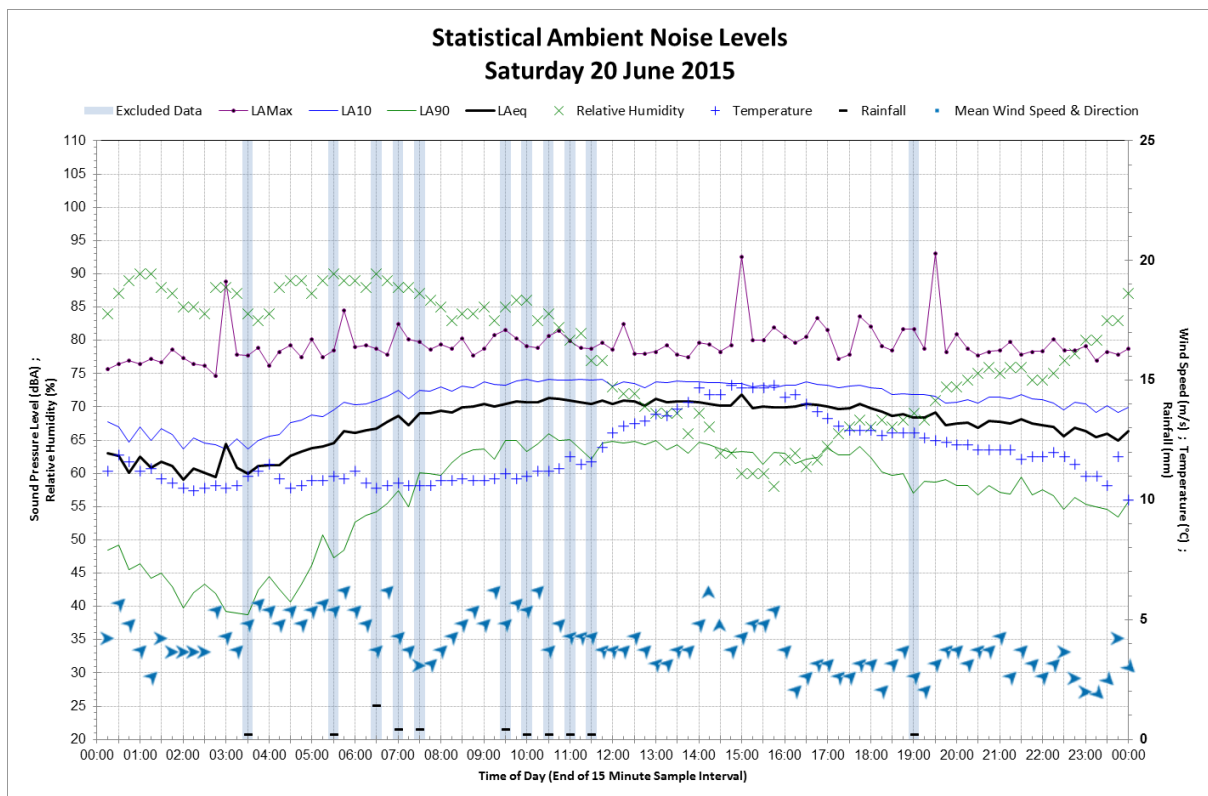
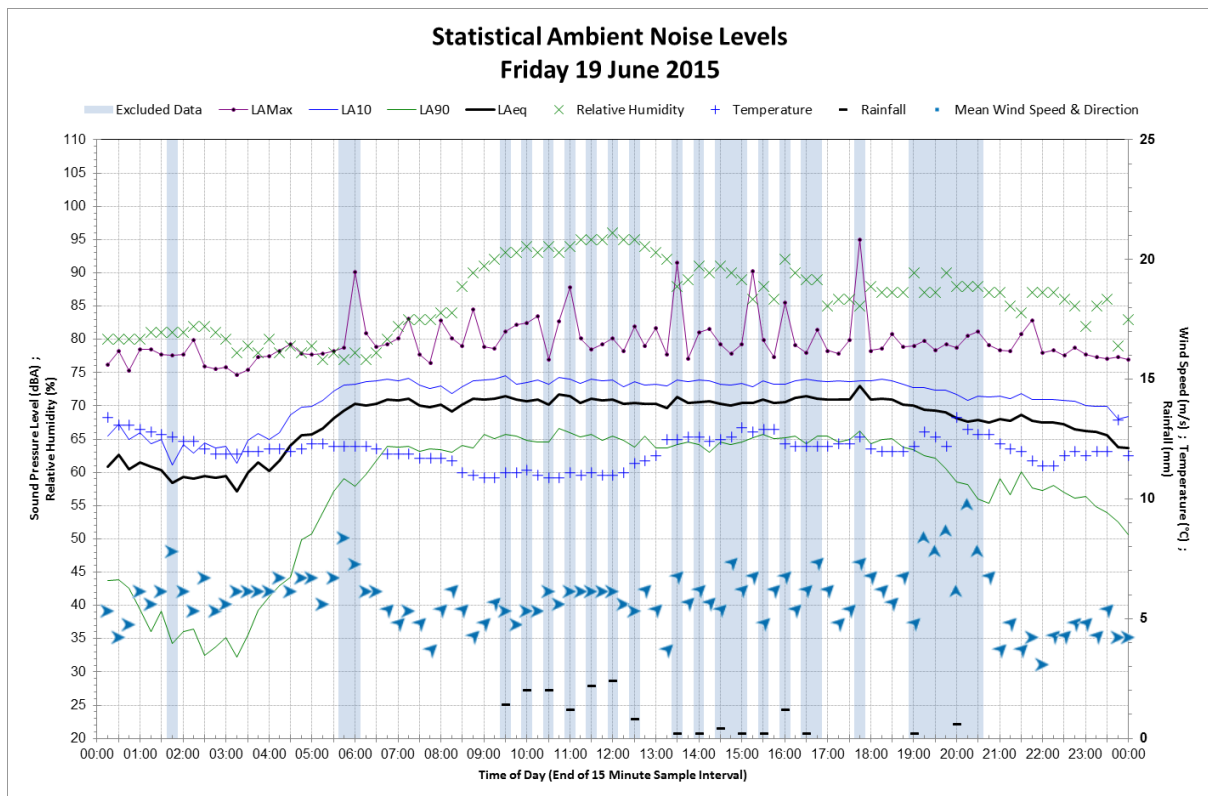
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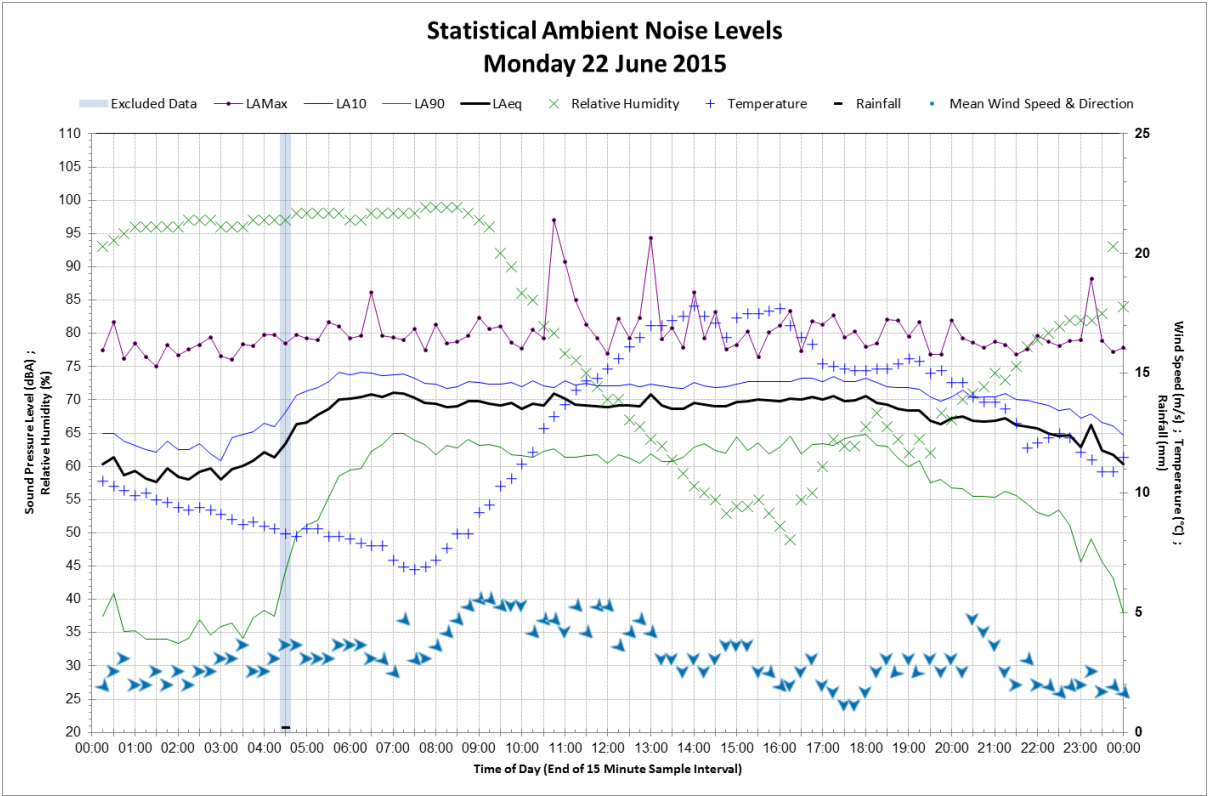
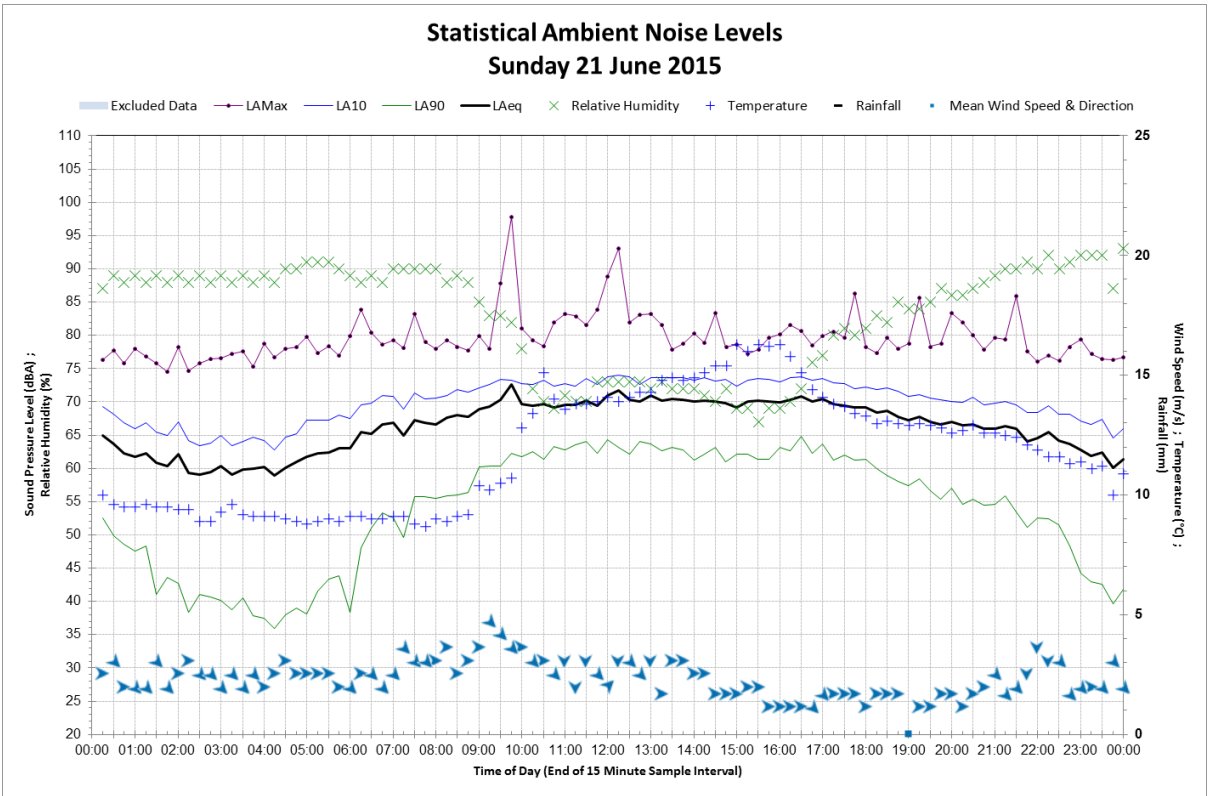
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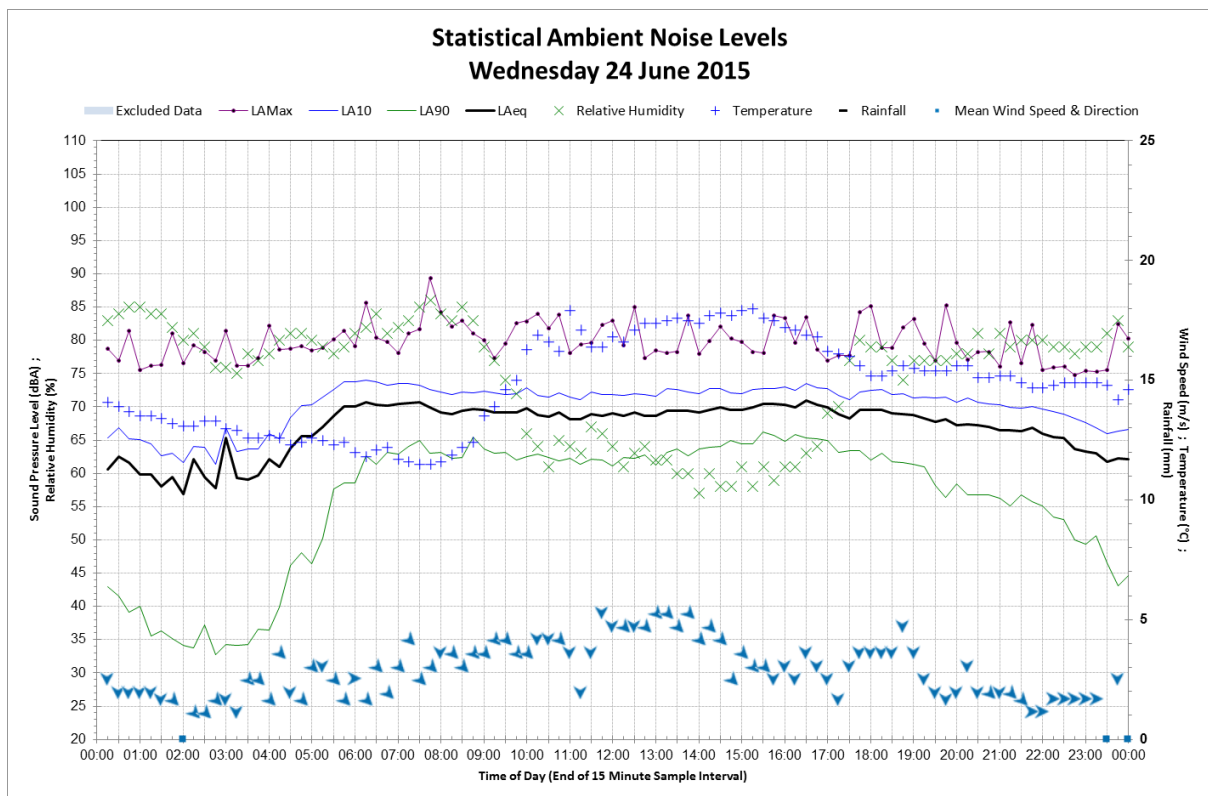
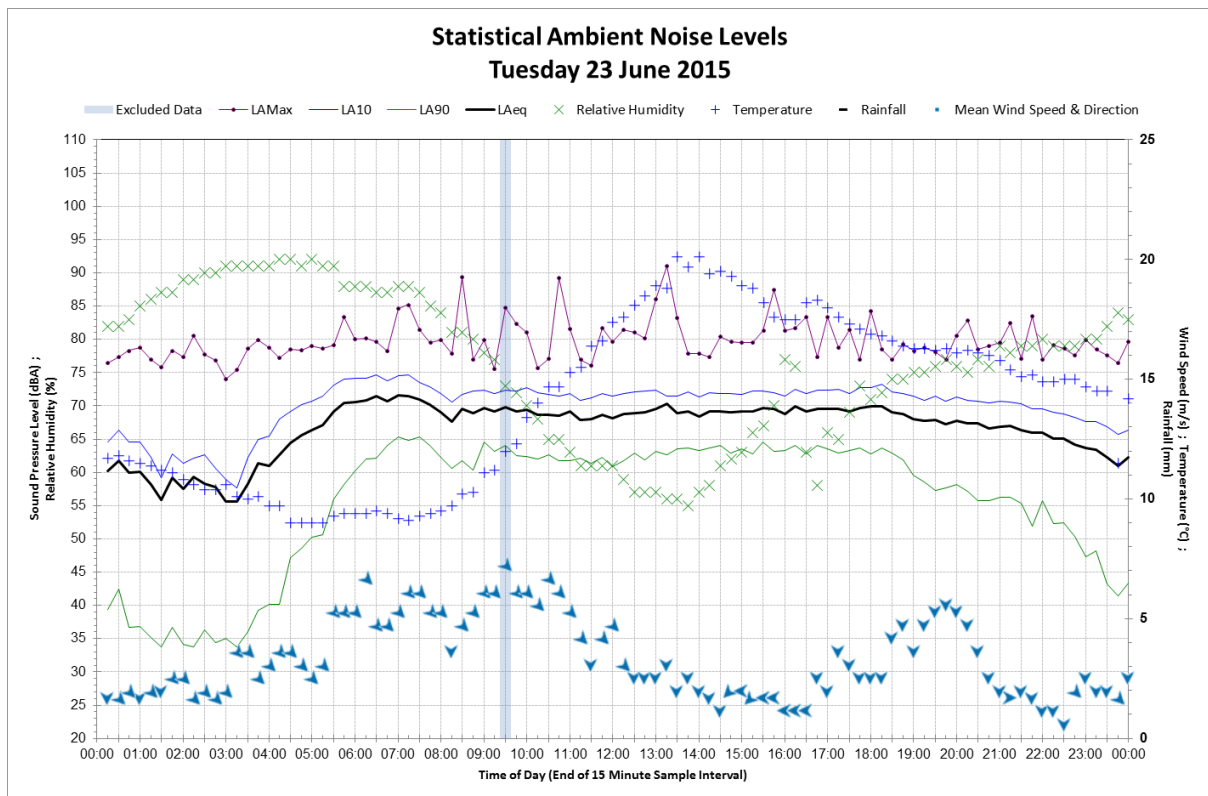
Appendices

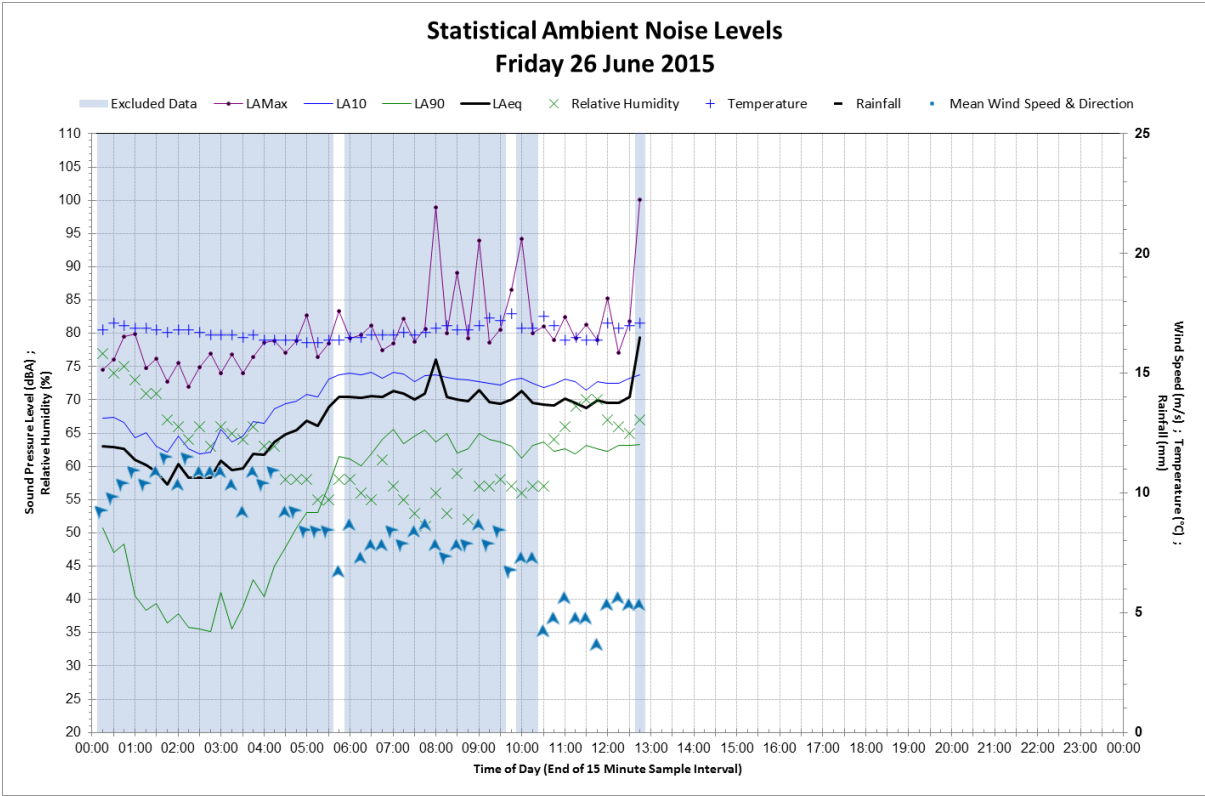
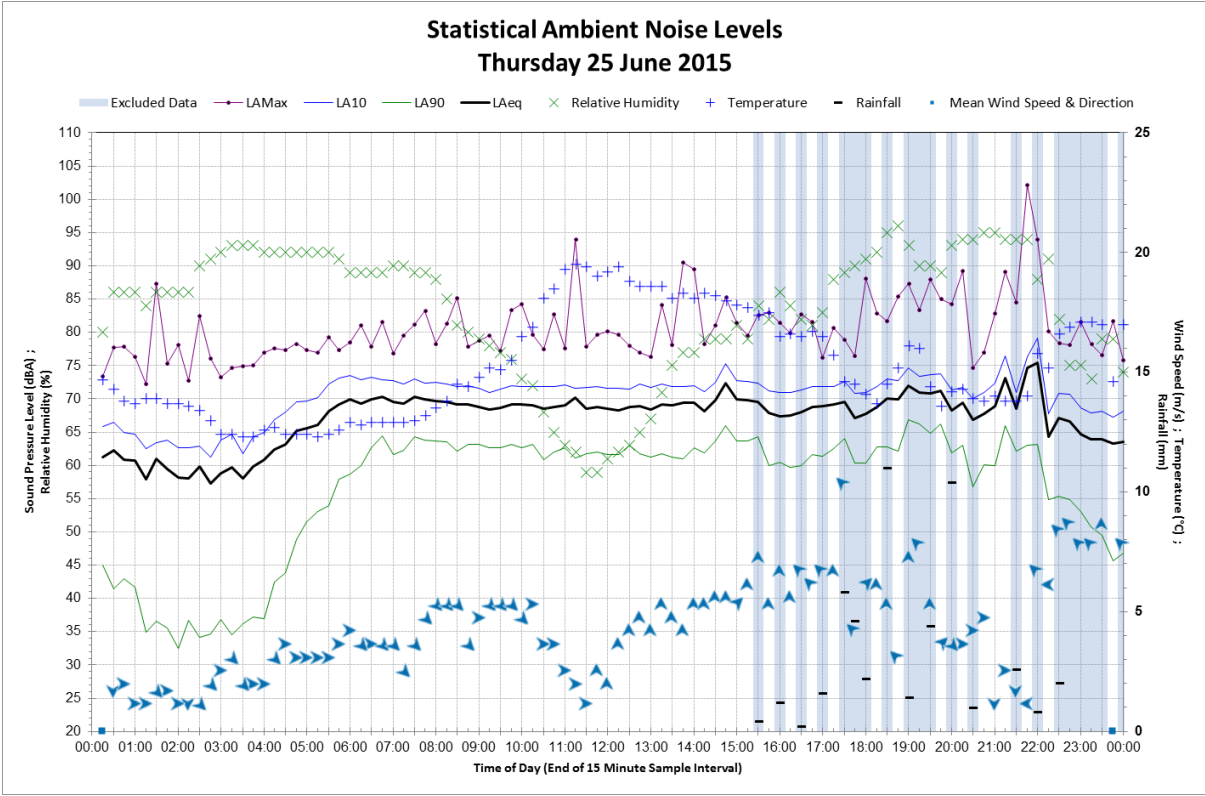
Appendix A – Noise logging charts

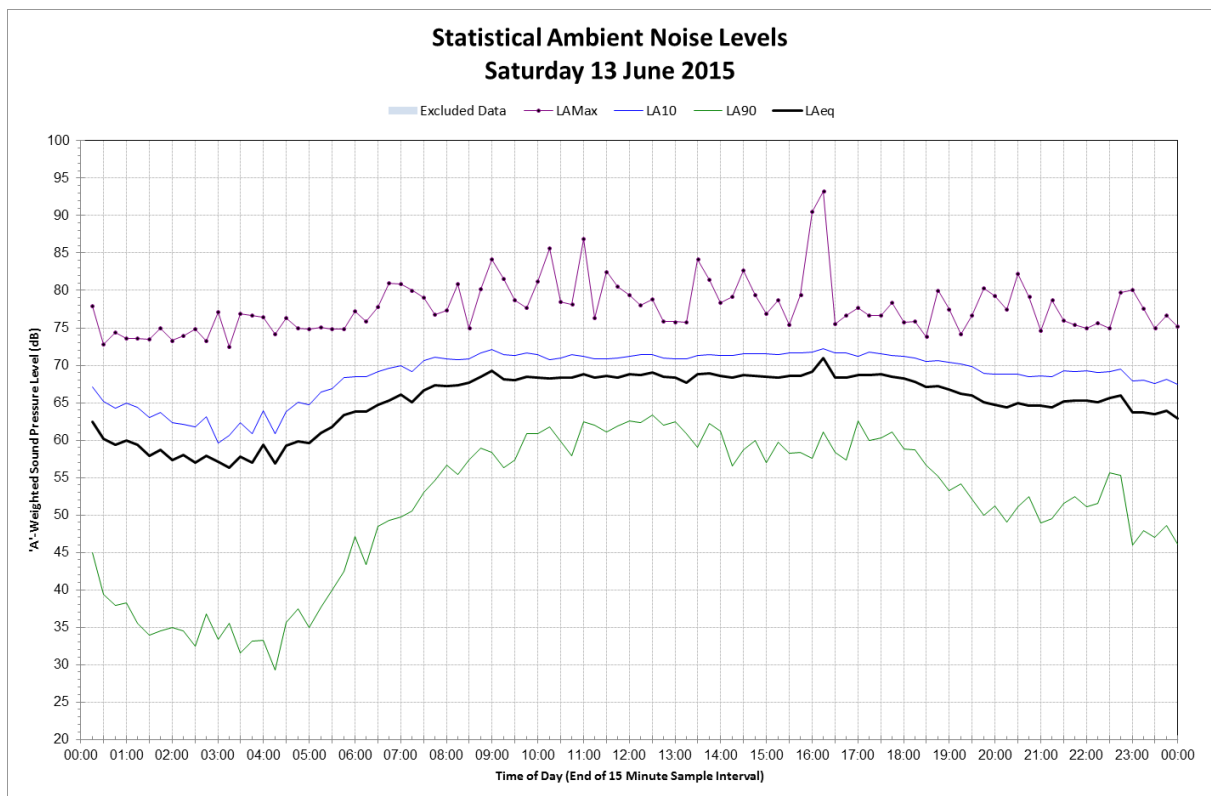
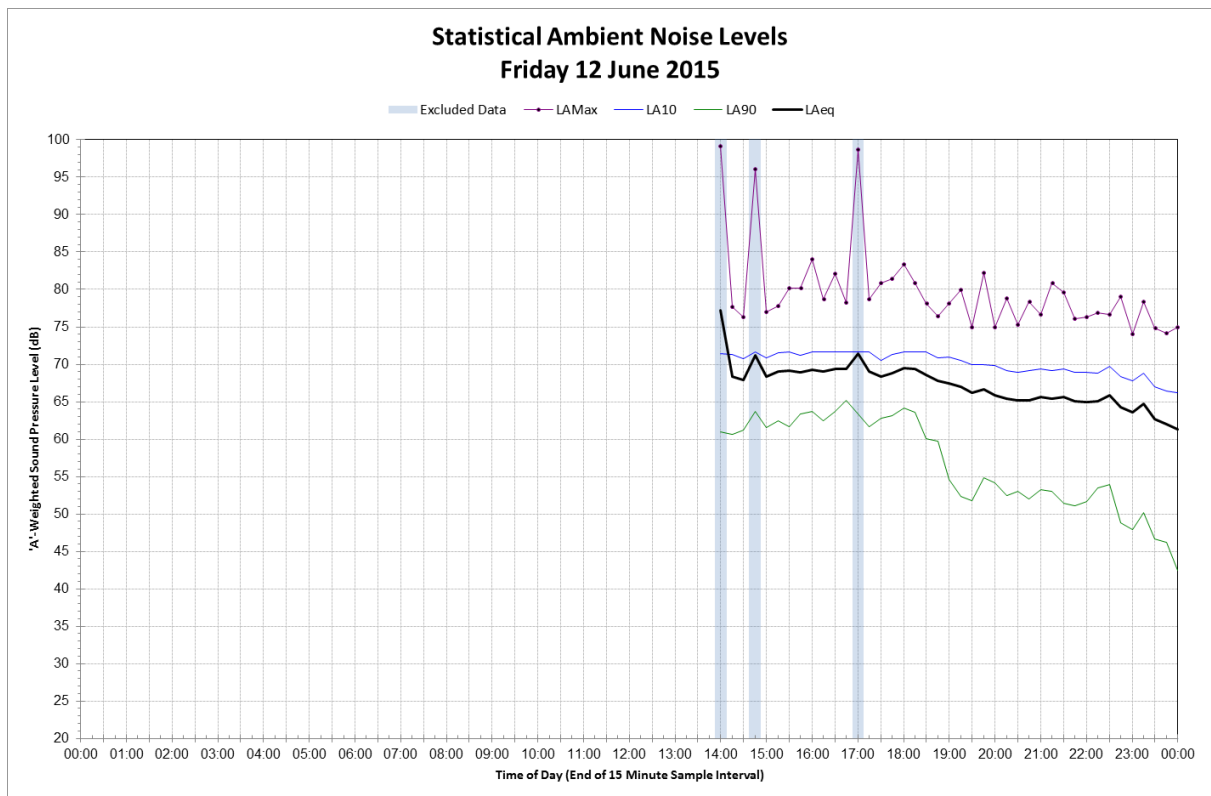


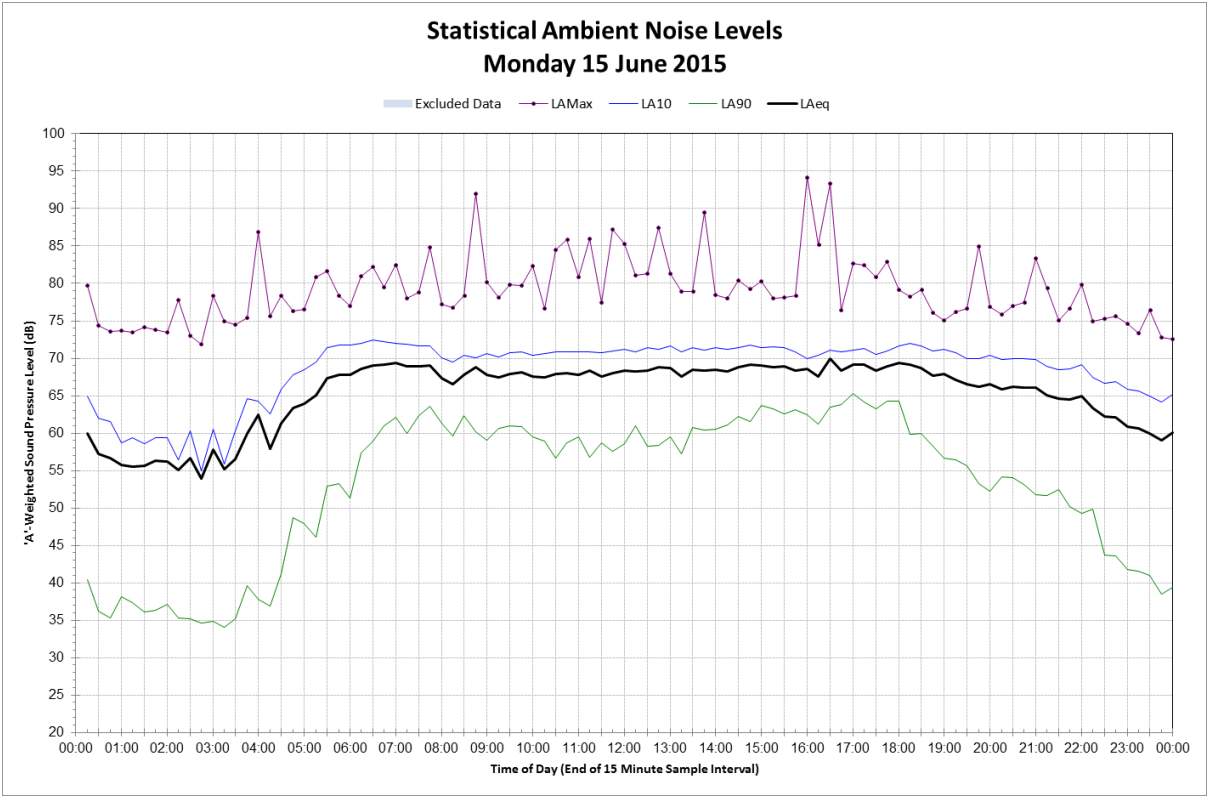
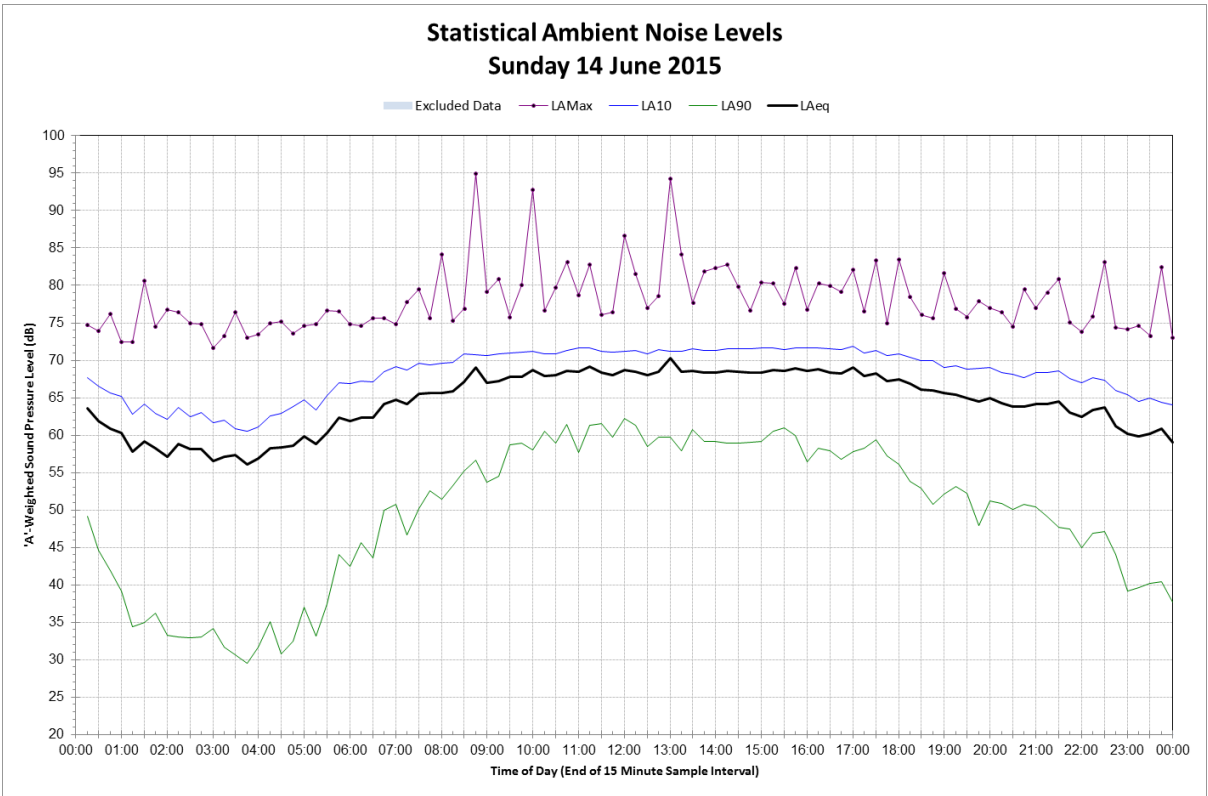


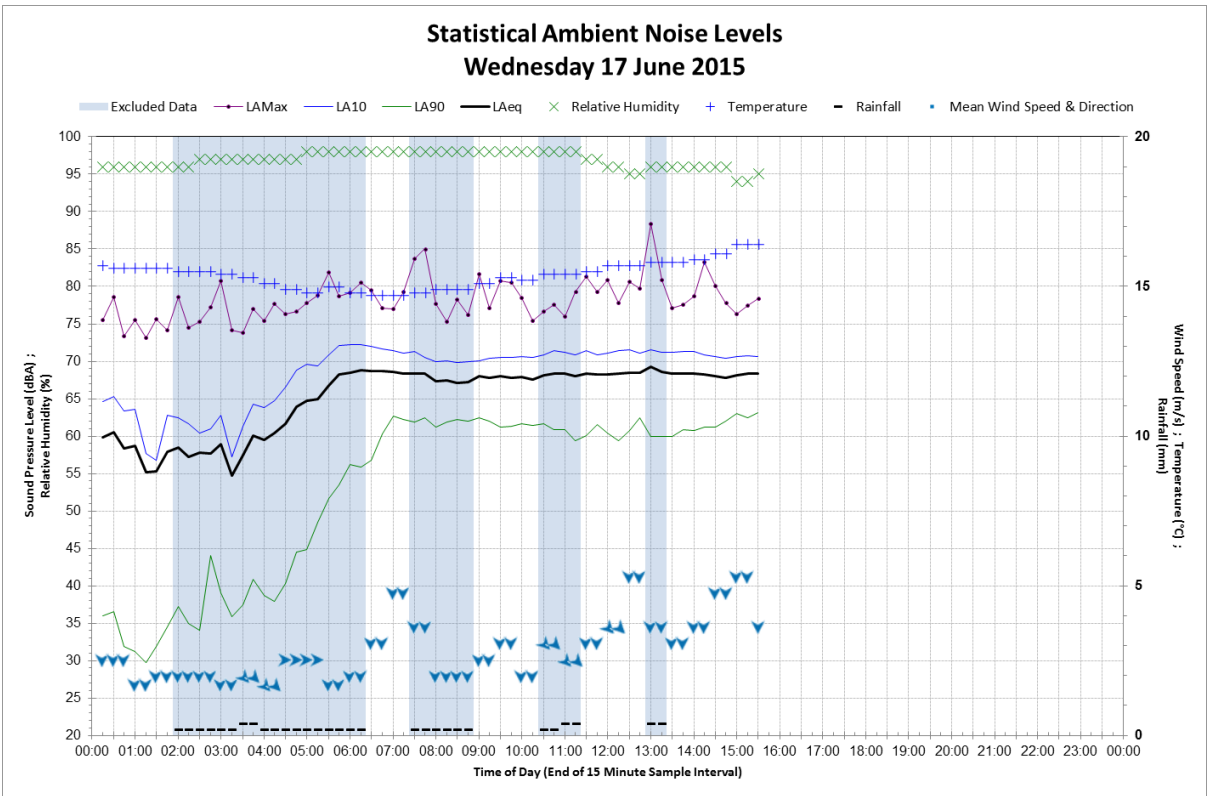
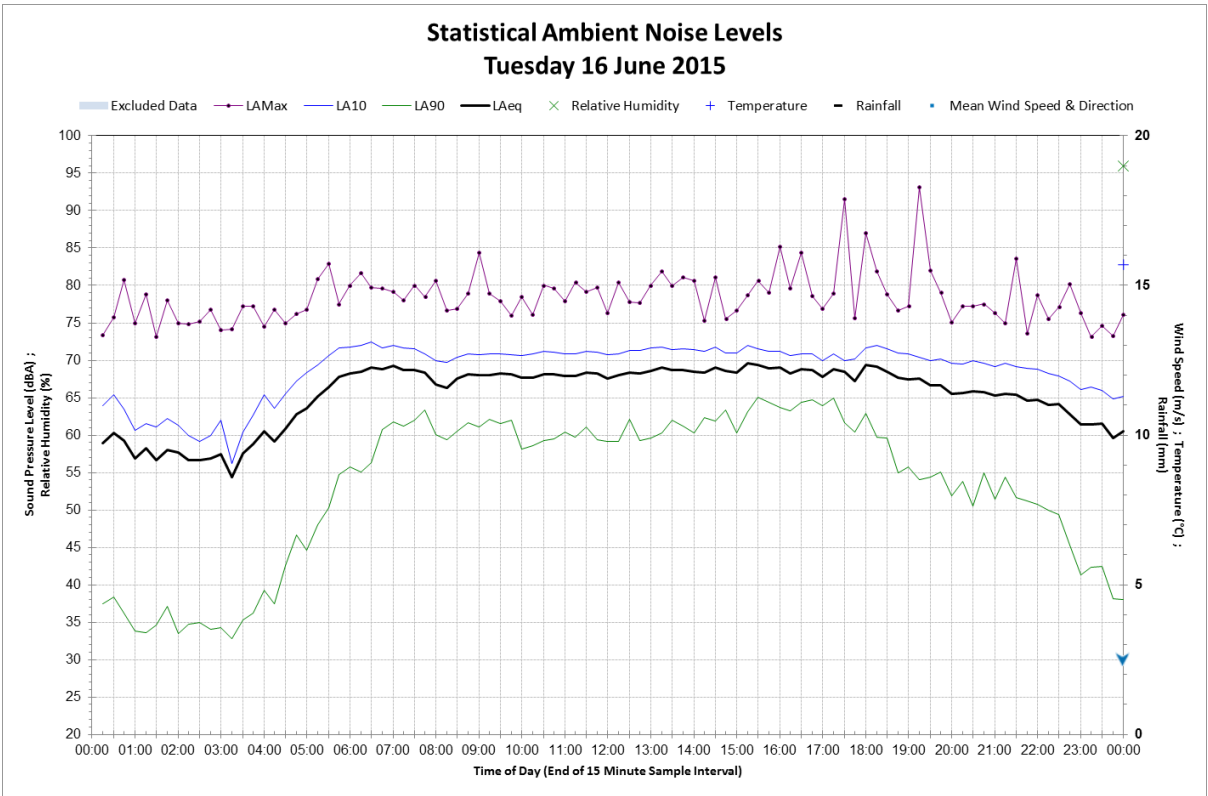


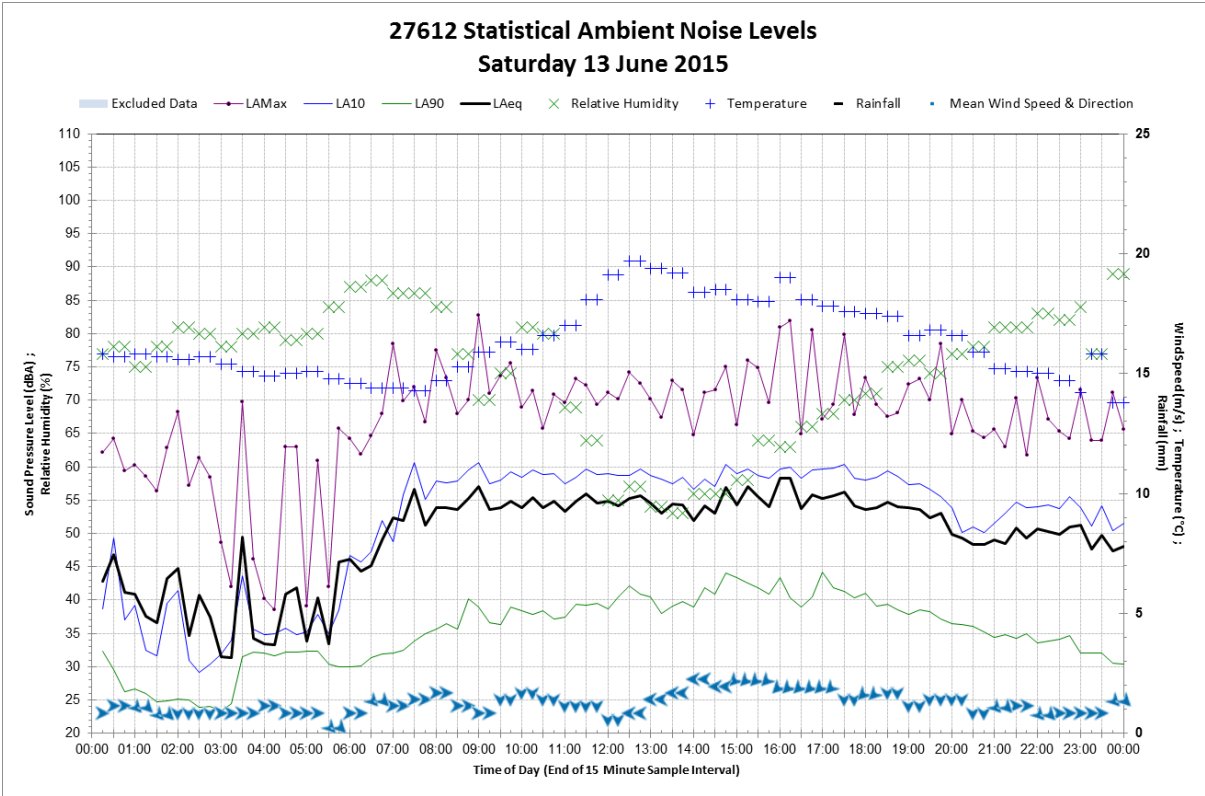
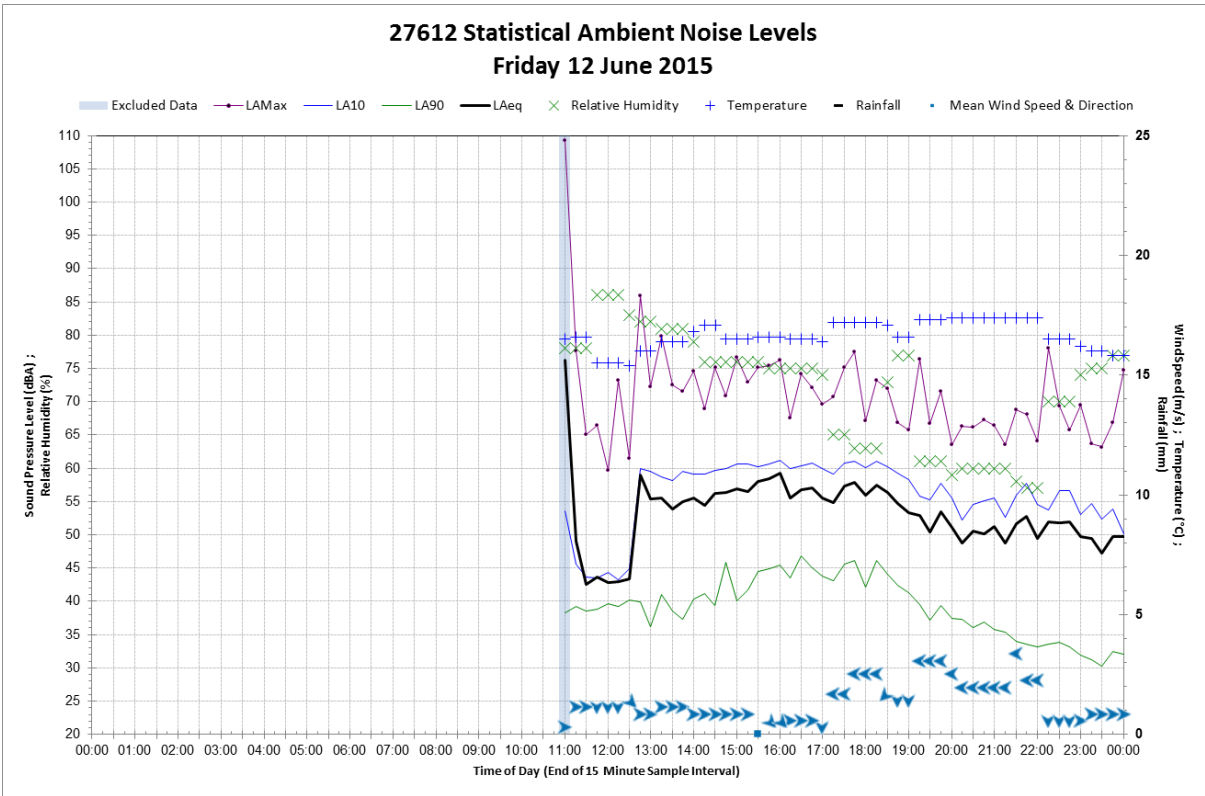


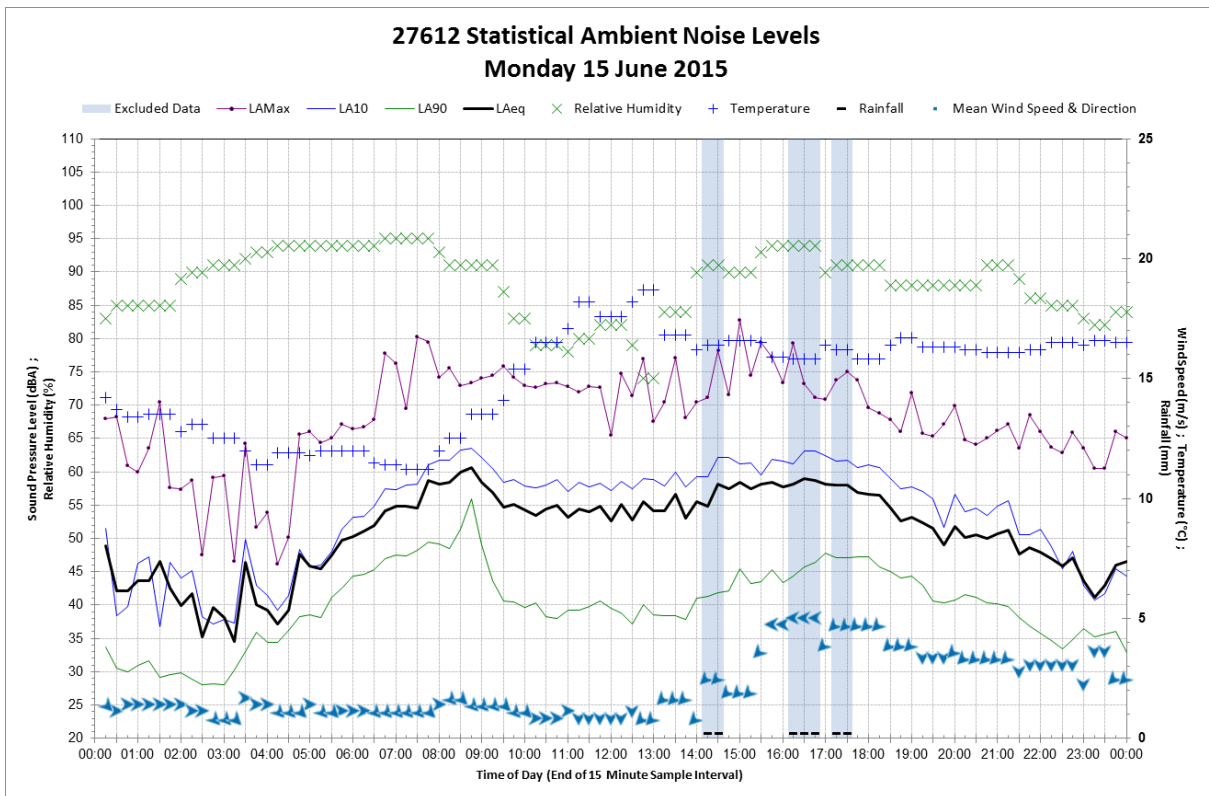
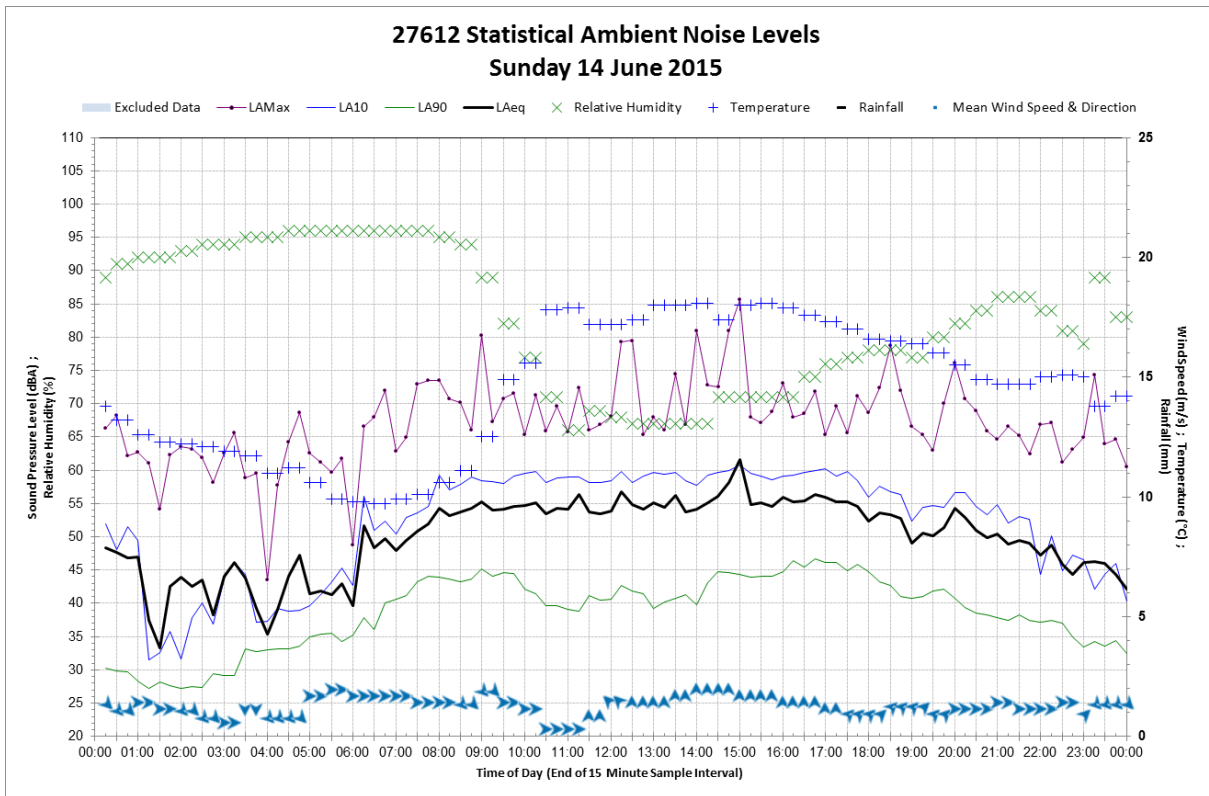




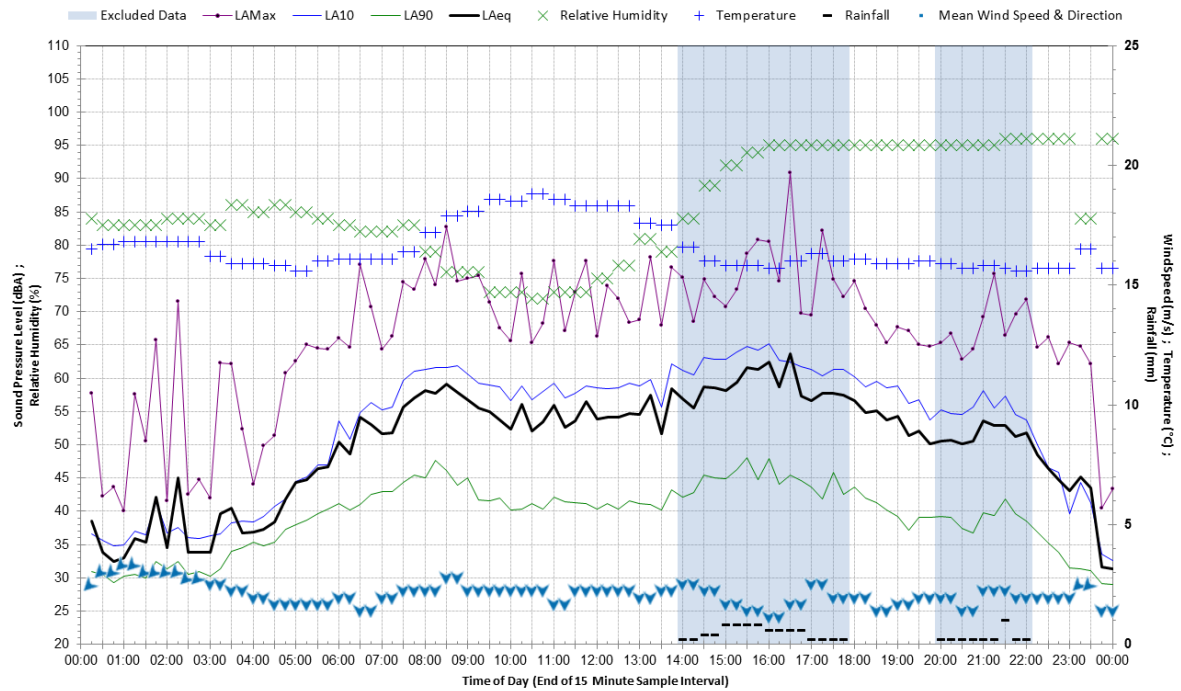




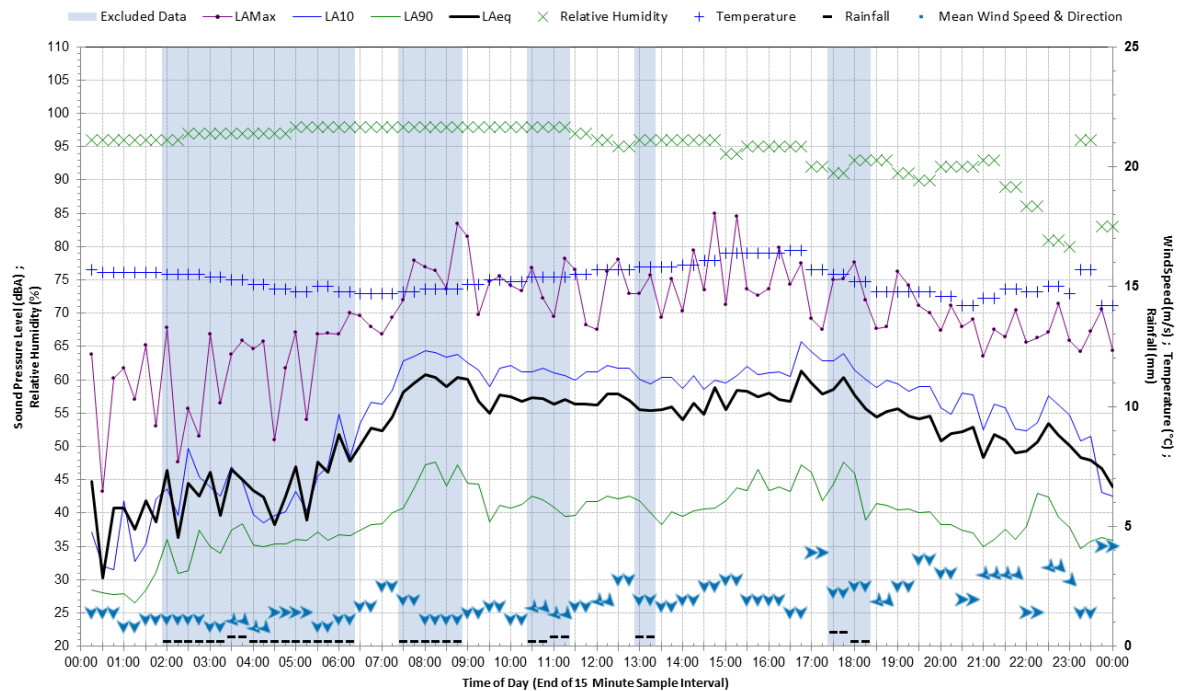


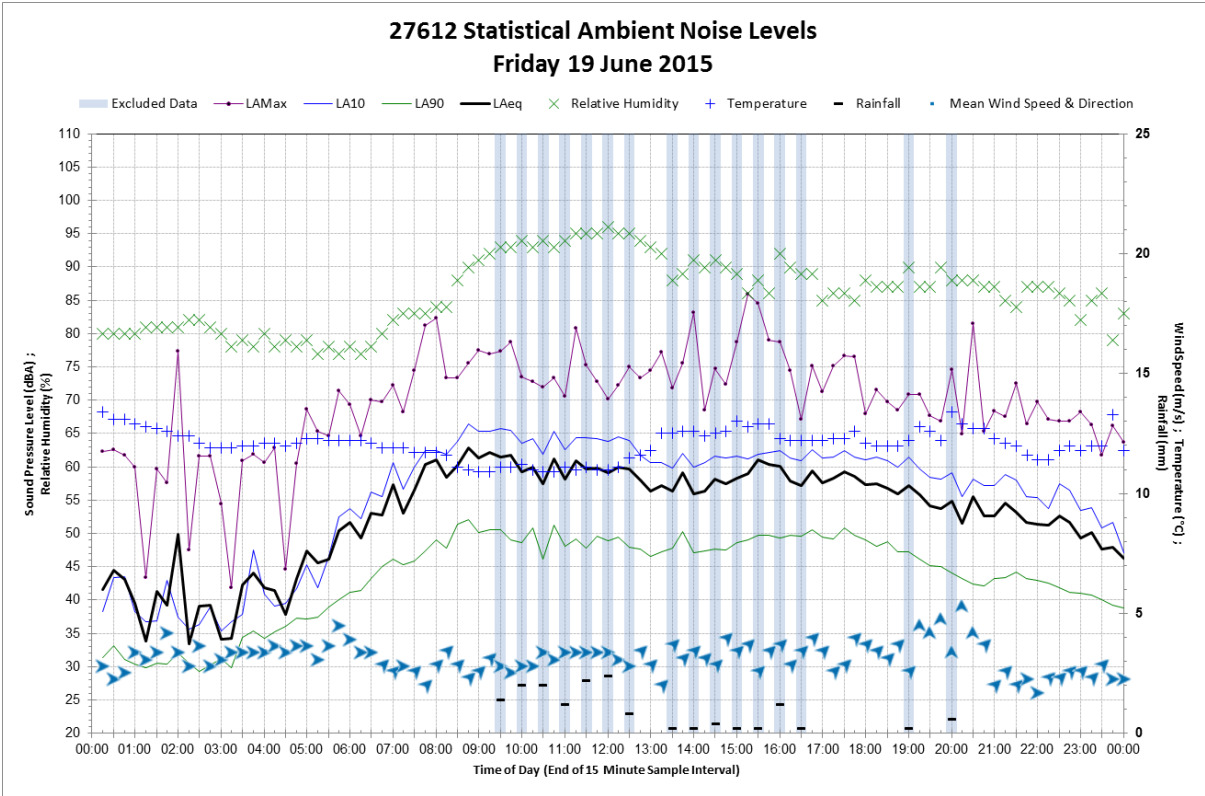
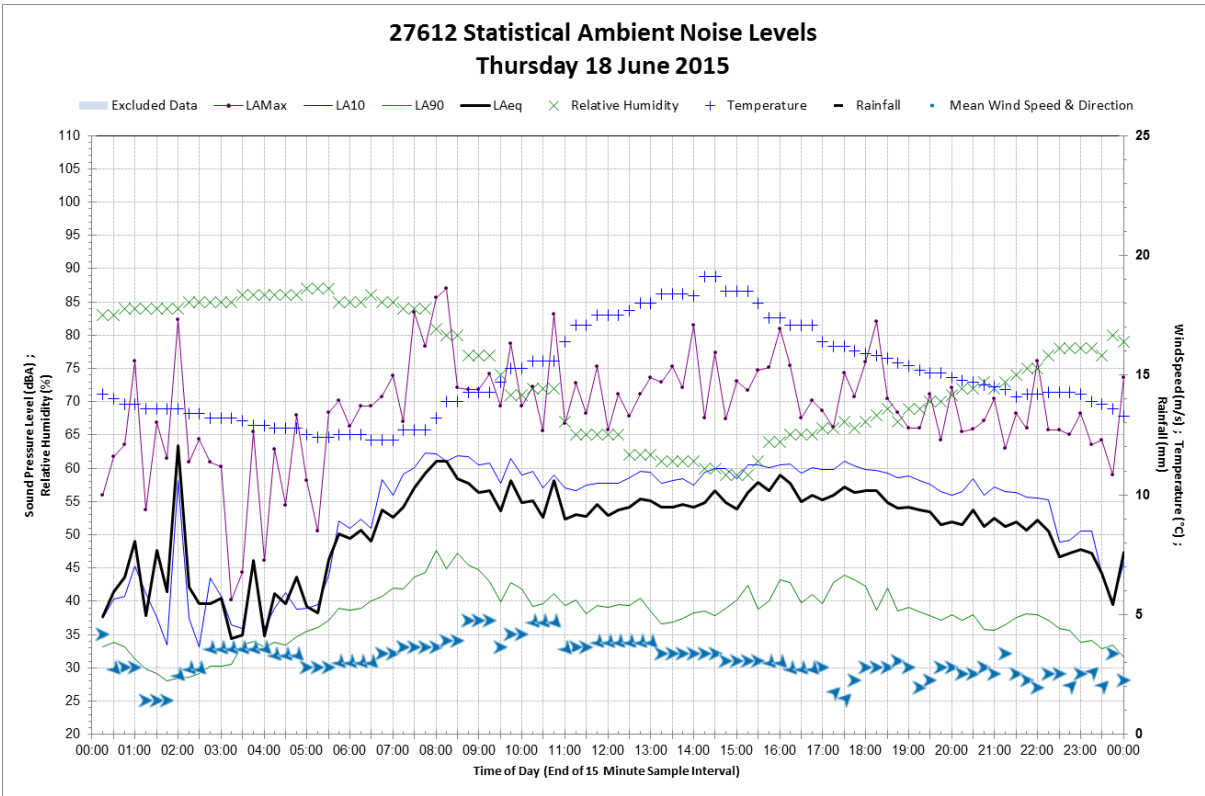


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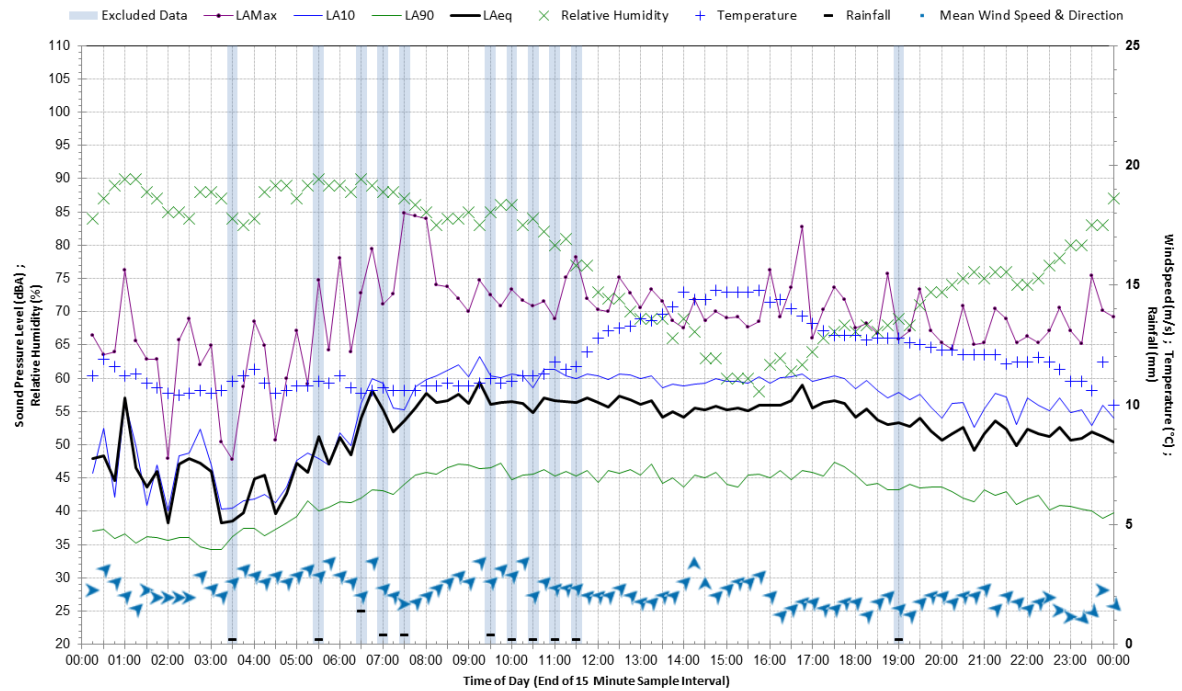


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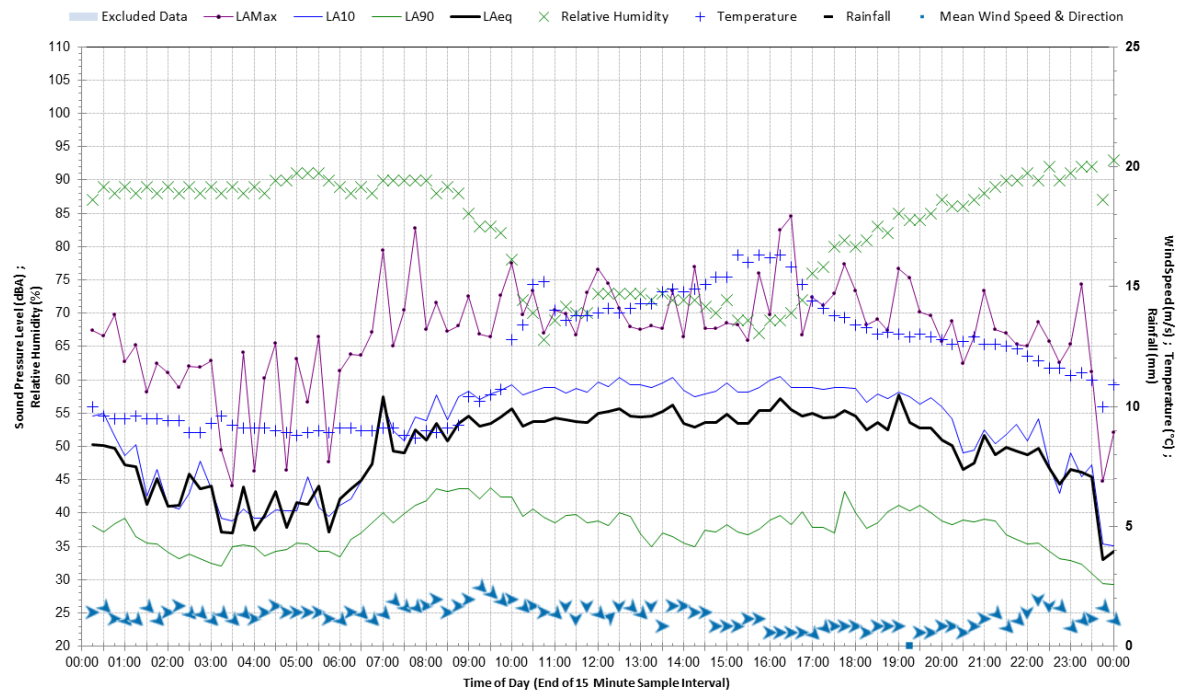


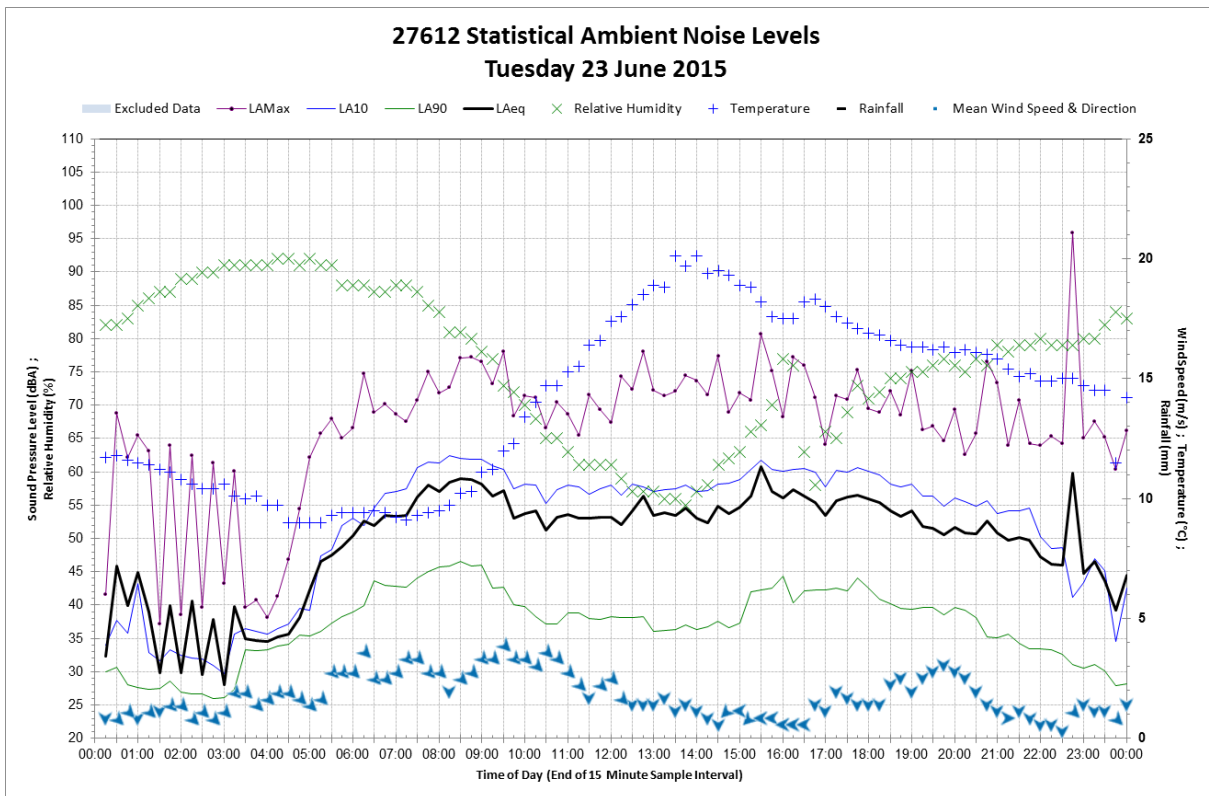
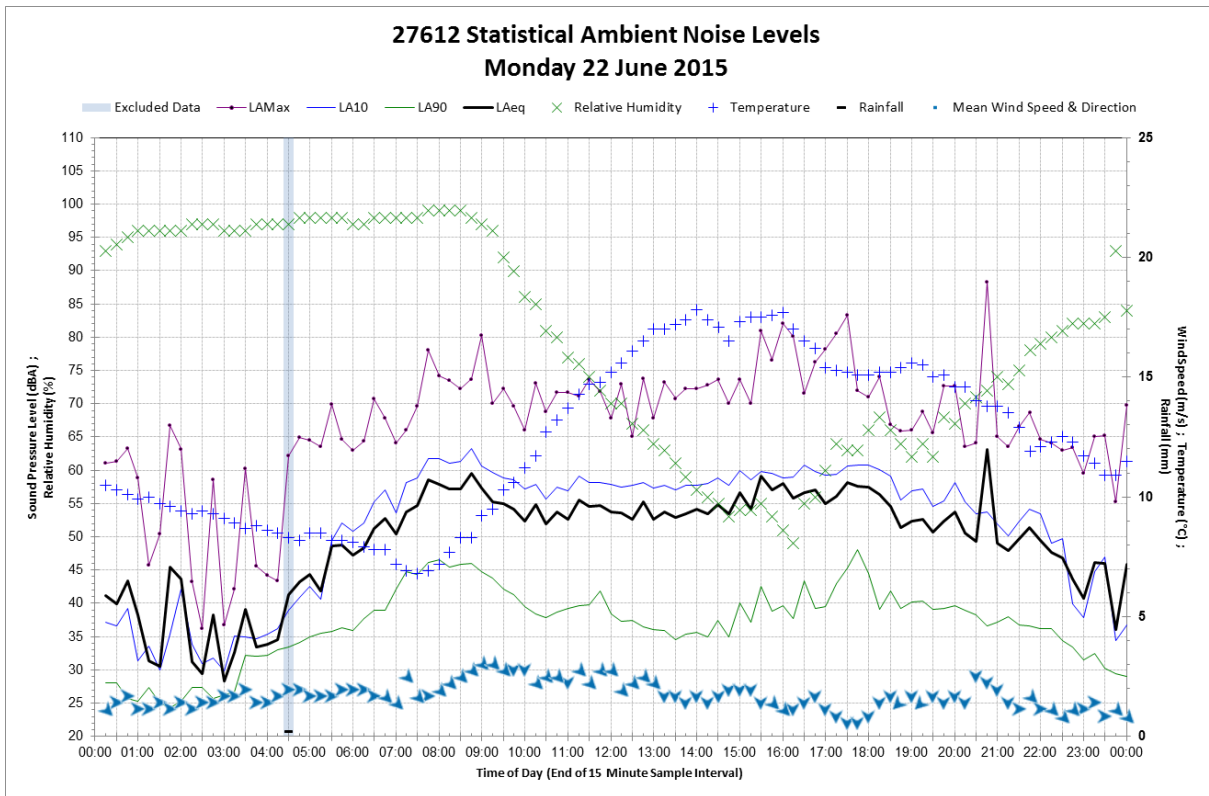


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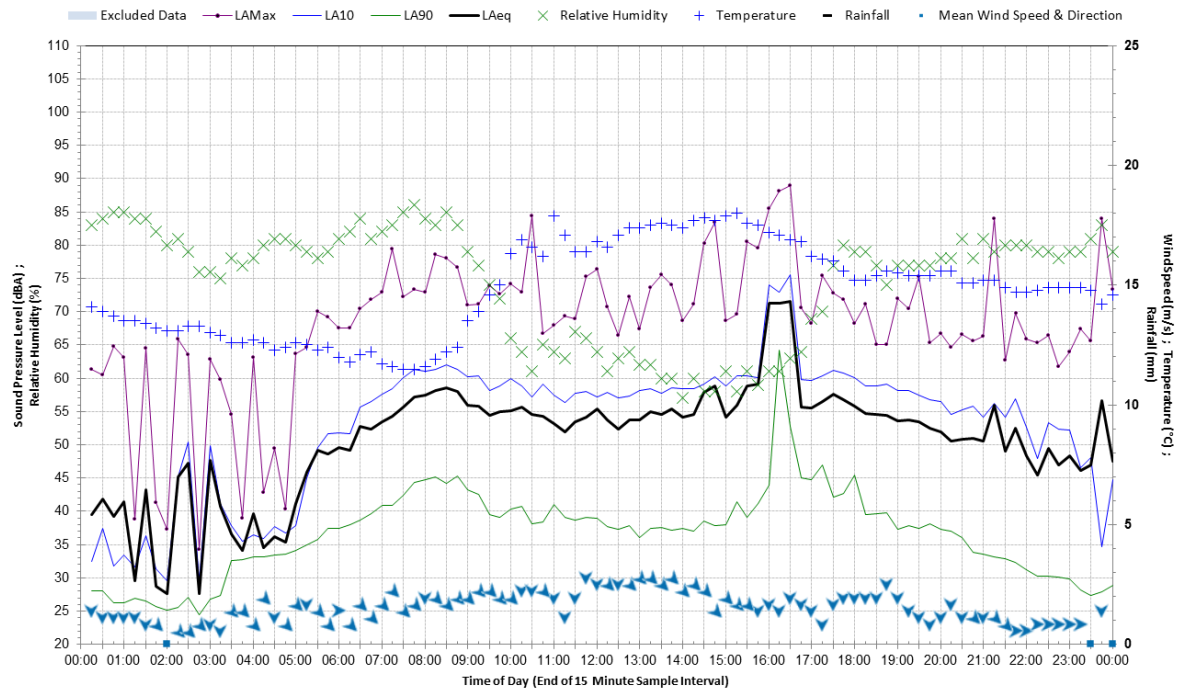


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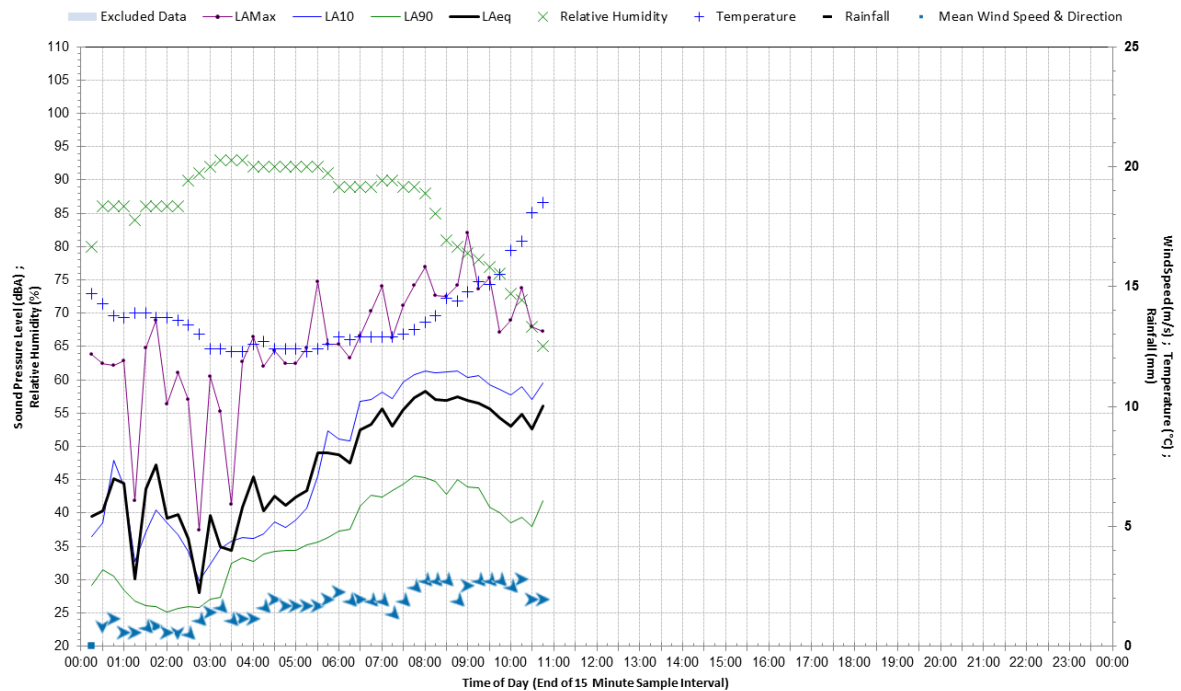


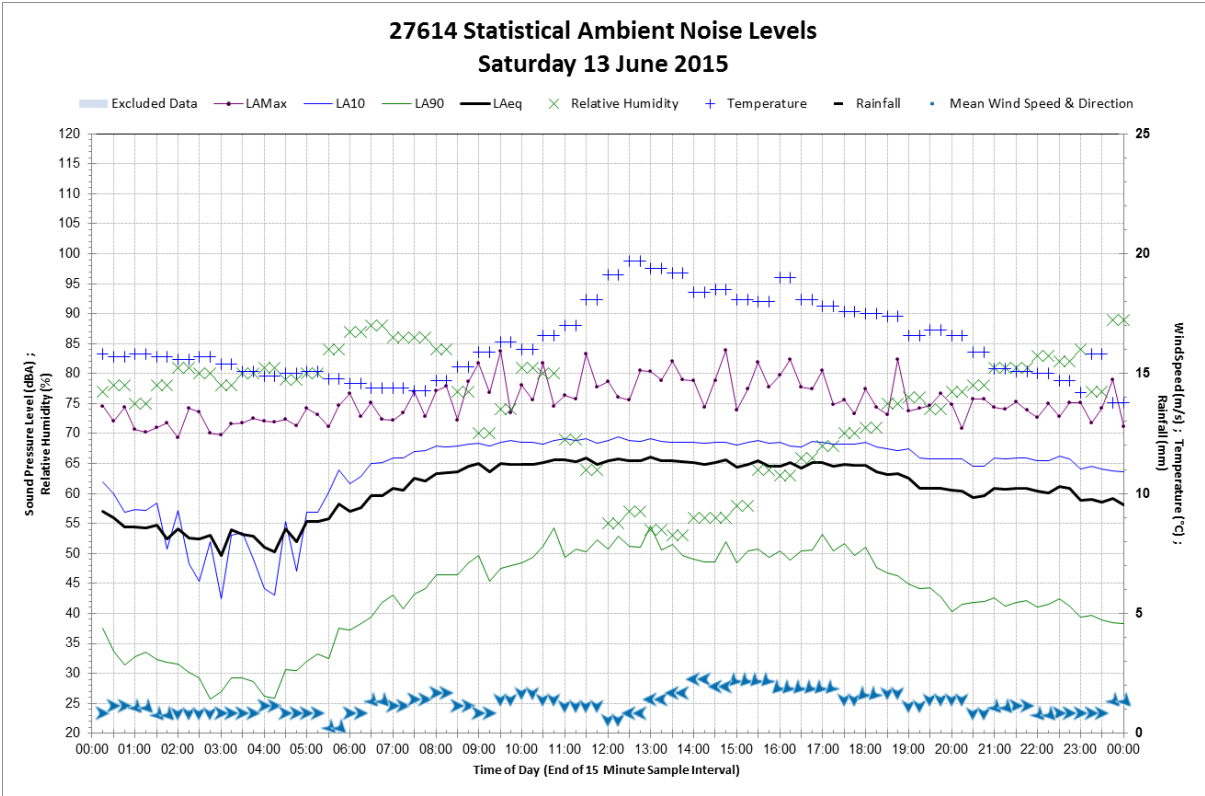
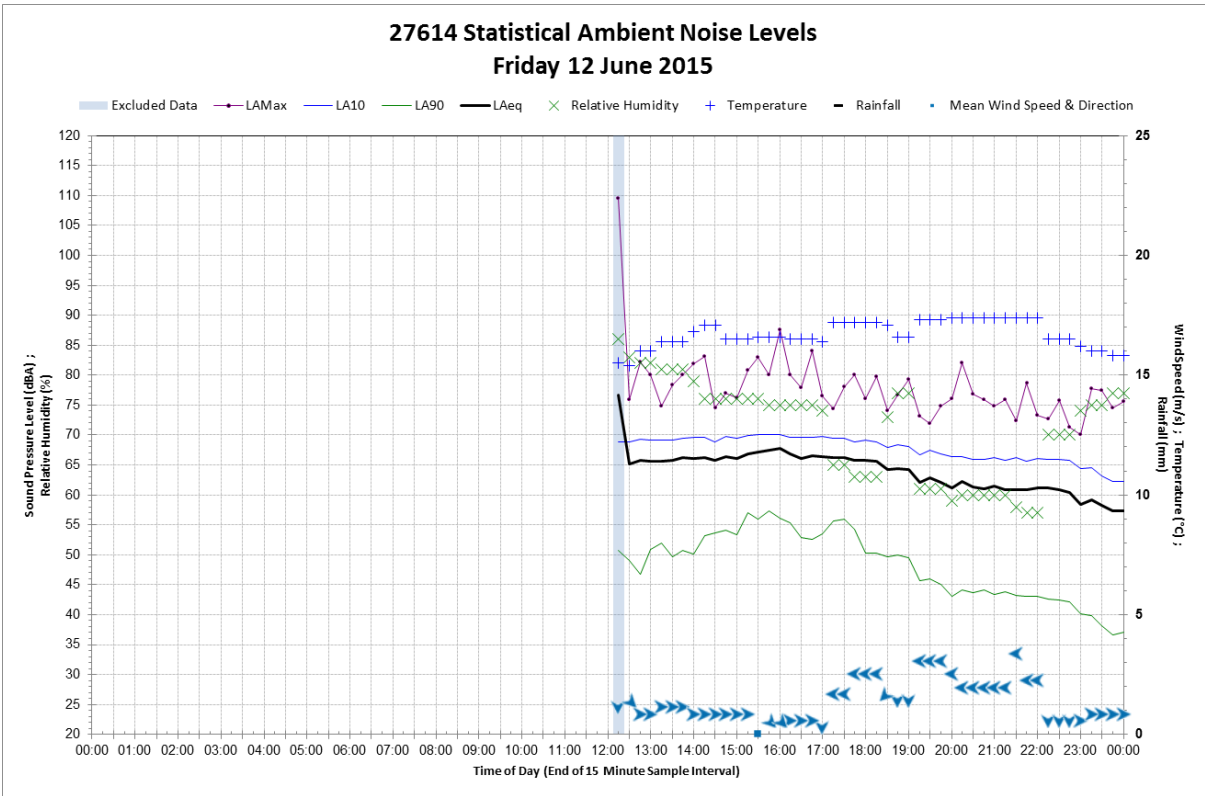


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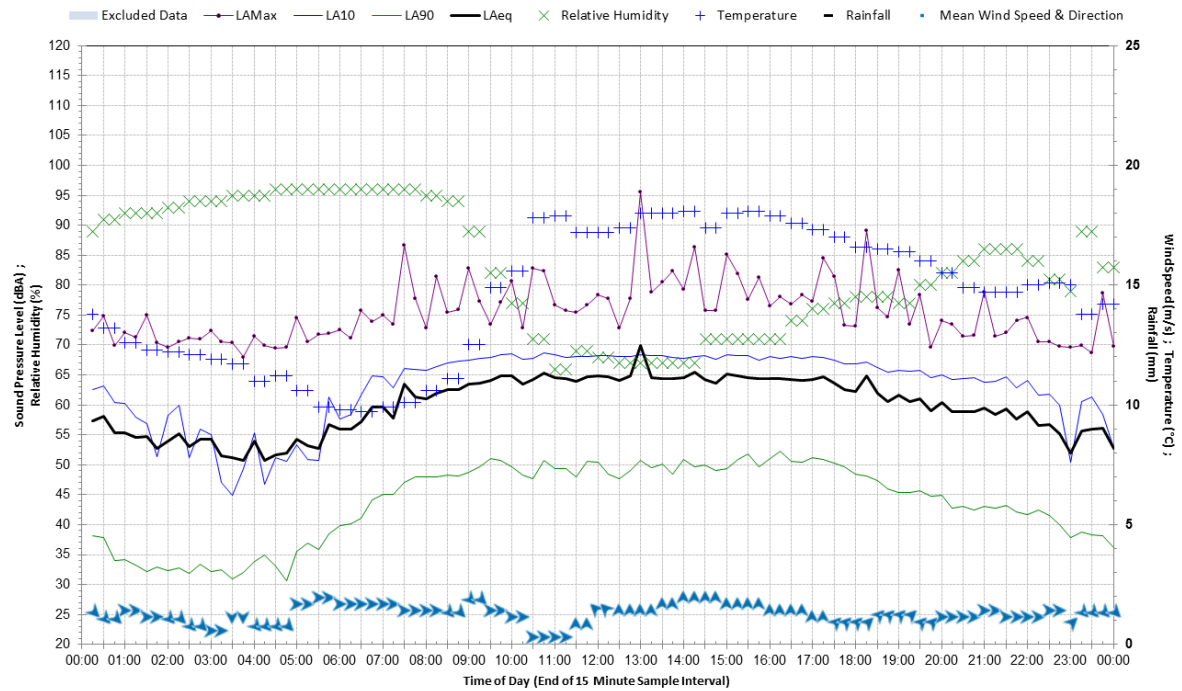


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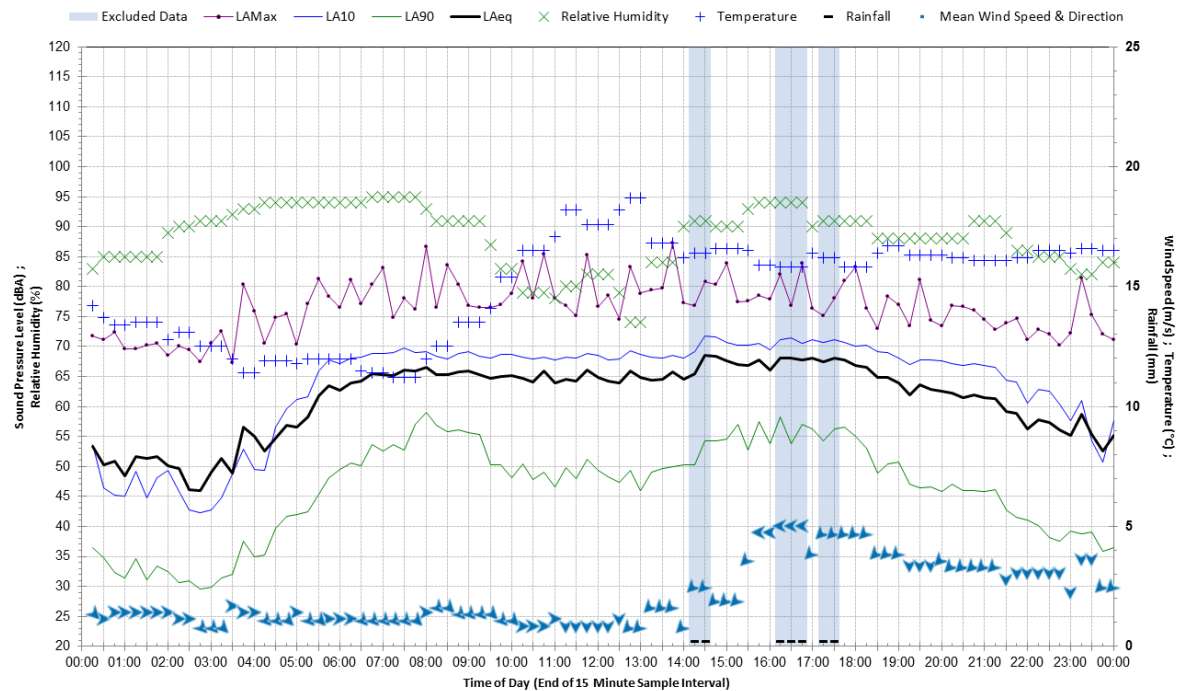




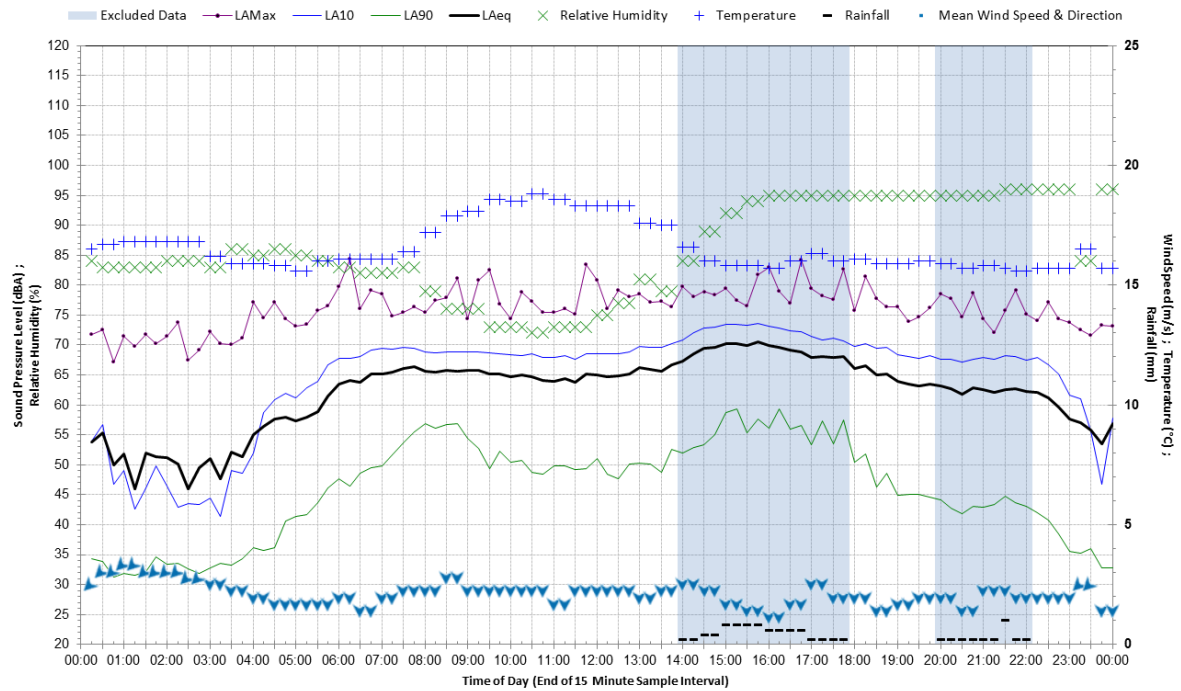
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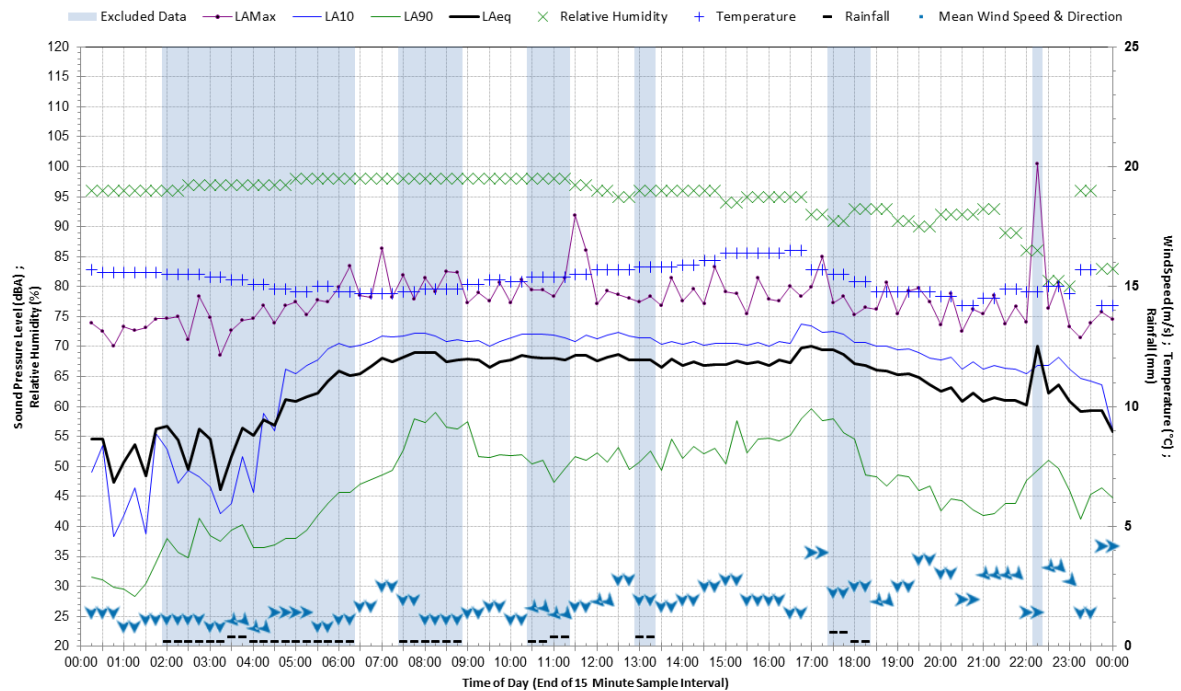
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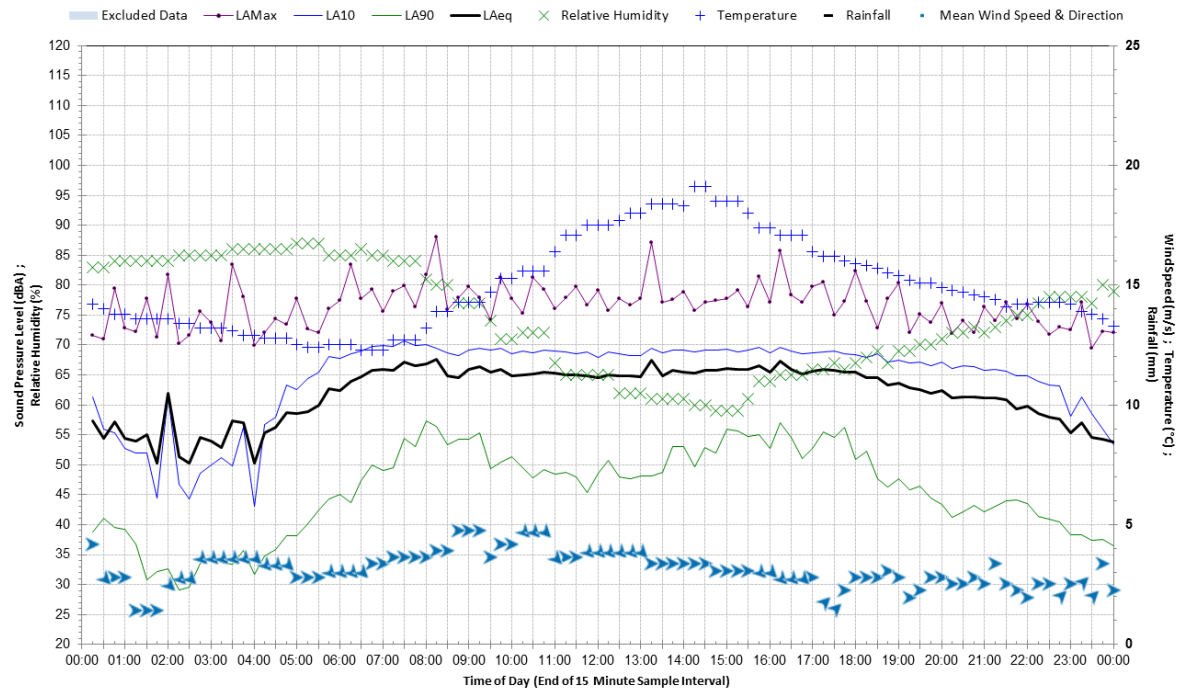
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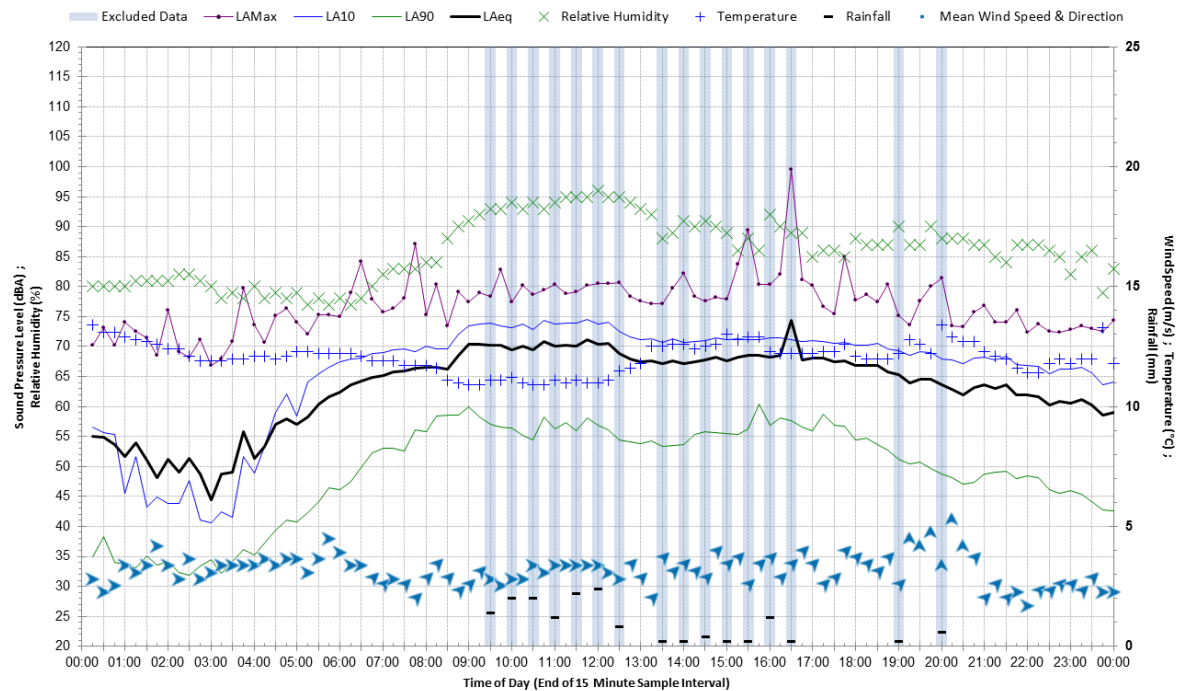
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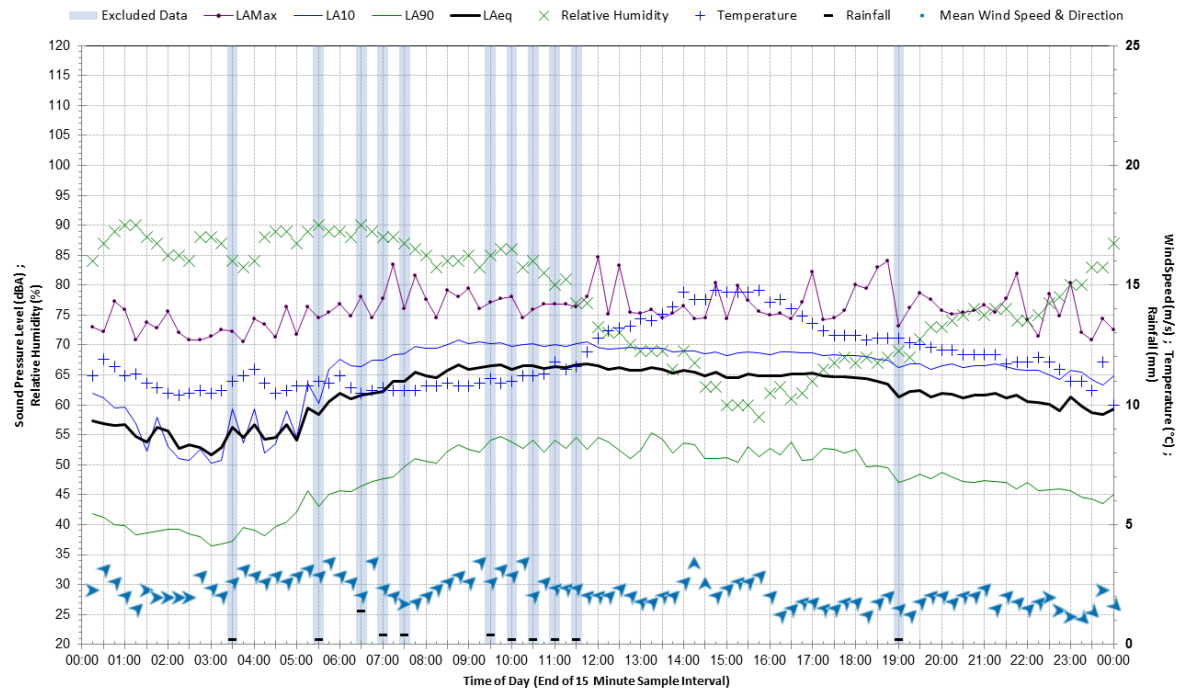
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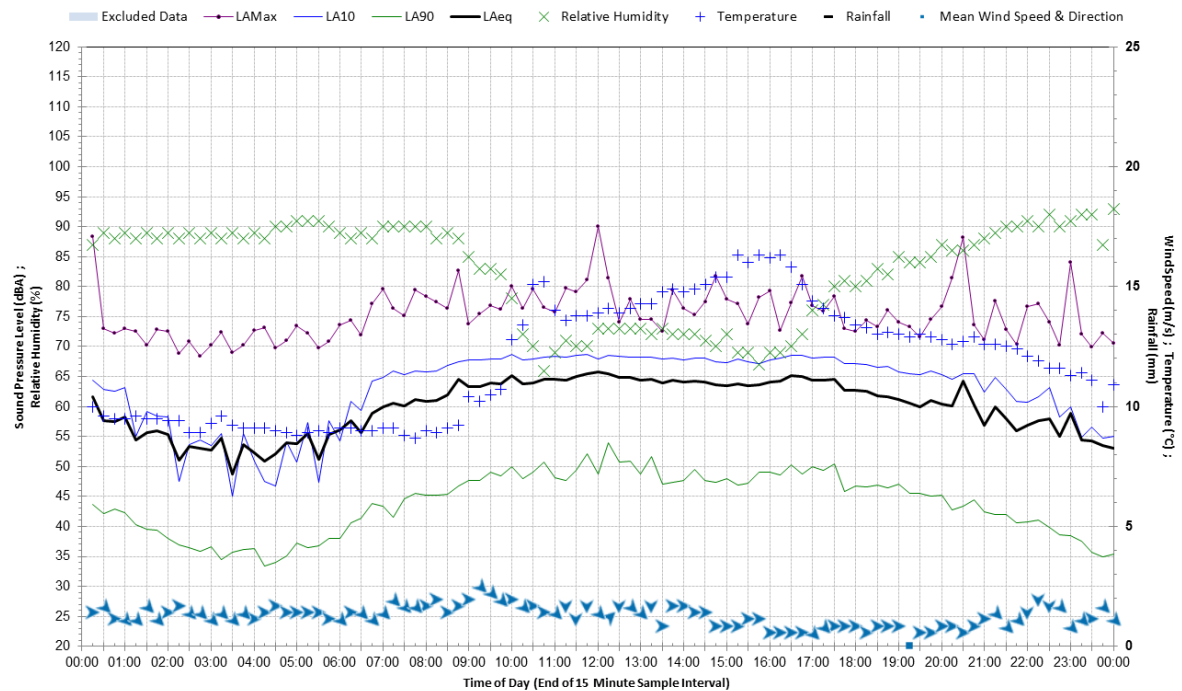
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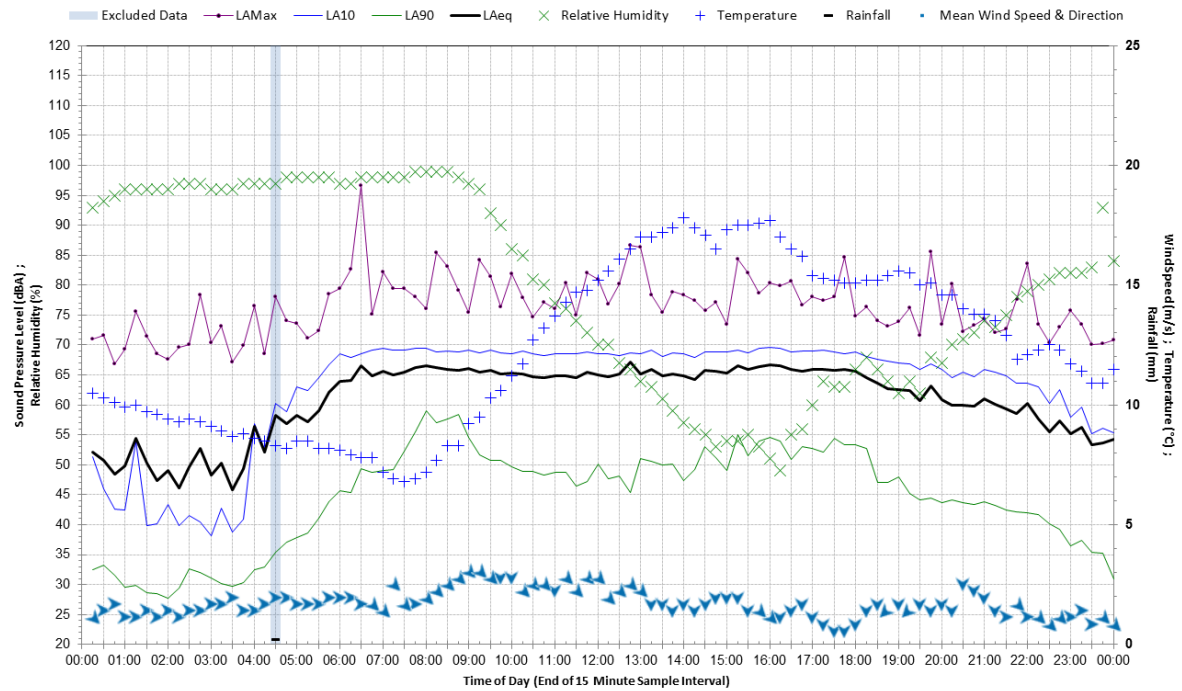
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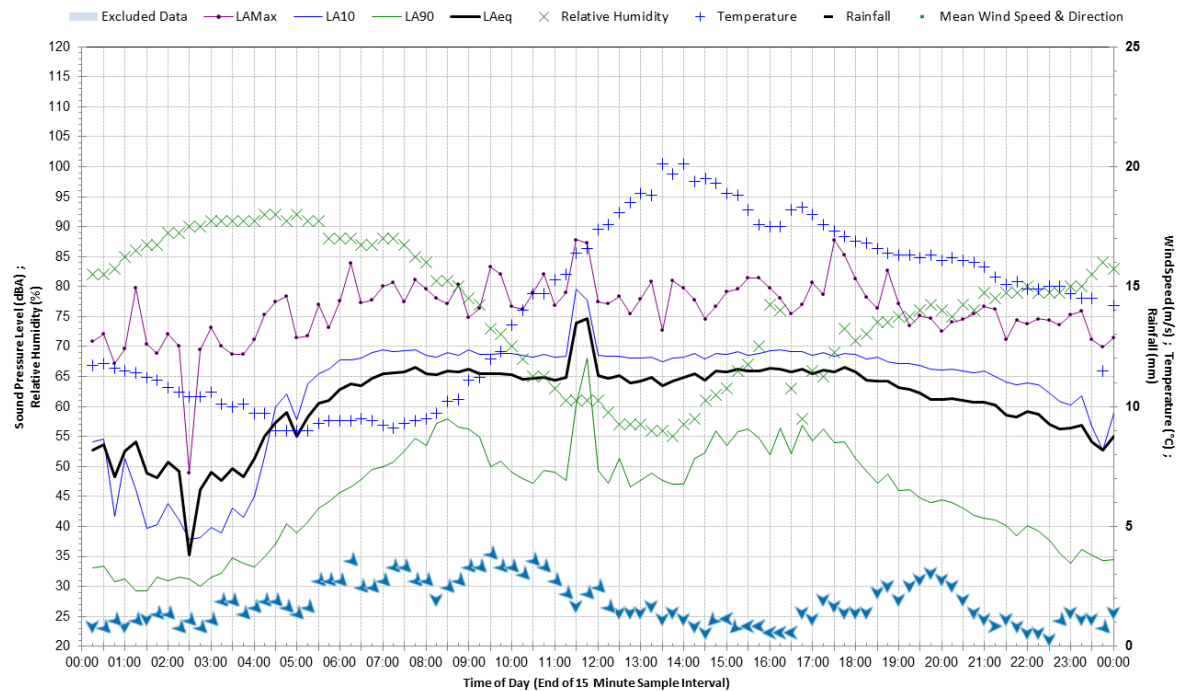
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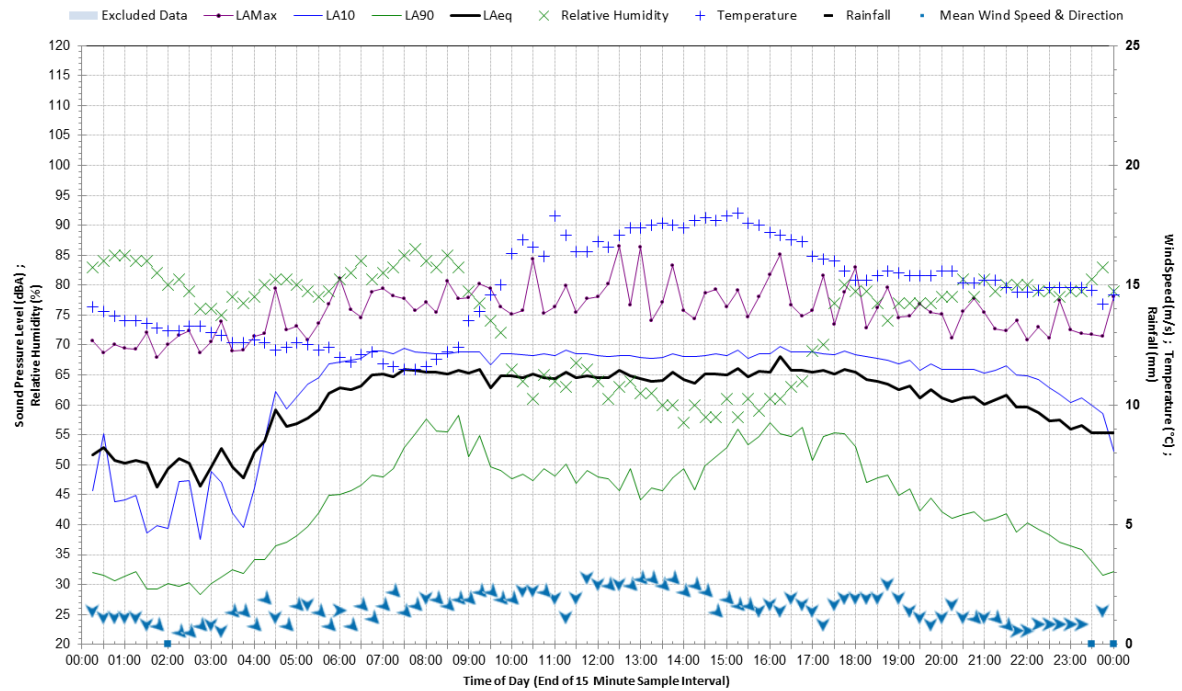
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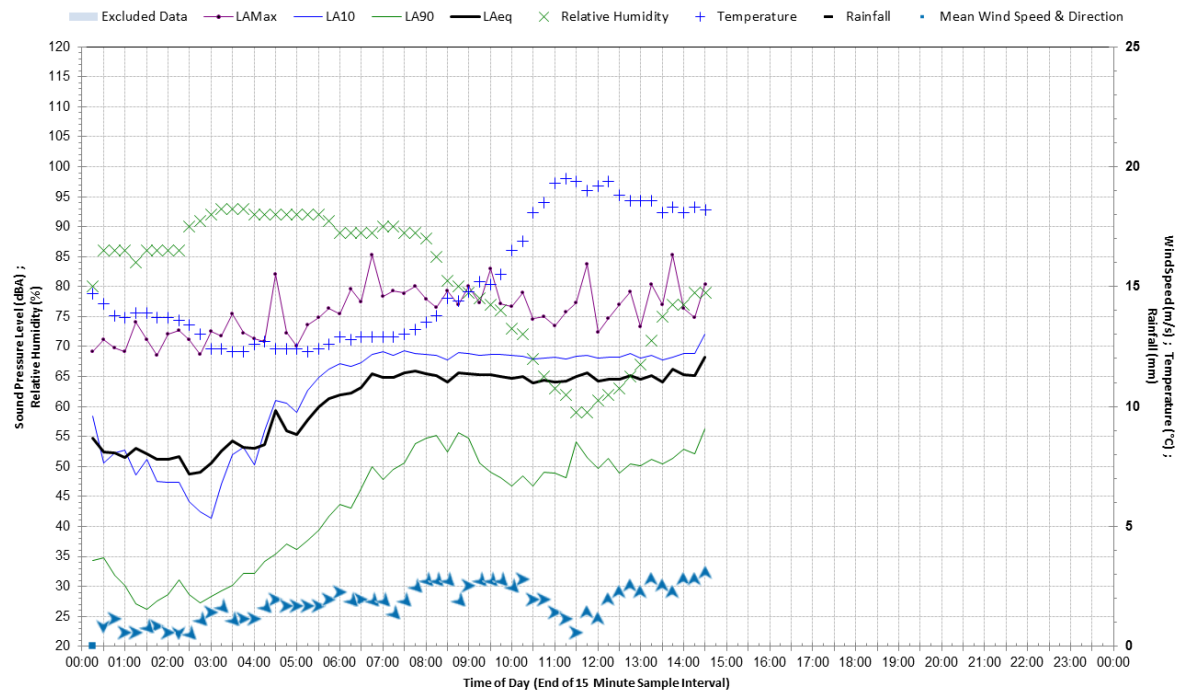
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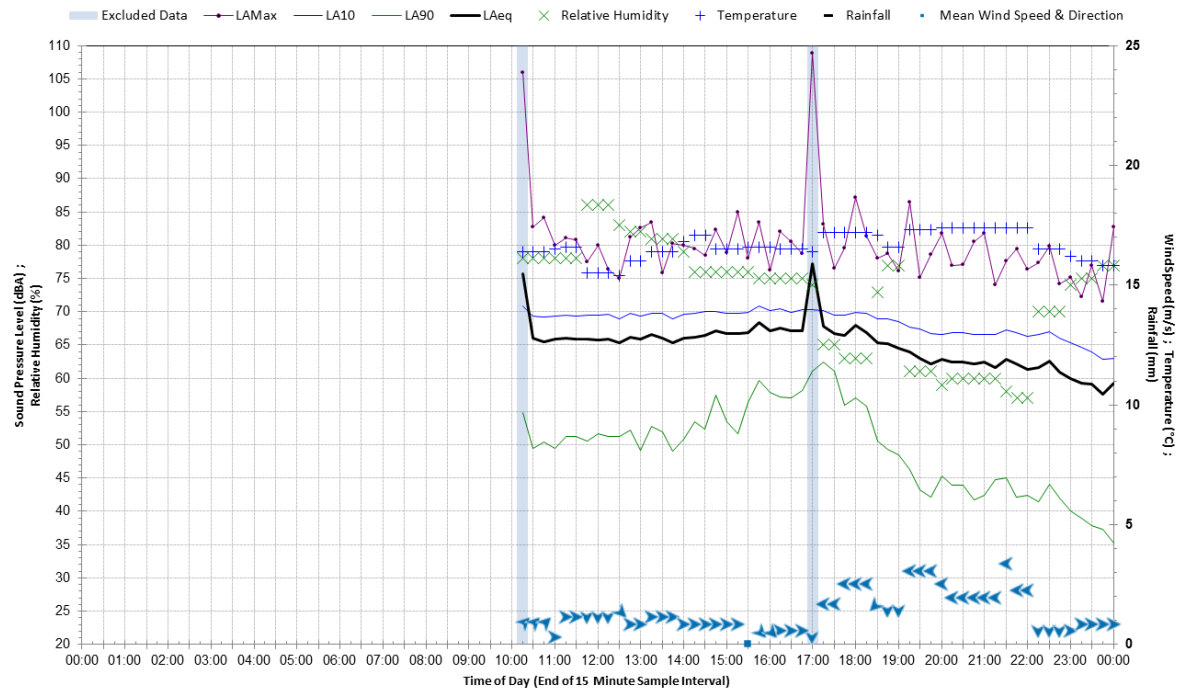
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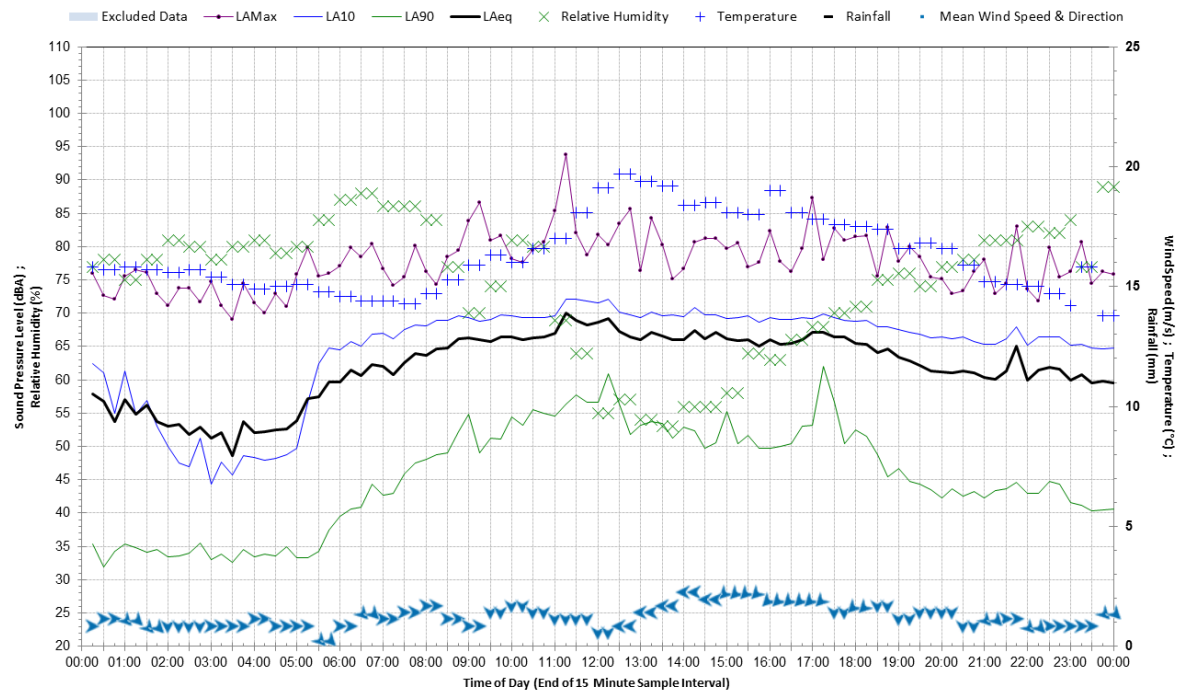
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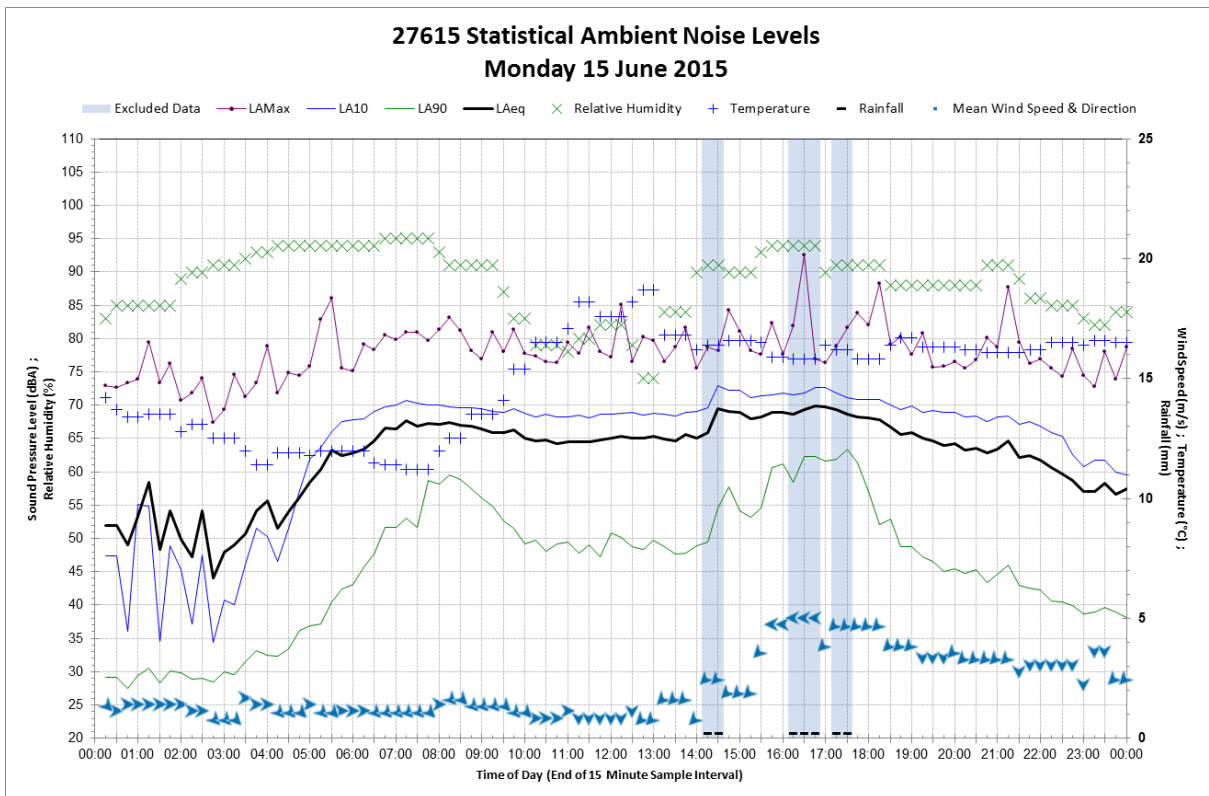
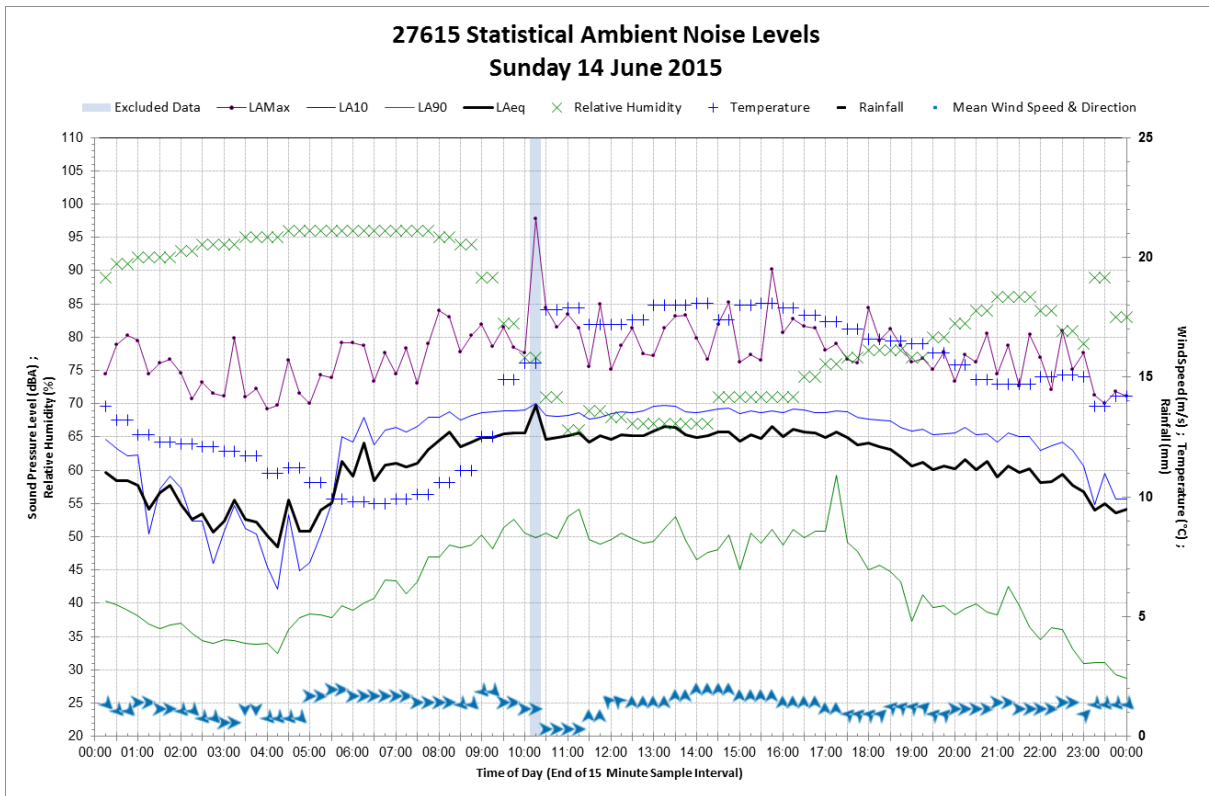


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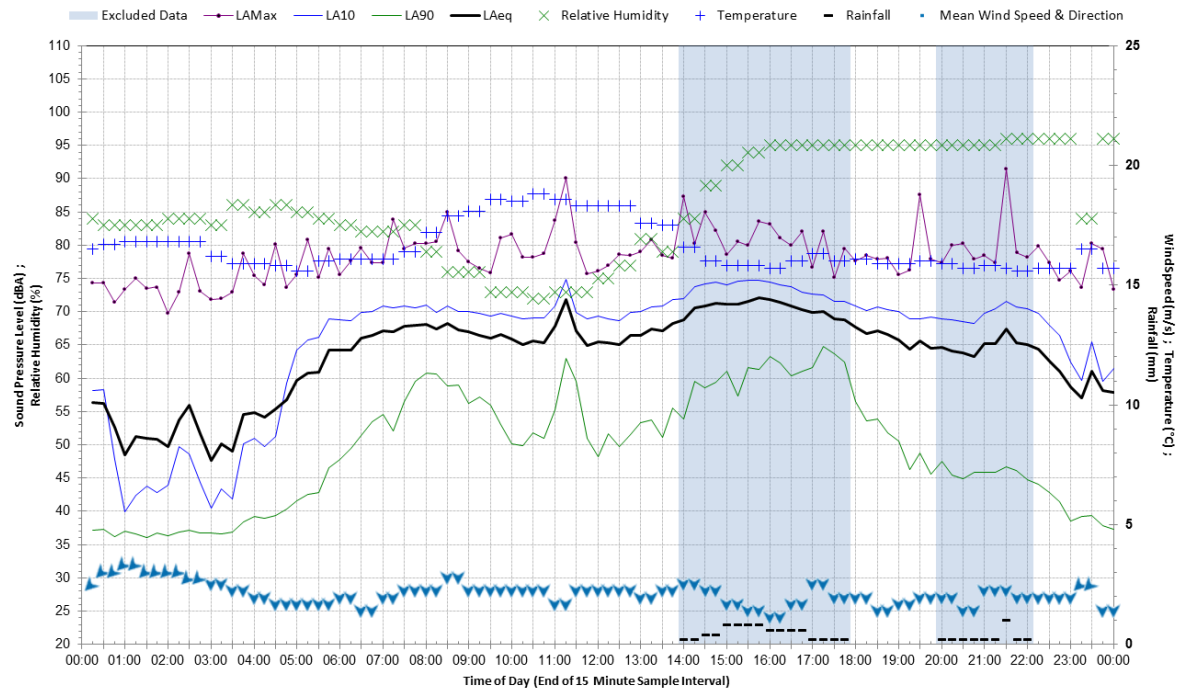


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