
B5 Detailed construction aircraft noise results

Receiver ID	NCA	Receiver Type ¹	Maximum aircraft noise criterion (dBA)	Drone Stringing Overflight (dBA)	Airbus AS350 Helicopter Stringing Overflight (dBA)	Airbus EC135 Helicopter Platform Works Overflight (dBA)	Dinawan substation		Balranald Road		Cobb Highway (N)		Cobb Highway (S)		Gregadoo Road, Wagga A		Gregadoo Road, Wagga B		Livingstone Gully Road	
							AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)
VNI002	1	RES	75	21	41	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI003	1	RES	75	21	41	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI004	1	RES	75	26	45	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI006	1	RES	75	34	52	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI007	1	RES	75	37	55	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI008	1	RES	75	38	56	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI009	1	PREC	N/A	45	64	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI010	1	PREC	N/A	52	71	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI011	1	PREC	N/A	52	71	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI012	1	PREC	N/A	49	69	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI013	1	RES	75	44	64	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI014	2	RES	75	34	53	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI015	2	RES	75	32	50	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI016	2	RES	75	39	59	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI017	2	RES	75	47	66	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI018	2	RES	75	30	48	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI020	2	RES	75	40	58	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI021	2	RES	75	36	56	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI022	2	RES	75	36	56	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI023	2	RES	75	36	56	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI024	2	RES	75	39	59	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI025	2	RES	75	48	67	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI026	2	RES	75	45	64	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI027	2	RES	75	43	62	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI028	2	RES	75	30	48	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI029	2	RES	75	34	53	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI032	2	RES	75	31	51	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI033	2	RES	75	38	58	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI034	2	RES	75	49	69	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI035	2	RES	75	37	57	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI036	3	RES	75	30	49	41	0	0	28	18	0	0	0	0	0	0	0	0	0	0
VNI037	3	RES	75	30	48	40	0	0	29	19	0	0	0	0	0	0	0	0	0	0
VNI038	3	RES	75	48	68	64	0	0	35	22	0	0	0	0	0	0	0	0	0	0
VNI039	3	RES	75	50	68	62	0	0	35	22	0	0	0	0	0	0	0	0	0	0
VNI040	3	RES	75	33	53	48	0	0	41	29	0	0	0	0	0	0	0	0	0	0
VNI041	3	RES	75	33	53	47	0	0	41	29	0	0	0	0	0	0	0	0	0	0
VNI042	3	RES	75	35	53	46	0	0	33	23	0	0	0	0	0	0	0	0	0	0
VNI043	3	RES	75	33	51	44	0	0	34	26	0	0	0	0	0	0	0	0	0	0
VNI044	3	RES	75	34	52	44	0	0	34	26	0	0	0	0	0	0	0	0	0	0
VNI045	3	RES	75	37	55	48	0	0	36	27	0	0	0	0	0	0	0	0	0	0
VNI046	3	RES	75	37	56	49	0	0	36	28	0	0	0	0	0	0	0	0	0	0
VNI047	3	RES	75	40	60	56	0	0	44	34	0	0	0	0	0	0	0	0	0	0
VNI048	3	RES	75	33	51	44	0	0	37	30	0	0	0	0	0	0	0	0	0	0
VNI049	3	RES	75	38	58	53	0	0	53	47	0	0	0	0	0	0	0	0	0	0
VNI050	3	RES	75	29	49	43	0	0	47	41	0	0	0	0	0	0	0	0	0	0
VNI051	3	RES	75	29	47	39	0	0	55	52	0	0	0	0	0	0	0	0	0	0
VNI052	3	RES	75	38	58	53	0	0	52	47	0	0	0	0	0	0	0	0	0	0
VNI055	4	RES	75	30	49	41	0	0	0	0	12	0	12	0	0	0	0	0	0	0
VNI056	4	RES	75	24	43	34	3	0	0	0	28	13	28	13	0	0	0	0	0	0
VNI057	4	RES	75	26	45	35	3	0	0	0	28	13	28	13	0	0	0	0	0	0

1) Residential area (RES), Passive recreation areas (PREC), Industrial premises (IND)

Cells highlighted in red meet or exceed maximum aircraft noise criterion

Receiver ID	NCA	Receiver Type ¹	Maximum aircraft noise criterion (dBA)	Drone Stringing Overflight (dBA)	Airbus AS350 Helicopter Stringing Overflight (dBA)	Airbus EC135 Helicopter Platform Works Overflight (dBA)	Dinawan substation		Balranald Road		Cobb Highway (N)		Cobb Highway (S)		Gregadoo Road, Wagga A		Gregadoo Road, Wagga B		Livingstone Gully Road	
							AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)
VNI058	4	RES	75	26	45	36	3	0	0	0	28	14	28	13	0	0	0	0	0	0
VNI059	4	RES	75	26	45	36	3	0	0	0	28	14	28	14	0	0	0	0	0	0
VNI060	4	RES	75	26	45	35	3	0	0	0	28	14	28	14	0	0	0	0	0	0
VNI061	4	RES	75	35	55	50	17	0	0	0	12	2	12	2	0	0	0	0	0	0
VNI062	4	RES	75	29	49	43	18	0	0	0	11	2	11	2	0	0	0	0	0	0
VNI063	4	RES	75	32	50	42	20	3	0	0	10	0	10	0	0	0	0	0	0	0
VNI064	4	RES	75	39	57	50	42	34	0	0	5	0	5	0	0	0	0	0	0	0
VNI101	6	RES	75	23	42	43	0	0	0	0	0	0	0	0	32	26	56	52	58	51
VNI102	5	RES	75	33	54	38	0	0	0	0	0	0	0	0	64	60	0	0	0	0
VNI103	5	RES	75	31	52	35	0	0	0	0	0	0	0	0	62	58	0	0	0	0
VNI104	5	RES	75	27	47	29	0	0	0	0	0	0	0	0	55	51	0	0	0	0
VNI105	5	RES	75	25	46	28	0	0	0	0	0	0	0	0	55	49	0	0	0	0
VNI106	5	RES	75	30	50	33	0	0	0	0	0	0	0	0	60	56	0	0	0	0
VNI107	5	RES	75	29	49	32	0	0	0	0	0	0	0	0	60	55	0	0	0	0
VNI108	5	RES	75	49	70	60	0	0	0	0	0	0	0	0	76	76	0	0	0	0
VNI109	5	RES	75	30	50	33	0	0	0	0	0	0	0	0	60	56	0	0	0	0
VNI110	5	RES	75	24	45	27	0	0	0	0	0	0	0	0	57	51	0	0	0	0
VNI111	5	RES	75	29	49	32	0	0	0	0	0	0	0	0	62	56	0	0	0	0
VNI112	5	RES	75	30	50	33	0	0	0	0	0	0	0	0	62	56	0	0	0	0
VNI113	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	57	51	0	0	0	0
VNI114	5	RES	75	30	50	33	0	0	0	0	0	0	0	0	66	60	0	0	0	0
VNI115	5	RES	75	29	50	33	0	0	0	0	0	0	0	0	68	63	0	0	0	0
VNI116	5	RES	75	24	45	27	0	0	0	0	0	0	0	0	58	52	0	0	0	0
VNI117	6	RES	75	43	67	68	0	0	0	0	0	0	0	0	62	59	37	26	36	25
VNI118	5	RES	75	29	49	32	0	0	0	0	0	0	0	0	68	63	0	0	0	0
VNI119	6	RES	75	49	69	67	0	0	0	0	0	0	0	0	55	53	38	28	37	27
VNI120	5	RES	75	28	48	31	0	0	0	0	0	0	0	0	66	60	0	0	0	0
VNI121	5	RES	75	28	49	31	0	0	0	0	0	0	0	0	67	61	0	0	0	0
VNI122	6	RES	75	48	69	67	0	0	0	0	0	0	0	0	53	51	39	29	38	27
VNI123	6	RES	75	51	71	69	0	0	0	0	0	0	0	0	54	52	38	29	37	27
VNI124	6	RES	75	40	61	61	0	0	0	0	0	0	0	0	56	53	38	28	37	26
VNI125	6	RES	75	33	58	60	0	0	0	0	0	0	0	0	43	40	44	37	43	36
VNI126	6	RES	75	39	60	60	0	0	0	0	0	0	0	0	46	43	42	34	40	32
VNI127	6	RES	75	31	52	53	0	0	0	0	0	0	0	0	50	48	40	30	38	28
VNI128	6	RES	75	55	75	73	0	0	0	0	0	0	0	0	46	43	42	33	41	32
VNI129	6	RES	75	30	52	53	0	0	0	0	0	0	0	0	42	39	45	38	43	35
VNI130	6	RES	75	49	69	68	0	0	0	0	0	0	0	0	42	38	46	39	44	37
VNI131	6	RES	75	33	58	60	0	0	0	0	0	0	0	0	43	40	45	37	44	36
VNI132	6	RES	75	34	59	61	0	0	0	0	0	0	0	0	43	39	45	38	44	36
VNI133	5	RES	75	28	48	31	0	0	0	0	0	0	0	0	64	58	0	0	0	0
VNI134	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	52	47	0	0	0	0
VNI135	5	RES	75	28	48	31	0	0	0	0	0	0	0	0	56	52	0	0	0	0
VNI136	5	RES	75	29	49	32	0	0	0	0	0	0	0	0	58	54	0	0	0	0
VNI137	5	RES	75	25	45	27	0	0	0	0	0	0	0	0	52	47	0	0	0	0
VNI138	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	52	47	0	0	0	0
VNI139	5	RES	75	24	45	27	0	0	0	0	0	0	0	0	52	47	0	0	0	0
VNI140	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	52	47	0	0	0	0
VNI141	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI142	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI143	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	52	47	0	0	0	0

1) Residential area (RES), Passive recreation areas (PREC), Industrial premises (IND)

Cells highlighted in red meet or exceed maximum aircraft noise criterion

Receiver ID	NCA	Receiver Type ¹	Maximum aircraft noise criterion (dBA)	Drone Stringing Overflight (dBA)	Airbus AS350 Helicopter Stringing Overflight (dBA)	Airbus EC135 Helicopter Platform Works Overflight (dBA)	Dinawan substation		Balranald Road		Cobb Highway (N)		Cobb Highway (S)		Gregadoo Road, Wagga A		Gregadoo Road, Wagga B		Livingstone Gully Road	
							AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)
VNI144	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI145	6	RES	75	23	48	51	0	0	0	0	0	0	0	0	39	35	50	44	48	43
VNI146	6	RES	75	31	56	58	0	0	0	0	0	0	0	0	39	35	50	45	49	44
VNI147	6	RES	75	23	48	51	0	0	0	0	0	0	0	0	62	59	37	26	36	26
VNI148	6	RES	75	41	62	62	0	0	0	0	0	0	0	0	47	45	41	32	40	30
VNI149	6	RES	75	30	52	53	0	0	0	0	0	0	0	0	39	35	49	44	46	39
VNI150	6	RES	75	30	51	52	0	0	0	0	0	0	0	0	39	35	50	44	46	39
VNI151	6	RES	75	26	44	45	0	0	0	0	0	0	0	0	36	31	61	57	58	54
VNI152	6	RES	75	50	73	73	0	0	0	0	0	0	0	0	38	34	52	47	50	45
VNI153	6	RES	75	34	55	56	0	0	0	0	0	0	0	0	37	33	55	50	50	44
VNI154	6	RES	75	33	54	55	0	0	0	0	0	0	0	0	37	33	55	50	50	44
VNI155	6	RES	75	30	51	52	0	0	0	0	0	0	0	0	39	35	50	45	46	40
VNI156	6	RES	75	38	59	59	0	0	0	0	0	0	0	0	37	33	54	50	50	44
VNI157	6	RES	75	46	65	64	0	0	0	0	0	0	0	0	35	30	68	65	62	56
VNI158	6	RES	75	24	44	46	0	0	0	0	0	0	0	0	36	32	57	51	53	49
VNI159	6	RES	75	28	49	50	0	0	0	0	0	0	0	0	37	33	53	48	49	44
VNI160	6	RES	75	32	54	54	0	0	0	0	0	0	0	0	36	31	61	57	56	51
VNI161	6	RES	75	28	46	48	0	0	0	0	0	0	0	0	35	30	68	63	62	58
VNI162	6	RES	75	37	56	57	0	0	0	0	0	0	0	0	32	27	59	56	62	59
VNI163	6	RES	75	40	58	59	0	0	0	0	0	0	0	0	34	29	75	75	67	62
VNI164	6	RES	75	29	48	49	0	0	0	0	0	0	0	0	35	30	66	61	61	56
VNI165	6	RES	75	19	44	47	0	0	0	0	0	0	0	0	63	59	34	22	33	22
VNI166	5	RES	75	23	44	24	0	0	0	0	0	0	0	0	48	42	0	0	0	0
VNI167	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	48	42	0	0	0	0
VNI168	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	49	44	0	0	0	0
VNI169	6	RES	75	21	45	49	0	0	0	0	0	0	0	0	70	68	35	23	34	23
VNI170	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI171	6	RES	75	20	45	49	0	0	0	0	0	0	0	0	63	59	34	22	33	22
VNI172	5	RES	75	24	45	27	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI173	5	RES	75	23	44	24	0	0	0	0	0	0	0	0	49	43	0	0	0	0
VNI174	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI175	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI176	5	RES	75	25	45	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI177	5	RES	75	24	45	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI178	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI179	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI180	5	RES	75	24	45	25	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI181	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI182	5	RES	75	23	44	25	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI183	5	RES	75	24	45	25	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI184	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI185	5	RES	75	23	44	24	0	0	0	0	0	0	0	0	49	44	0	0	0	0
VNI186	6	RES	75	30	55	58	0	0	0	0	0	0	0	0	66	63	34	23	34	22
VNI187	5	RES	75	23	44	25	0	0	0	0	0	0	0	0	50	44	0	0	0	0
VNI188	5	RES	75	23	44	25	0	0	0	0	0	0	0	0	50	44	0	0	0	0
VNI189	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI190	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI191	5	RES	75	25	45	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI192	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI193	5	RES	75	24	45	25	0	0	0	0	0	0	0	0	50	45	0	0	0	0

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							AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)	AS350 (dBA)	EC135 (dBA)
VNI194	5	RES	75	23	44	25	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI195	5	RES	75	37	62	51	0	0	0	0	0	0	0	0	64	60	0	0	0	0
VNI196	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI197	6	RES	75	30	54	57	0	0	0	0	0	0	0	0	71	69	35	23	34	23
VNI198	5	RES	75	40	65	54	0	0	0	0	0	0	0	0	66	63	0	0	0	0
VNI199	5	RES	75	23	44	24	0	0	0	0	0	0	0	0	49	44	0	0	0	0
VNI200	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI201	6	RES	75	22	47	50	0	0	0	0	0	0	0	0	72	69	36	25	35	24
VNI202	5	RES	75	23	44	25	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI203	5	RES	75	23	44	24	0	0	0	0	0	0	0	0	50	44	0	0	0	0
VNI204	5	RES	75	38	63	52	0	0	0	0	0	0	0	0	65	61	0	0	0	0
VNI205	5	RES	75	23	44	25	0	0	0	0	0	0	0	0	50	45	0	0	0	0
VNI206	6	RES	75	40	64	65	0	0	0	0	0	0	0	0	71	69	35	23	34	23
VNI207	5	RES	75	26	46	28	0	0	0	0	0	0	0	0	53	48	0	0	0	0
VNI208	5	RES	75	25	46	28	0	0	0	0	0	0	0	0	52	48	0	0	0	0
VNI209	5	RES	75	26	46	28	0	0	0	0	0	0	0	0	53	48	0	0	0	0
VNI210	5	RES	75	24	45	25	0	0	0	0	0	0	0	0	51	46	0	0	0	0
VNI211	5	RES	75	26	46	28	0	0	0	0	0	0	0	0	53	48	0	0	0	0
VNI212	5	RES	75	25	46	27	0	0	0	0	0	0	0	0	52	48	0	0	0	0
VNI213	5	IND	N/A	28	49	31	0	0	0	0	0	0	0	0	56	52	0	0	0	0
VNI214	5	RES	75	24	45	26	0	0	0	0	0	0	0	0	52	46	0	0	0	0
VNI215	5	RES	75	26	47	28	0	0	0	0	0	0	0	0	53	49	0	0	0	0
VNI216	5	RES	75	38	59	43	0	0	0	0	0	0	0	0	64	60	0	0	0	0
VNI217	5	RES	75	24	45	25	0	0	0	0	0	0	0	0	52	46	0	0	0	0
VNI218	5	RES	75	30	51	34	0	0	0	0	0	0	0	0	59	55	0	0	0	0
VNI219	6	RES	75	51	75	74	0	0	0	0	0	0	0	0	74	73	35	24	34	23
VNI220	6	RES	75	53	76	76	0	0	0	0	0	0	0	0	74	74	35	24	34	23
VNI221	5	RES	75	26	47	28	0	0	0	0	0	0	0	0	55	50	35	0	34	0
VNI222	5	RES	75	30	50	33	0	0	0	0	0	0	0	0	59	54	0	0	0	0
VNI223	5	RES	75	31	52	35	0	0	0	0	0	0	0	0	61	57	0	0	0	0
VNI224	6	RES	75	23	44	45	0	0	0	0	0	0	0	0	44	42	42	34	40	31
VNI225	6	RES	75	22	42	44	0	0	0	0	0	0	0	0	45	42	42	34	40	30
VNI226	6	RES	75	40	64	65	0	0	0	0	0	0	0	0	75	72	36	25	35	24
VNI228	6	RES	75	21	39	40	0	0	0	0	0	0	0	0	32	27	58	50	61	54
VNI229	5	RES	75	29	50	33	0	0	0	0	0	0	0	0	59	55	0	0	0	0
VNI230	5	RES	75	31	51	35	0	0	0	0	0	0	0	0	60	56	0	0	0	0
VNI231	1	RES	75	21	41	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNI232	1	RES	75	31	50	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1) Residential area (RES), Passive recreation areas (PREC), Industrial premises (IND)

Cells highlighted in red meet or exceed maximum aircraft noise criterion

B5.1 Aircraft noise model methodology

Aircraft noise model

Predictive aircraft noise modelling was conducted using the United States Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT), version 3d (released on March 29, 2021). The modelling data was sourced from previous aircraft noise assessments undertaken as part of the HumeLink project (refer to Noise and Vibration Impact Assessment of HumeLink (*SLR Report 160550-AMD-KK-009*, dated May 16, 2024)). This assessment included similar helicopter and drone operations for construction activities.

Modelling aircraft operations

Aircraft operations within in the AEDT noise model comprise of Arrival (ARR) and Departure (DEP) operations at the helipads, as well as overflights (OVF) for stringing and platform work inside the transmission line corridor.

These operations are defined as follows:

- **ARR:** The aircraft starts in airspace at a height of 1,000 ft above ground level (AGL) and finishes on the helipad, assuming a 30-degree approach angle.
- **DEP:** The aircraft starts at the helipad and finishes in airspace at a height of 1,000 ft AGL, assuming a 30-degree departure angle.
- **OVF:** The aircraft travels at level flight at a height of 170 ft AGL (representative of flight around transmission line structure height) at a speed of 60 knots for helicopters and 40 knots for drones.

Terrain and meteorological parameters

AEDT can account for terrain and meteorological effects and allows for the inclusion of ground terrain data and meteorological data in the model and is summarised in Table B5.1.

Table B5.1 Terrain and meteorological modelling parameters

Parameter	Modelling input
Ground terrain	The ground terrain data (digital surface model) in the format of a GEOTIFF file, was directly inputted into AEDT without any post processing.
Weather data and atmospheric absorption	AEDT includes the option to applying atmospheric absorption to aircraft noise data, which can be adjusted for temperature, relative humidity and atmospheric pressure values when processing the aircraft noise model. The option allows for the use of airport site-specific weather data or International Standard Atmosphere (ISA) conditions. Since the aircraft noise model for VNI West is based on flights within the NCAs, rather for flights for a specific airport, the unadjusted' SAE-AIR-1845 atmosphere was selected as the atmospheric absorption type option using ISA weather. This means noise data is unadjusted for atmospheric absorption and presents a conservative assessment.
Lateral attenuation	AEDT provides an option to select hard ground attenuation for helicopters and propeller aircraft, which was selected in this study to present a conservative assessment.

B6 Construction aircraft noise contours



VNI West – Technical Paper Noise Appendix B6.1a

Construction aircraft noise contours -
AS350 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

- Main road
- Named waterway

- Project footprint
- Combined temporary worker accommodation facility
- Telecommunication facility

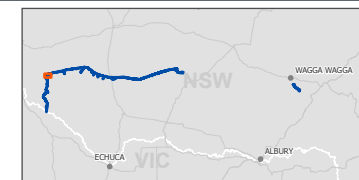
Noise and vibration sensitive receivers

- Residential

Construction aircraft noise contours L_{Fmax}

- Leq dBA
- 75-80
- 80-85
- 85-90

- 90-95
- >95







**VNI West – Technical Paper Noise
Appendix B6.1b**

Construction aircraft noise contours -
AS350 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

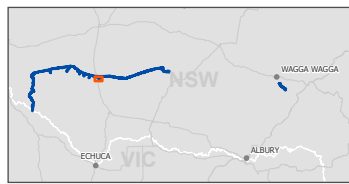
Legend

- Main road
- Project footprint
- Combined temporary worker accommodation facility

Construction aircraft noise contours L_{Fmax}

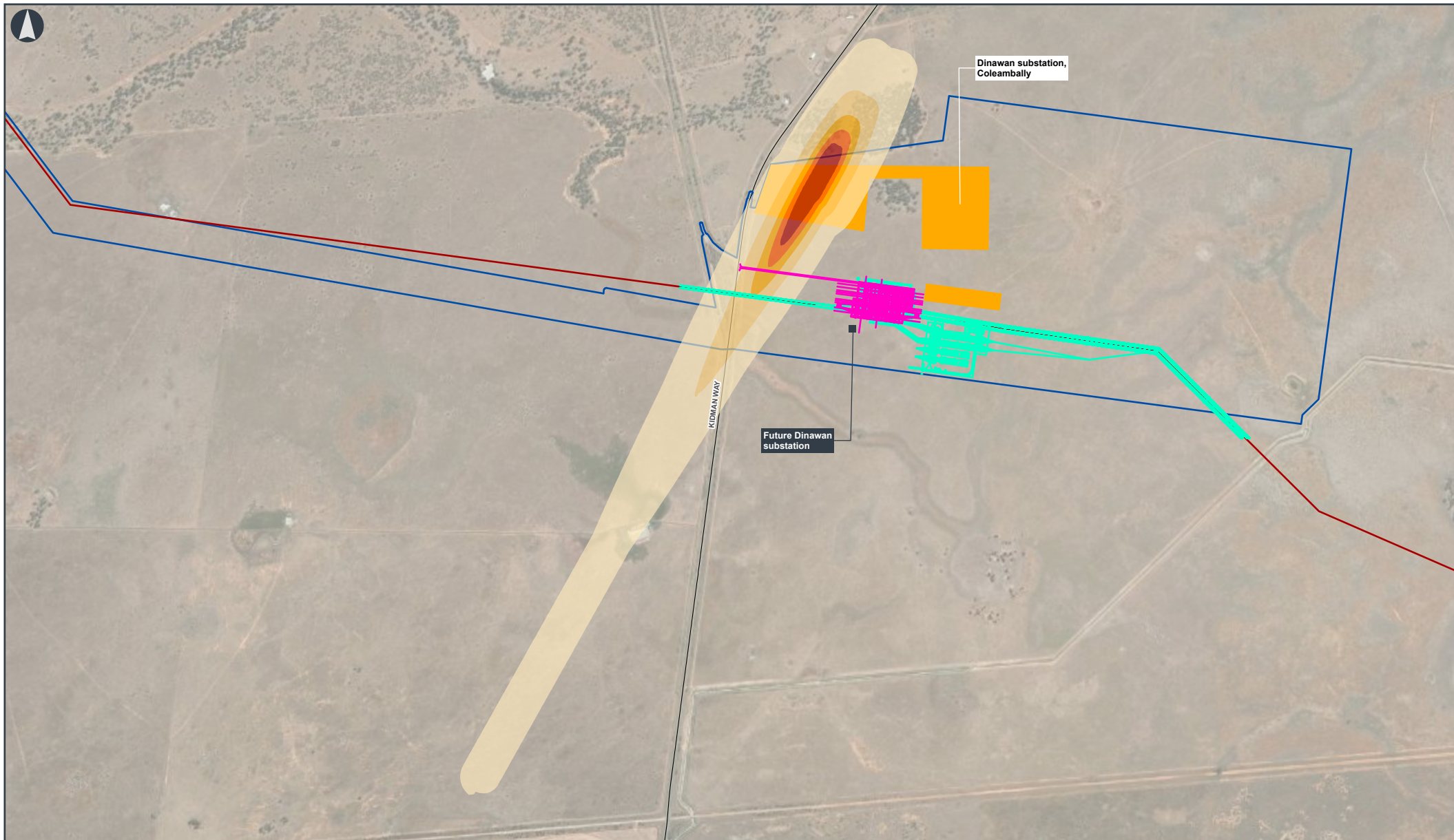
Leq dBA

- 75-80
- 80-85
- 85-90
- 90-95
- >95



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Data sources: NSW EPI, DELWP, WSP, EnergyConnect



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wsp

VNI West – Technical Paper Noise
Appendix B6.1c

Construction aircraft noise contours -
AS350 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

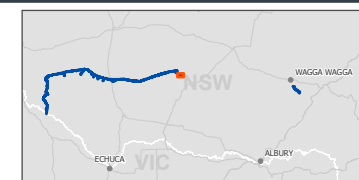
- Main road
- EnergyConnect (NSW - Eastern section) project (under construction)
- Dinawan substation works - proposed 500 kV
- Dinawan substation works - existing 330 kV
- Project footprint
- Combined temporary worker accommodation facility

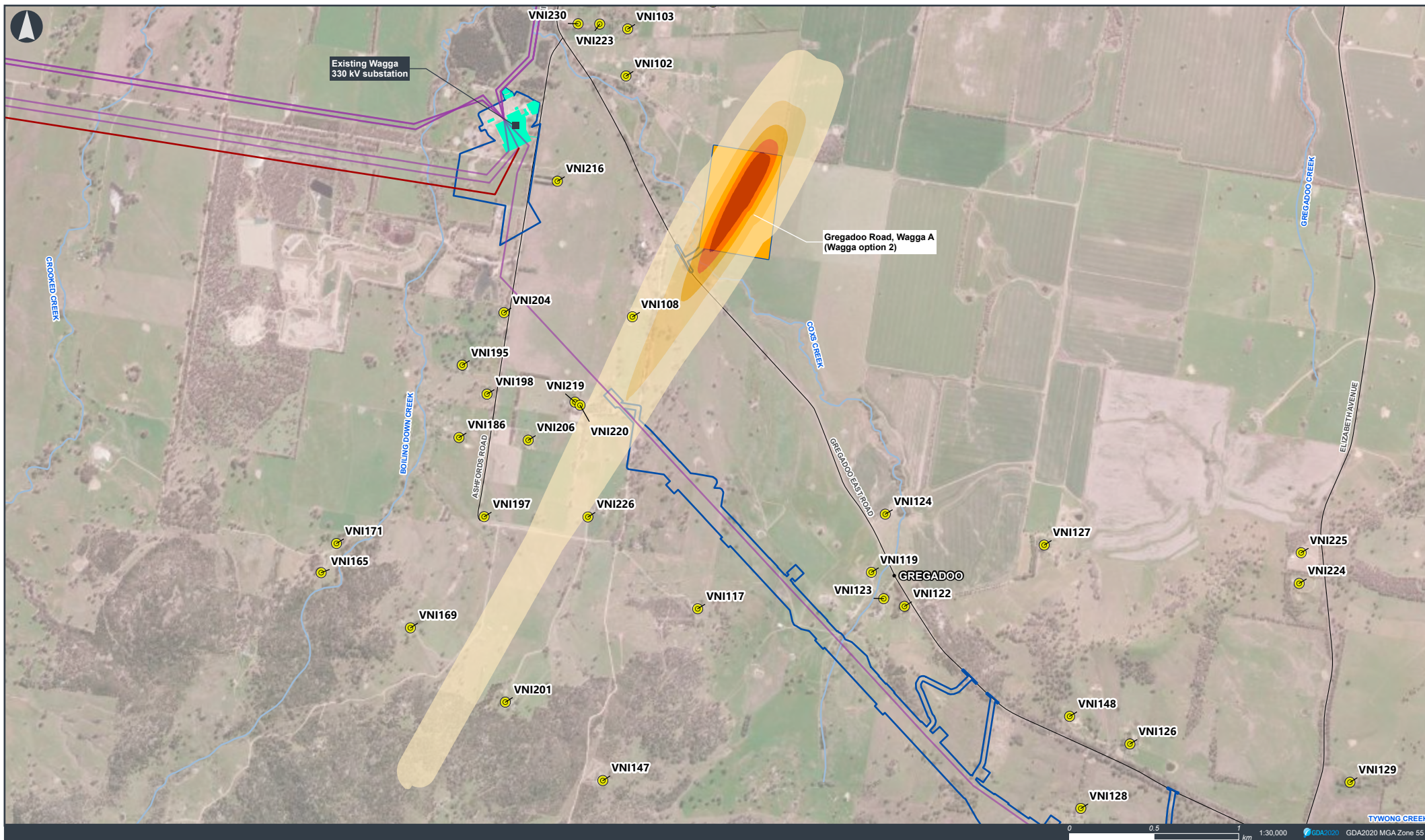
Construction aircraft noise contours L_{Fmax}

Leq dBA

- 75-80
- 80-85
- 85-90

- 90-95
- >95





wsp

VNI West – Technical Paper Noise
Appendix B6.1d

Construction aircraft noise contours -
AS350 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

— Main road
— Named waterway
— EnergyConnect (NSW -
Eastern section) project (under
construction)

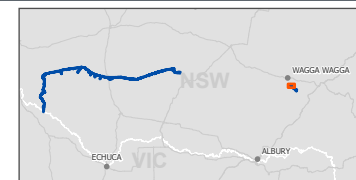
— Existing transmission line
■ Substation

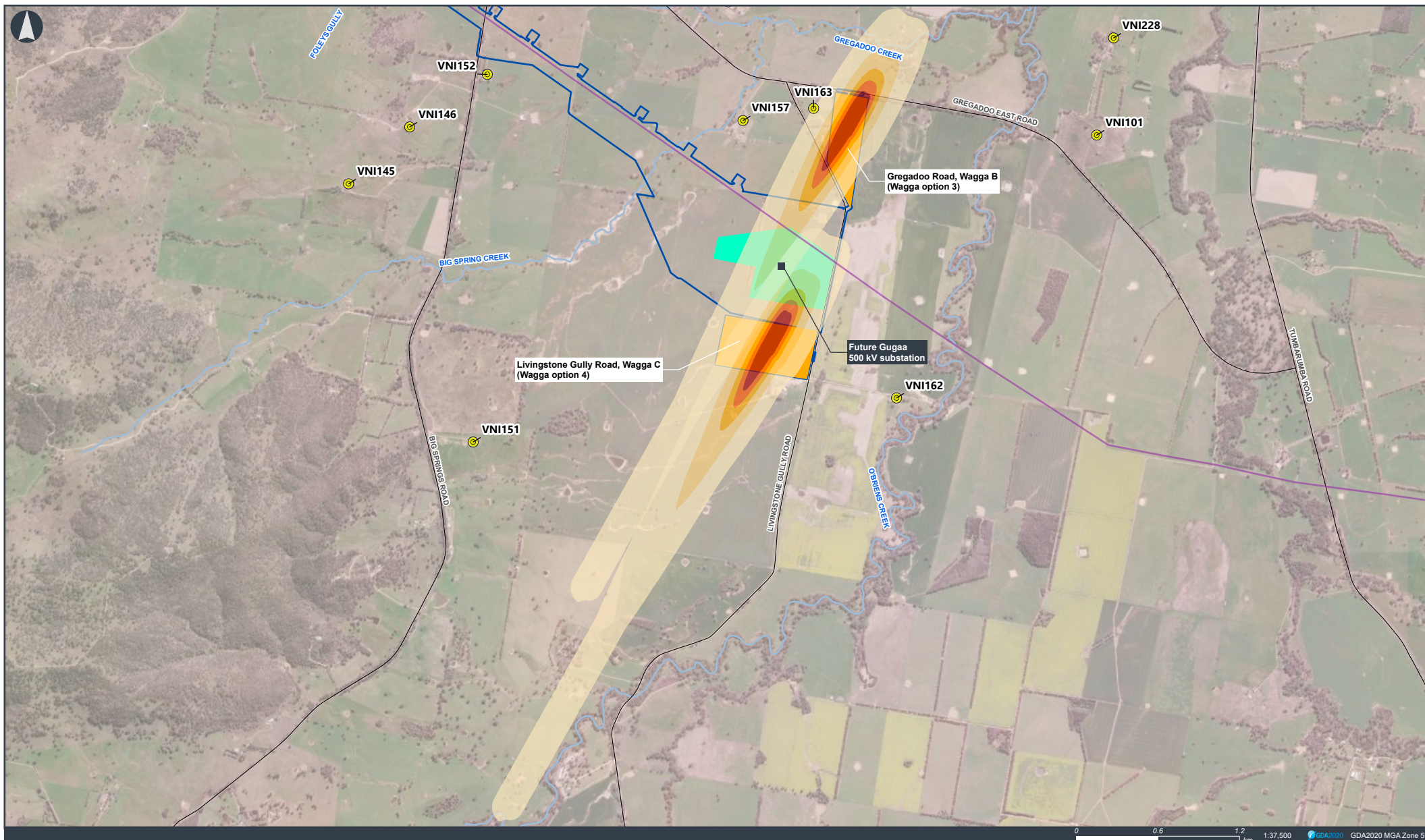
□ Project footprint
■ Combined temporary worker
accommodation facility

**Noise and vibration sensitive
receivers**
● Residential

**Construction aircraft noise
contours L_{max}**
Leq dBA
75-80
80-85
85-90

90-95
>95





VNI West – Technical Paper Noise Appendix B6.1e

Construction aircraft noise contours -
AS350 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

— Main road
— Named waterway

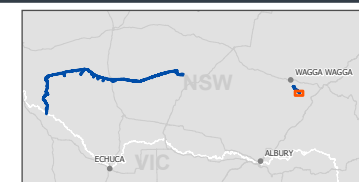
— Existing transmission line
■ Substation

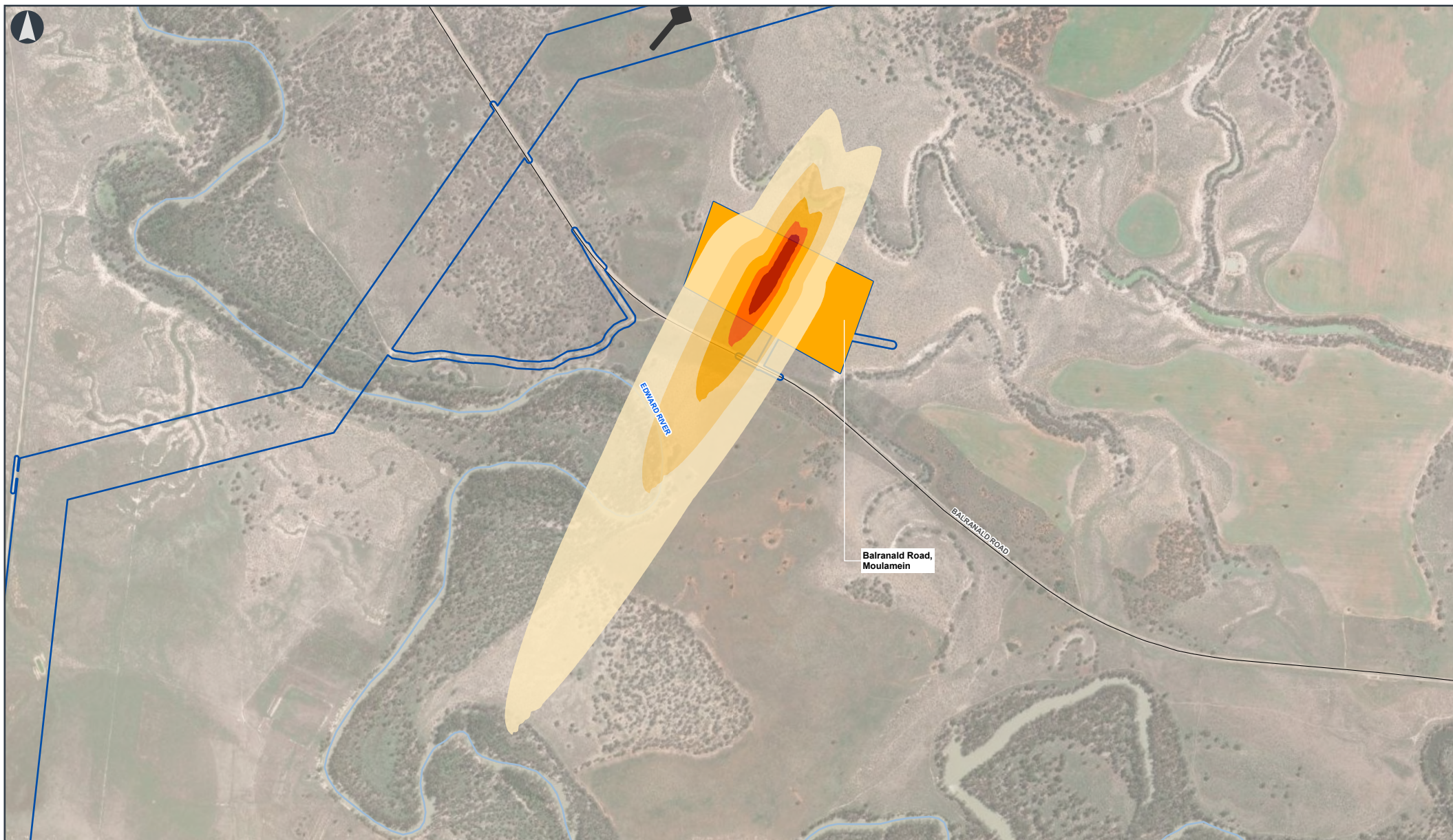
□ Project footprint
■ Combined temporary worker accommodation facility

Noise and vibration sensitive receivers
● Residential

Construction aircraft noise contours L_{Fmax}
Leq dBA
75-80
80-85
85-90

90-95
>95





VNI West – Technical Paper Noise Appendix B6.2a

Construction aircraft noise contours -
EC-135 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

- Main road
- Named waterway

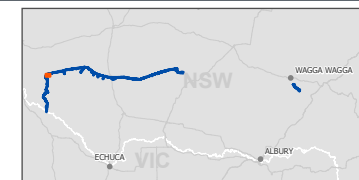
- Project footprint
- Combined temporary worker accommodation facility
- Telecommunication facility

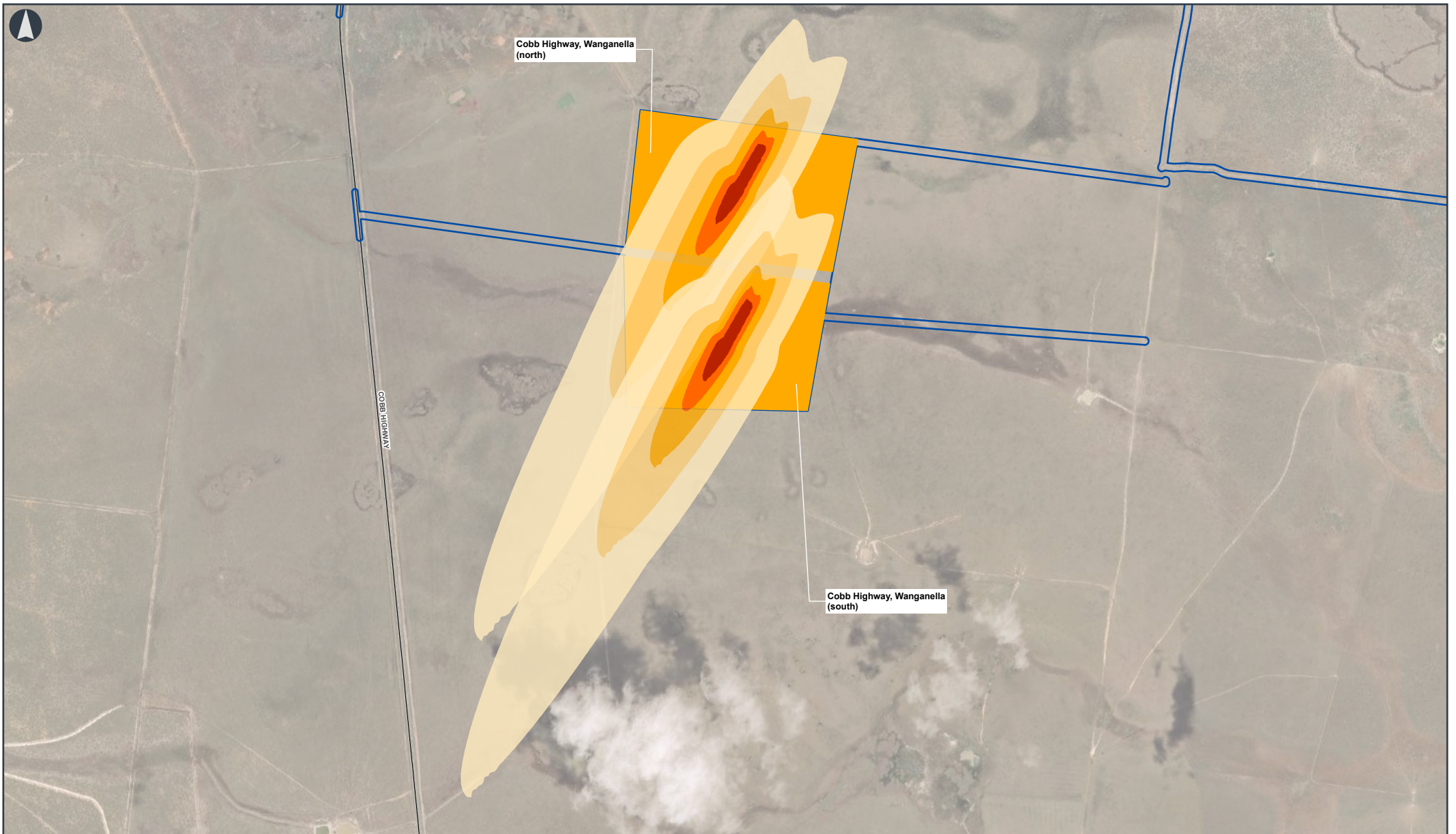
Construction aircraft noise contours L_{max}

Leq dBA

- 75-80
- 80-85
- 85-90

- 90-95
- >95





**VNI West – Technical Paper Noise
Appendix B6.2b**

Construction aircraft noise contours -
EC-135 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

— Main road

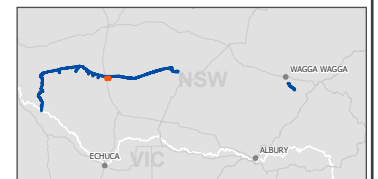
- Project footprint
- Combined temporary worker accommodation facility

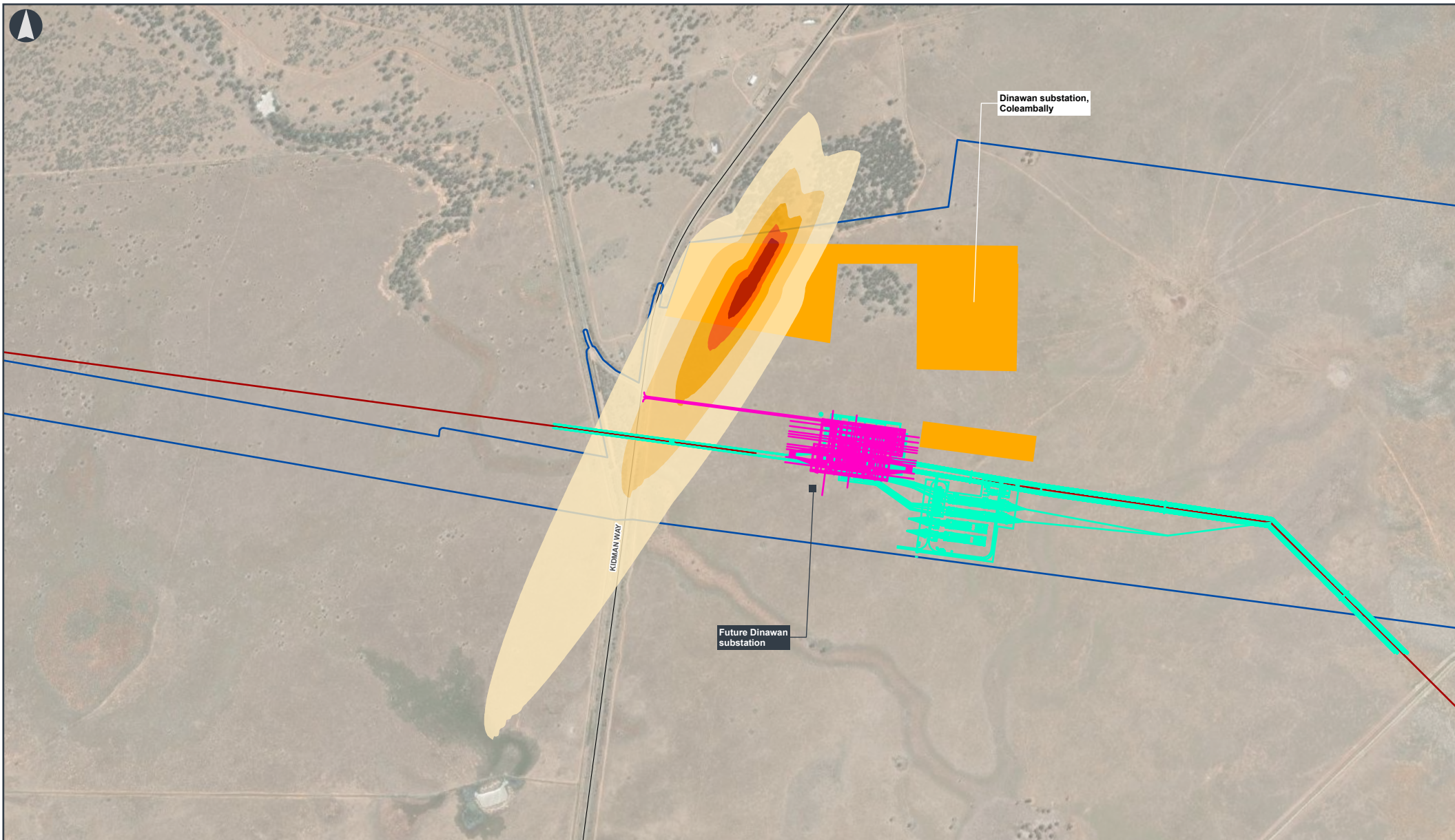
**Construction aircraft noise
contours L_{Fmax}**

Leq dBA

- 75-80
- 80-85
- 85-90

- 90-95
- >95





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wsp

VNI West – Technical Paper Noise
Appendix B6.2c

Construction aircraft noise contours -
EC-135 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

— Main road

EnergyConnect (NSW -
Eastern section) project (under
construction)

Dinawan substation works -
proposed 500 kV
Dinawan substation works -
existing 330 kV

Project footprint

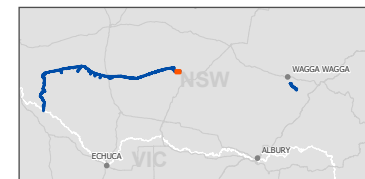
Combined temporary worker
accommodation facility

**Construction aircraft noise
contours L_{Fmax}**

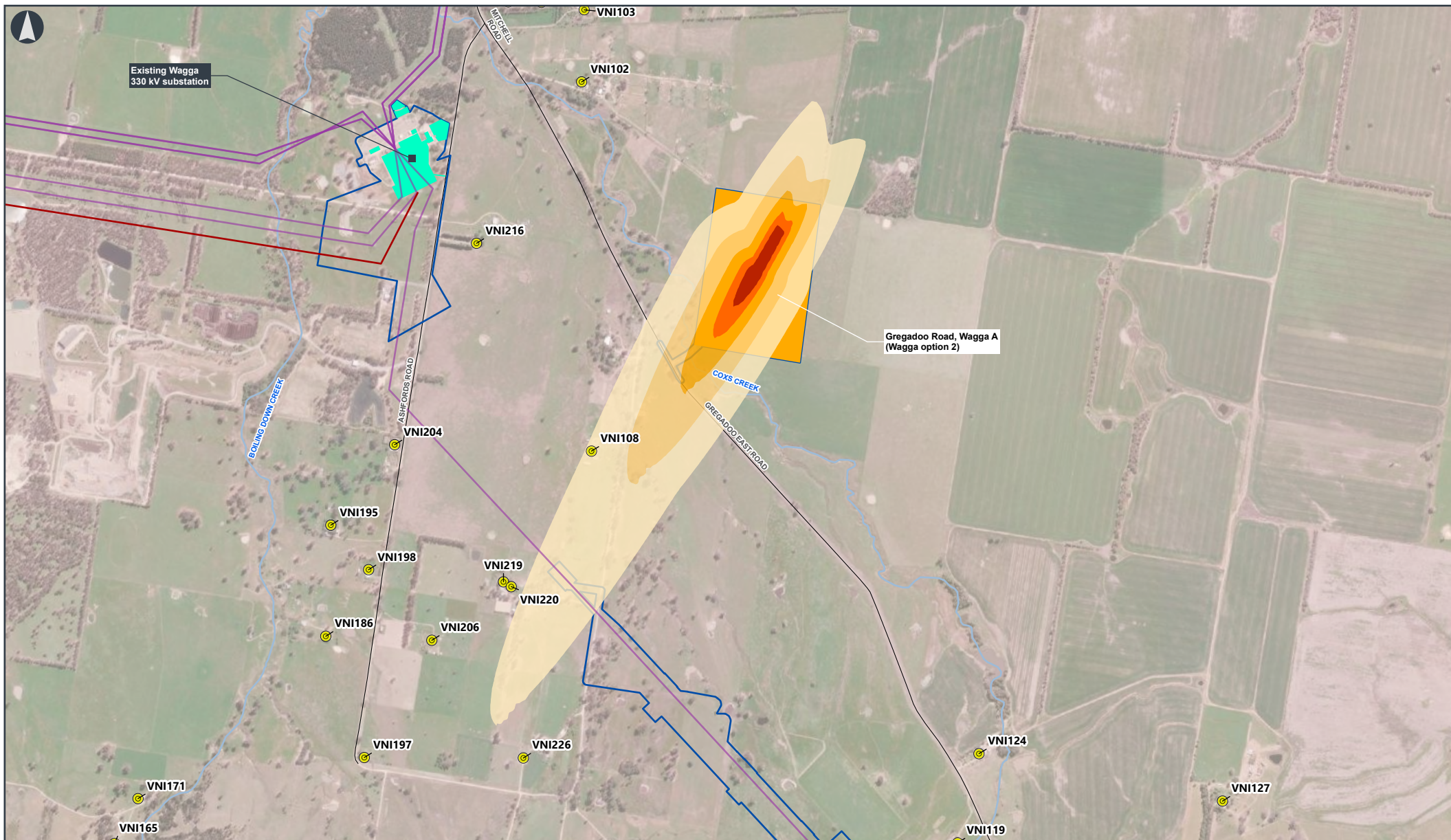
Leq dBA

75-80
80-85
85-90

90-95
>95



Data sources: NSW EPI, DELWP, WSP, EnergyConnect

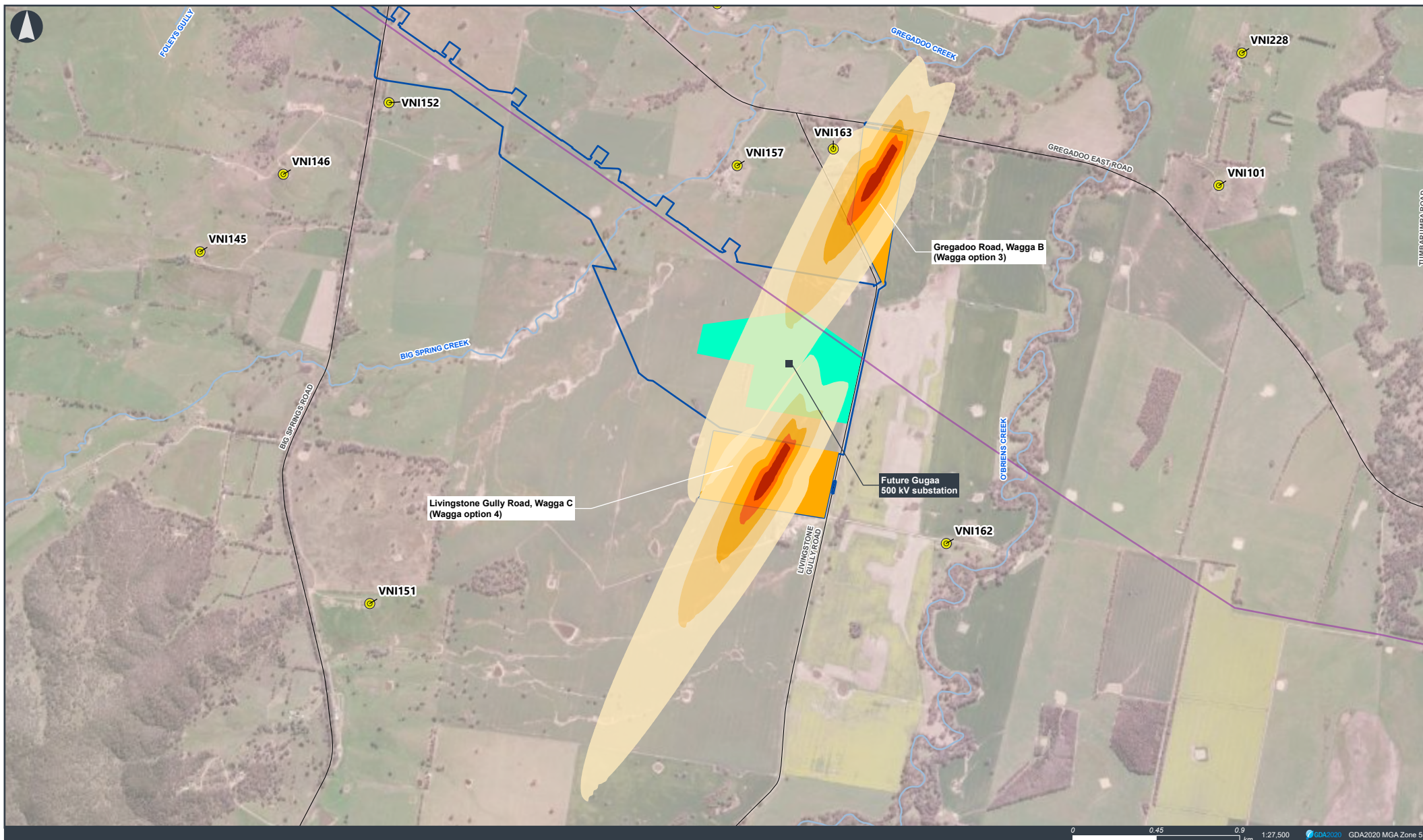


wsp

VNI West – Technical Paper Noise
Appendix B6.2d

Construction aircraft noise contours -
EC-135 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend — Main road — Named waterway — EnergyConnect (NSW - Eastern section) project (under construction) — Existing transmission line ■ Substation □ Project footprint ■ Combined temporary worker accommodation facility	Noise and vibration sensitive receivers ● Residential	Construction aircraft noise contours L_{Fmax} Leq dBA 75-80 80-85 85-90	90-95 >95	
--	--	--	----------------------------	--



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VNI West – Technical Paper Noise Appendix B6.2e

Construction aircraft noise contours -
EC-135 helicopters departures and arrivals -
Combined temporary worker accommodation
facilities and construction compounds

Legend

— Main road
— Named waterway

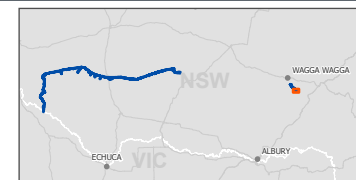
— Existing transmission line
Substation

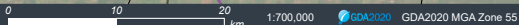
Project footprint
Combined temporary worker accommodation facility

Noise and vibration sensitive receivers
Residential

Construction aircraft noise contours L_{Fmax}
Leq dBA
75-80
80-85
85-90

90-95
>95

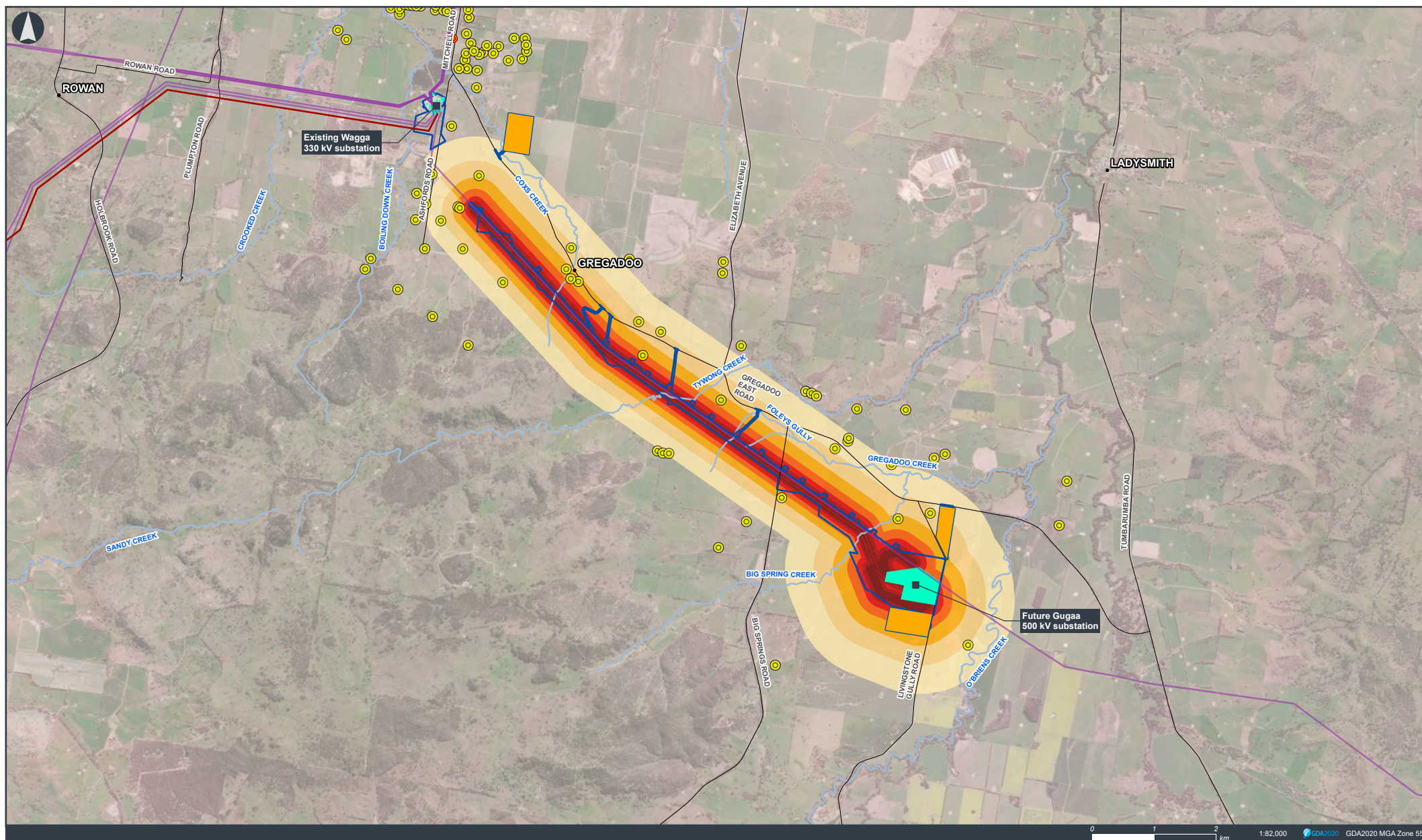




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50-55
 55-60
 60-65
 65-70
 70-75
 >75





VNI West – Technical Paper Noise Appendix B6.3b

Construction aircraft noise contours -
Helicopter and drone operation within
transmission line corridor - Drone stringing
and platform work

Legend

- Main road
- Named waterway
- EnergyConnect (NSW - Eastern section) project (under construction)
- Existing transmission line
- Substation

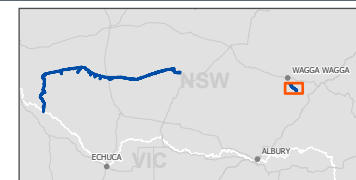
- Project footprint
- NSW/Victorian border
- Combined temporary worker accommodation facility

Noise and vibration sensitive receivers

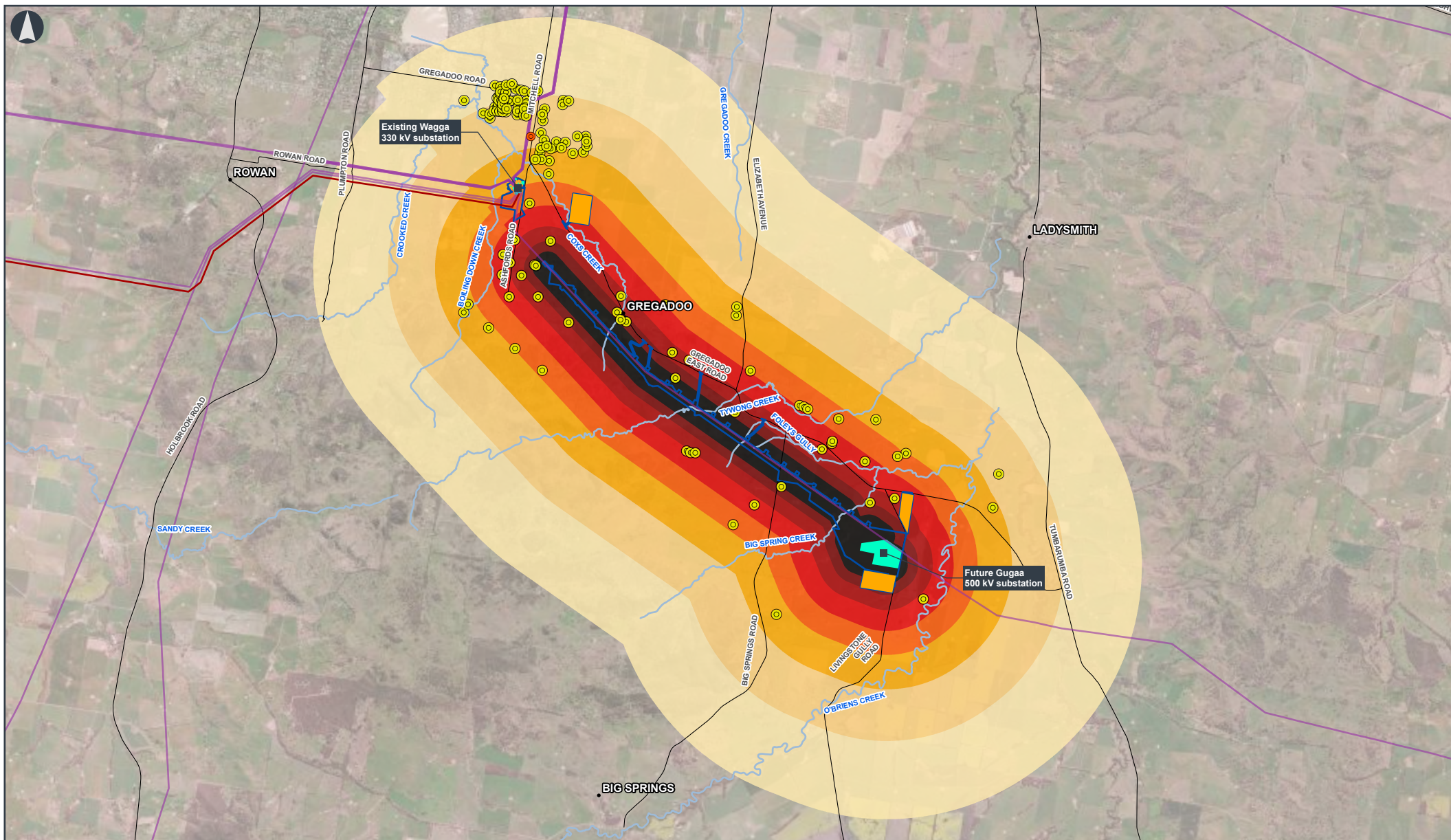
- Industrial
- Residential

Construction aircraft noise contours L_{max} Leq dBA

- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- 65-70
- 70-75
- >75



Data sources: NSW EPI, DELWP, WSP, EnergyConnect



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**VNI West – Technical Paper Noise
Appendix B6.4b**

Construction aircraft noise contours -
Helicopter and drone operation within
transmission line corridor - AS350 stringing

Legend

- Main road
- Named waterway
- Existing transmission line
- Substation
- EnergyConnect (NSW - Eastern section) project (under construction)

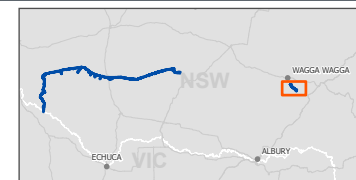
- Project footprint
- NSW/Victorian border
- Combined temporary worker accommodation facility

Noise and vibration sensitive receivers

- Industrial
- Residential

**Construction aircraft noise contours L_{Fmax}
Leq dBA**

- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- 65-70
- 70-75
- >75





Legend

- Rail line
- Main road
- Named waterway
- EnergyConnect (NSW - Eastern section) project (under construction)

- Existing transmission line
- Dinawan substation works - proposed 500 kV
- Dinawan substation works - existing 330 kV
- National park
- State forest

-  Project footprint
-  NSW/Victorian border
-  Combined temporary worker accommodation facility
-  Construction compound
-  Telecommunication facility

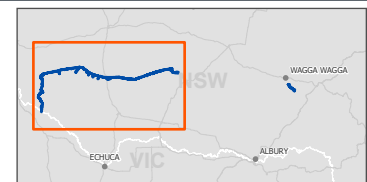
Noise and vibration sensitive receivers

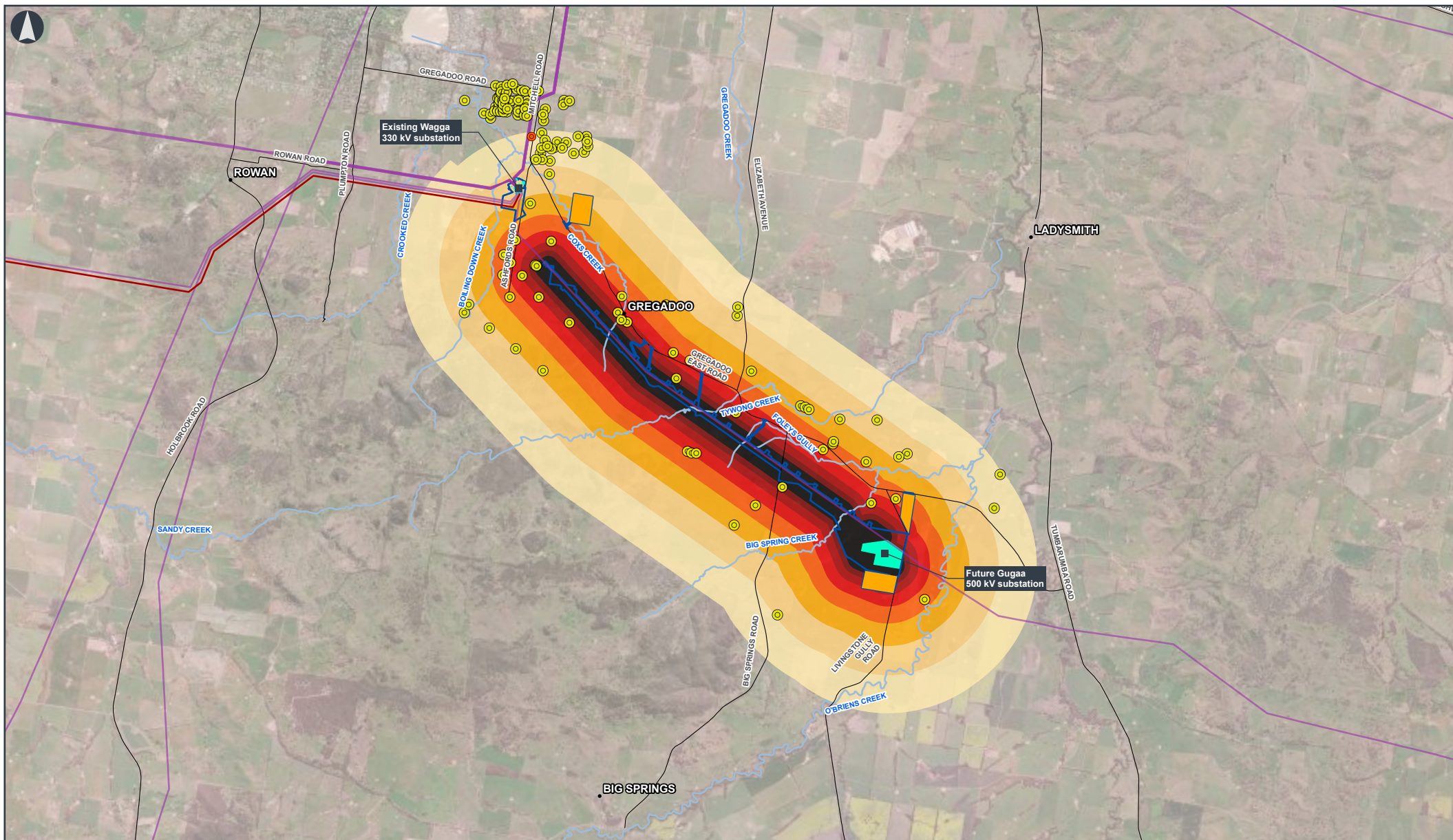
- Passive recreation
- Residential

Construction aircraft noise contours L_{Fmax}

- Leq dBA
- | |
|-------|
| 30-35 |
| 35-40 |
| 40-45 |
| 45-50 |

- | |
|-------|
| 50-55 |
| 55-60 |
| 60-65 |
| 65-70 |
| 70-75 |
| >75 |





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VNI West – Technical Paper Noise Appendix B6.5b

Construction aircraft noise contours -
Helicopter and drone operation within
transmission line corridor - EC-135
platform work

Legend

- Main road
- Named waterway
- EnergyConnect (NSW - Eastern section) project (under construction)
- Existing transmission line
- Substation

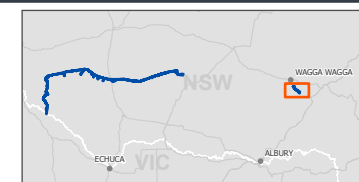
- Project footprint
- NSW/Victorian border
- Combined temporary worker accommodation facility

Noise and vibration sensitive receivers

- Industrial
- Residential

Construction aircraft noise contours L_{Fmax} Leq dBA

- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- 65-70
- 70-75
- >75



B7 Potentially vibration impacted structures

Appendix C

VNI West Audible Noise and
Radio Frequency Interference Study





Victoria to New South Wales Interconnector West (VNI West)

Audible Noise and Radio Frequency Interference Study

Prepared for Transgrid

Prepared by Beca Pty Ltd

ABN: 85 004 974 341

26 March 2025



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Appendices

Appendix A—VNI West 500 kV Double Circuit Transmission Line Tower Structure Drawings

Appendix B—Line 51 330 kV Double Circuit Transmission Line Tower Structure Drawings

Appendix C—Parallel Assessment

Revision History

Revision N°	Prepared By	Description	Date
A	Lasith De Silva, Arpana Korshapati	Issued for Client Review	27 August 2024
B	Arpana Korshapati	- Revised Section 6.2, Section 7.2: Line 51 330 kV Double Circuit Transmission Line Repl. AN and RFI Assessment - Included Section 6.4: VNI West 500 kV Double Circuit Parallel Lines Assessment - Included Section 7.4: Line 51 330 kV Double Circuit Parallel Lines Assessment	29 November 2024
C	Arpana Korshapati	- Updated project scope description to align with VNI West EIS document. - Updated to reflect Transgrid review comments. - Included EnergyConnect Line 2 330 kV double circuit transmission line parallel section assessment.	26 February 2025
D	Arpana Korshapati, Genevieve Steel	- Revised the results and recommendations - Updated section 1, 2, 6 and 7 to align with Transgrid EIS requirements.	26 March 2025

Document Acceptance

Action	Name	Signed	Date
Prepared by	Arpana Korshapati		26/03/2025
Reviewed by	Chris Taylor		26/03/2025
Approved by	Adriana Loreto		26/03/2025
on behalf of	Beca Pty Limited		

Glossary of Terms

ACSR	Aluminium Conductor Steel Reinforced
AVP	Australian Energy Market Operator Victorian Planning
AN	Audible Noise
AS	Australian Standard
AS/NZS	Australian Standard/New Zealand Standard
ANSI	American National Standards Institute
BPA	Bonneville Power Administration
BoM	Bureau of Meteorology
CB	Citizen Band
CIGRE	International Council on Large Electric Systems
CISPR	International Special Committee on Radio Interference
CDEGS	Current Distribution Electromagnetic Interference Grounding and Soil Structure Analysis
EPA	Environment Protection Authority
EPRI	Electric Power Research Institute
FZ	Fresnel Zone
ITU	International Telecommunication Union
LOS	Line-of-sight
NPfI	Noise Policy for Industry
p.u	per unit
QP	Quasi Peak
RFI	Radio Frequency Interference
RMS	Root Mean Square
REZs	Renewable Energy Zones
RW	Round Wire
STD	Standard Deviation
SVG	Surface Voltage Gradient
TLDM	Transmission Line Design Manual
TV	Television
TCV	Transmission Company Victoria

TVI	Television Interference
TW	Trapezoidal Wire
UHF	Ultra High Frequency
VHF	Very High Frequency

Executive Summary

Transgrid and Transmission Company Victoria (TCV) are jointly developing a new electrical connection between NSW and Victoria called the Victoria NSW Interconnector West project (VNI West). Transgrid is responsible for developing the NSW component of VNI West (referred to as 'the project' or 'VNI West (NSW)') in the Riverina Region of NSW and would provide the 500 kV transmission line component of the connection for the project between the NSW/Victorian border and the future Dinawan substation. The project would also include replacement of around nine kilometres of an existing single circuit 330 kV transmission line (Line 51) with a double circuit 330 kV transmission line generally between Ivydale Road (south of the existing Wagga 330 kV substation) and the future Gugaa 500 kV substation (the substation component of which is subject to separate planning approval as part of the HumeLink project (SSI-36656827)).

Transgrid has commissioned Beca to assess the electrical performance of the 500 kV double circuit transmission line between the NSW/Victorian border and the Dinawan substation (i.e VNI West 500 kV double circuit transmission line), and the 330 kV double circuit transmission line generally between Ivydale Road and the future Gugaa 500 kV substation (i.e. Line 51 330 kV double circuit transmission line) with respect to Audible Noise (AN) and Radio Frequency Interference (RFI). Transgrid's primary objective is to avoid and minimise any impacts associated with AN and RFI. This report will support the environmental studies for the Environmental Impact Statement (EIS).

The AN and RFI performance of both lines have been assessed at 1 metre and 2 metres above ground for the average conductor heights corresponding to the absolute minimum ground clearance of 12.5 metres for VNI West 500 kV double circuit transmission line and 8.0 meters for Line 51 330 kV double circuit transmission line (VNI West Electric and Magnetic Field Study).

A summary of the key concepts discussed in this document, along with the relevant findings and subsequent recommendations are summarised below.

Surface Voltage Gradients of Conductors

Transgrid and Australian standards recommend that the conductor surface voltage gradient (SVG) be limited to less than 16 kV/cm to minimise the impact of AN and RFI. Higher values of SVG may be used where acceptable AN and RFI performance is demonstrated. The following have been observed:

- For the VNI West 500 kV double circuit transmission line, the maximum SVG for the smooth cylindrical equivalent to the stranded round wire conductor is calculated to be 16.1 kV/cm.
- For the Line 51 330 kV double circuit transmission line, the maximum SVG for the smooth cylindrical equivalent to the stranded round wire conductor is calculated to be 15.9 kV/cm.

Audible Noise

The Electric Power Research Institute (EPRI) semi-empirical calculation method has been applied to determine the wideband AN level for both lines considered in this study. The following has been observed:

- Fair weather AN levels will be within the project noise trigger level of 35 dB(A) within or close to the edge of the line easement.
- The maximum observed AN limits under the wet weather conditions are within, or close to, the 50 dB limit at the edge of its easement.

- Under wet conditions, the project noise trigger level of 35 dB(A) is 395 metres from the centreline of the VNI West 500 kV double circuit transmission line and 359 metres from the centreline of the Line 51 330 kV double circuit transmission line.
- Modifying factors for tonality may need to be considered at sensitive receivers identified within the AN risk zone.

Radio Frequency Interference

The International Council on Large Electric Systems (CIGRE) empirical calculation method has been used to determine the RFI levels for the VNI West transmission lines.

- For both lines the calculated RFI emission levels will exceed the AS 2344 limits at the edge of the transmission line easement during L₅₀ wet conditions for AM radio reception only.
- For VNI West 500 kV double circuit transmission line, the distance from the edge of the transmission line easement at which the RFI is likely to negatively impact commercial AM radio reception during rain conditions is limited to 122 metres from the centre of the easement.
- For Line 51 330 kV double circuit transmission line, the distance from the edge of the transmission line easement at which the RFI is likely to negatively impact commercial AM radio reception during rain conditions is limited to 141 metres from the centre of the easement.
- Transmission lines identified to parallel to the VNI West 500 kV double circuit transmission line and Line 51 330 kV double circuit transmission line do not significantly impact AM radio operation.

Other forms of communication are not noticeably affected by RFI at the edge of the transmission line easement.

Recommendations and Next Steps

The following next steps and recommendations are proposed:

- Noise measurements are undertaken to determine the level of ambient noise (background noise) present in the identified (potential) AN risk zones, as low levels of ambient noise would be susceptible to the increased perception of disruption to amenity levels.
- Investigations are carried out to identify sensitive receivers (e.g. residential dwellings and places of work, education, or worship) within 395 metres of the centre of the VNI West 500 kV double circuit transmission line easement and within 359 metres of the centre of the Line 51 330 kV double circuit transmission line easement. In addition to identifying existing sensitive receivers, publicly available council Local Environmental Plans (LEP) should be reviewed to identify any authorised, but not yet constructed developments. Modifying factors for tonality may need to be considered at sensitive receivers identified within the AN risk zone.
- RFI investigations to be undertaken to identify any sensitive receivers within 122 metres from the centre VNI West 500 kV double circuit transmission line easement and 141 metres from the centre of Line 51 330 kV double circuit transmission line easement. The impact to each receiver should be assessed for compliance with the 80/80 rule in accordance with AS 2344.
- Perceived impacts on point-to-point communication links i.e. microwave beams operating in the vicinity of the VNI West 500 kV double circuit transmission line and Line 51 330 kV double circuit transmission line alignment should be assessed during detailed design.

Qualifications and Assumptions

- The findings of this report consider general requirements only. Some locations may have additional, more stringent requirements, these areas may include but are not limited to defence sites, precision agriculture, and medical facilities.
- It is assumed that transmission-line hardware is designed and tested such that the corona discharge is insignificant when compared to the conductors. Transmission line hardware is not considered by this study.

1. Introduction

Transgrid and the Australian Energy Market Operator Victorian Planning (AVP) are currently investigating a new interconnector between Victoria and New South Wales (NSW). The Victoria to NSW Interconnector (VNI) West project, jointly developed by Transgrid and Transmission Company Victoria (TCV) comprises the following works:

Transmission Lines

500 kV transmission line between the NSW/Victorian border and future Dinawan substation

This component of the project comprises a new 500 kV double-circuit transmission line from NSW/Victorian border (high tide mark on the southern side of the Murray River) to future Dinawan substation (currently under construction as part of EnergyConnect (NSW Eastern Section) project). The nominal distance of the NSW component of the project would be around 240 kilometres.

Transmission line work at the future Dinawan substation

In order for the transmission line currently being constructed under the EnergyConnect (NSW – Eastern Section) project to operate at 500 kV, the following line diversion work would be required (as part of the VNI West project) at the future Dinawan substation:

- Construction of around 150 metres of new double circuit 330 kV transmission line, supported by a new transmission line structure between the future 330 kV switchyard (currently being constructed under EnergyConnect (NSW Eastern Section) project) and the proposed 500 kV switchyard at Dinawan substation.
- Realignment of around 1.5 kilometres of the future transmission line on the eastern side of the future Dinawan substation (currently being constructed under the EnergyConnect (NSW Eastern section) project) south by around 100 metres to facilitate the transfer of wires from the future 330 kV gantries to the proposed 500 kV gantries.

Network augmentation between the existing Wagga 330 kV substation and the future Gugaa 500 kV substation

The following section provides a description of work required as part of the network augmentation between Ivydale Road (south of the existing Wagga 330 kV substation) and the future Gugaa 500 kV substation.

Replacement of a section of Line 51

The project would require the replacement of around 9 kilometres of a section of 330 kV single circuit transmissions line (Line 51) between Ivydale Road, Wagga and the future Gugaa 500 kV substation. The section of existing Line 51 would be demolished and replaced with a new double circuit 330 kV transmission line. The new transmission line structures would be located within the existing 60 metres easement.

Transmission line work within the vicinity of the existing Wagga 330 kV substation

The following activities would be required within the vicinity of the existing Wagga 330 kV substation to facilitate the network to operate at 500 kV:

- Disconnection of the future transmission lines being constructed under EnergyConnect (NSW Eastern Section) and HumeLink (that would initially operate at 330 kV) from the existing Wagga 330 kV substation.
- Installation of a new 500 kV transmission line structure to the south of the existing Wagga 330 kV substation to connect the two transmission lines to form a direct 500 kV connection between the future Dinawan and Gugaa 500 kV substations.

- Demolition of redundant 330 kV transmission line structures.

Transmission line work within the vicinity of the future Gugaa 500 kV substation

The proposed work within the vicinity of the future Gugaa 500 kV substation would include:

- Installation of around three transmission line structures to the northeast of the substation to connect the new 330 kV double circuit transmission line to the 330 kV switchyard
- Cut into the existing Line 51 on the eastern side of the substation for a second connection to the 330 kV switchyard
- Installation of around six new 500 kV transmission line structures (generally to the west and south of the future Gugaa 500 kV substation) to accommodate the relocation of around two kilometres of the proposed HumeLink transmission line between the 330 kV switchyard and the 500 kV switchyard.

Proposed Dinawan substation expansion:

To provide a connection point for the new 500 kV transmission lines, a new 500 kV switchyard would be constructed adjoining the future 330 kV switchyard (currently under construction as part of EnergyConnect (NSW Eastern Section)) on land owned by Transgrid. The area of the new 500 kV switchyard would be around 17 hectares (inclusive of the required buffer zone surrounding the site) and would include:

- Six single-phase 500 kV/330 kV transformers
- Seven three-phase shunt reactors (including one spare reactor)
- A range of supporting 500 kV electrical components including overhead conductors, busbars and gantries
- 500 kV circuit breaker switchgear equipment
- Neutral earth resistors and other electrical equipment
- Auxiliary services building

2. Scope of Study

Beca Pty Ltd (Beca) have been commissioned by Transgrid to assess Audible Noise (AN) and Radio Frequency Interference (RFI) study of the following VNI West lines sections:

1. The preferred transmission line alignment for the new 500 kV double circuit transmission line located between the crossing point on the Victoria/NSW border through to the future Dinawan 500 kV substation. This line is referred to as VNI West 500 kV double circuit transmission line and is approximately 240 kilometres long. The VNI West 500 kV double circuit transmission line is identified in **orange** line in Figure 1.
2. Replacement of around 9 kilometres of existing 330 kV single circuit transmission line (Line 51) between Ivydale Road (south of the existing Wagga 330 kV substation) and the future Gugaa 500 kV substation with a new double circuit 330 kV transmission line. This section of line is referred to as Line 51 330 kV double circuit transmission line. The section of line to be replaced is approximately 9 kilometres long. The Line 51 330 kV double circuit transmission line is identified as a portion of the **purple** line in Figure 1.

The scope of this study is to:

- Calculate the surface voltage gradients (SVG).
- Calculate the AN performance of the transmission line (at edge of easement) and determine the specific conditions where AN Levels exceed the allowable limits.
- Calculate the RFI performance of the transmission line (at edge of easement) and determine the specific conditions where RFI levels exceed the allowable limits for identified broadcasts (and typical broadcasts) in accordance with AS 2344, including: AM radio, FM radio, Aeronautical VHF, CB UHF and Digital TV.
- Identify the distance from the centre of the line easement whereby sensitive receivers may be impacted (AN – Intrusiveness criteria, and RFI – Class 3 reception).

Transgrid's primary objective is to quantify the potential risks of non-compliances (if any) with identified limits along the line and understand any impacts to stakeholders, as an input to further environmental studies and stakeholder engagement.

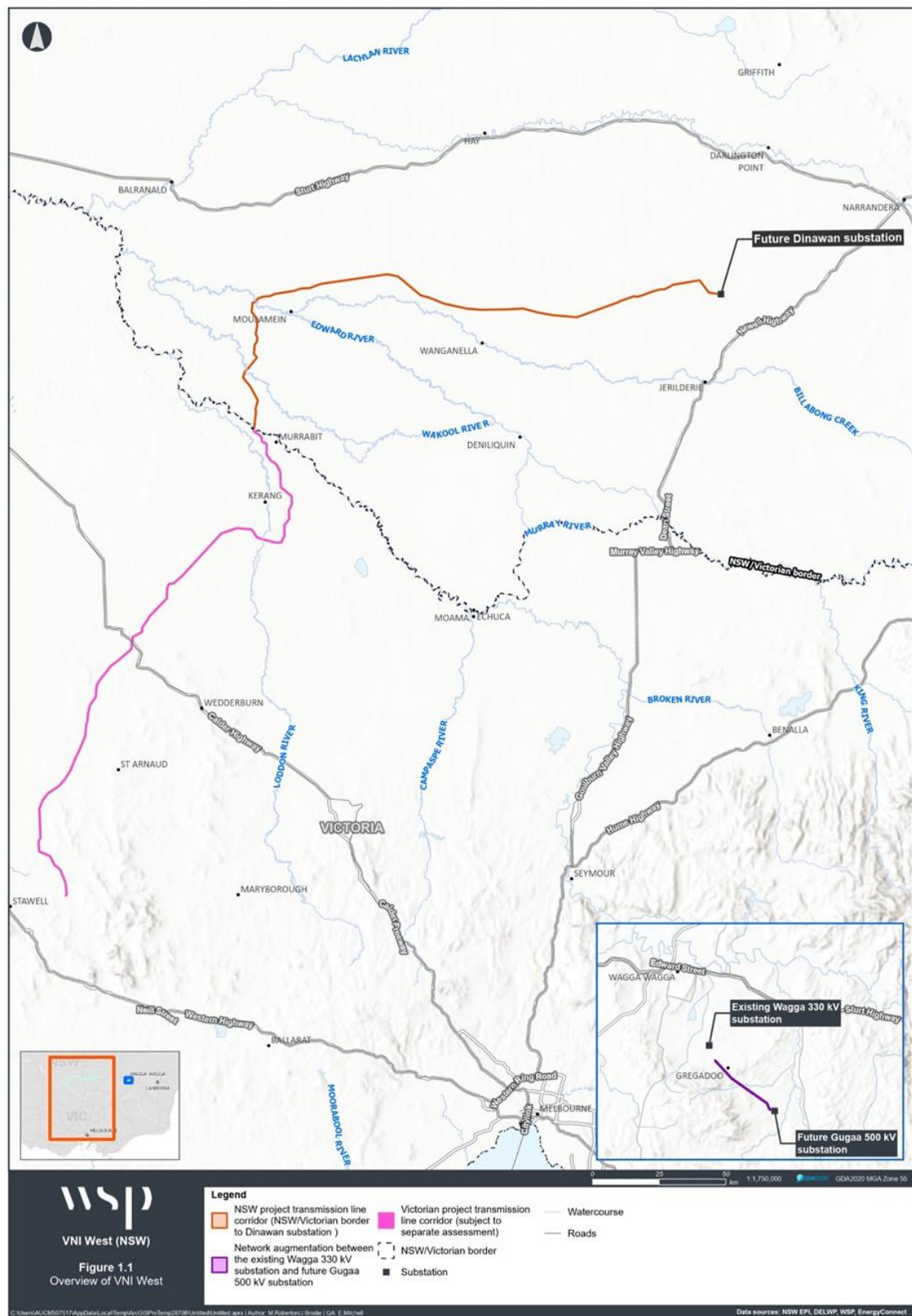


Figure 1: VNI West Project Overview

This study has been carried out in accordance with the requirements of the relevant Transgrid, Australian and international standards, industry guidelines and publications as specified in Table 1

Table 1: standards, policies and industry guidelines/publications referenced in the study.

Document / Org	Specification, Standards and Manuals	Revision
Transgrid Standards, Specifications and Manuals		
-	Transgrid transmission lines standards & guidelines	-
International Standards & Publications		
AS/NZS 7000	Overhead line design	2016
AS 1055	Acoustics: Description and measurement of environmental noise	2018
AS 2344	Limits of electromagnetic interference from overhead a.c. powerlines and high voltage equipment installation in the frequency range 0.15 MHz to 3000 MHz	2016
Policies and Guidelines, Technical Notes and Publications		
NSW EPA NPfI	New South Wales Environment Protection Authority – Noise Policy for Industry	2017
CISPR TR 18-1	Radio interference characteristics of overhead power lines and high-voltage equipment – Part 1: Description of phenomena	2017
CISPR TR 18-2	Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits	2017
EPRI	Transmission Line Reference Book 345 kV and Above	2 nd Edition
EPRI	EPRI AC Transmission Line Reference Book – 200 kV and Above	3 rd Edition
CIGRE TB 20	CIGRE Technical Brochure No. 20: Interferences produced by corona effect of electric systems – Description of phenomena, Practical guide for calculation	1974
IEEE	A Comparison of Methods for Calculating Audible Noise of High Voltage Transmission Lines	1982
IEEE	Formulas for Predicting Audible Noise from Overhead High Voltage AC and DC Lines	1981
IEEE	Comparison of Radio Noise Prediction Methods with CIGRE/IEEE Survey Results	1973
[A2] M. Ryan, M. Lanchester, S. Pugh (Paper No. 37)	“Noise Reduction through Facades with Open Windows”, Proceedings of ACOUSTICS 2011, Paper Number 37, 2 - 4 November 2011.	2011
[A3] Southwire Energy Division	“Corona Effects on Bare Overhead Conductors”, Oncor Presentation, 2015	2015

Qualifications and Assumptions

- The findings of this report consider general requirements only. Some locations may have additional, more stringent requirements, these areas may include but are not limited to defence sites, precision agriculture, and medical facilities.
- It is assumed that transmission-line hardware is designed and tested such that the corona discharge is insignificant when compared to the conductors. Transmission line hardware is not considered by this study.
- Substation infrastructure is not considered by this study.

- The transmission line between the NSW/Victorian border and the future Dinawan substation would be located within an easement approximately 70 metres wide except at two transposition locations (locations where the conductors of a transmission line swap positions to improve transmission voltage balance) no assessment has been undertaken at these locations.

3. System Definition

The corona performance of a transmission line is primarily dependent¹ on the average maximum Surface Voltage Gradient (SVG) on the phase conductor bundles.

The study of these phenomena depends on factors relating to the system definition, i.e. phase conductor and bundle arrangements, system operating conditions and structure/line configurations for conductor heights relative to an observation point and weather conditions.

The content and outcomes of this report are based on the documents referenced in this section. This information has been supplied and confirmed by Transgrid (or developed) under this project for use in this assessment. Any significant changes to this information will require a revision of this document.

3.1 Reference Documents

The listed information in Table 2 and Table 3 includes drawings and information which have been cited or used in this assessment.

Table 2: Reference documents used in this study

Reference	Title	Rev
B1	VNI West – Basis of Design	2.0
B2	VNI West – Preferred Transmission Line Alignment ² (.kmz)	-
B3	TL Network (.kmz)	-
B4	Project EnergyConnect EF and EMF Study-EIS2	3
B5	VNI West – Electric and Magnetic Field Study	3
B5	Line 51 Replacement Rev1.1 (.kmz)	-
B6	500 kV Line Design Rev 1.5 (.kmz)	-
B7	Humelink Line Design (.dxf)	-
B8	Yanco Delta WF 2.4 no PEC (.kmz)	-
B9	EnergyConnect (NSW- Eastern Section) project L2_Dinawan-Buronga (.kmz)	-
	Transgrid transmission lines standards & guidelines	-

Table 3: reference structure drawings used in the study

Reference	Title	Rev
TL 799229-01	Humelink 500 kV TL- Light tension tower type VTU	B
TL 799231-01	Humelink 500 kV TL- Light tension tower type VTU	B
TL 799231-02	Humelink 500 kV TL- Light tension tower type VTU	B
TL 799232-01	Humelink 500 kV TL- Medium tension tower type VTV	B
TL 799234-01	Humelink 500 kV TL- Medium tension tower type VTV	B
TL 799234-02	Humelink 500 kV TL- Medium tension tower type VTV	B

¹ The line's corona performance is less influenced by secondary factors such as altitude and pollution. Severe pollution may however have a more significant effect on the corona performance of a transmission line and is generally specific to a particular area.

² Project Update brochure available online (<https://media.caapp.com.au/pdf/0h3624/518f52ef-1bc1-4387-9f36-23568226954a/vni-west-project-update-brochure-march2024.pdf>).

Reference	Title	Rev
TL 799235-01	Humelink 500 kV TL- Terminal tension tower type VTW	B
TL 799237-01	Humelink 500 kV TL- Terminal tension tower type VTW	B
TL 799237-02	Humelink 500 kV TL- Terminal tension tower type VTW	B
TL 799226-01	Humelink 500 kV TL- Suspension tower type VSU	B
TL 799228-01	Humelink 500 kV TL- Suspension tower type VSU	B
TL190250	TransGrid 132 kV- General arrangement structure type LQH, concrete pole	01
TL190260	TransGrid 132 kV- Pole assembly structure type LQH, LQK & LQL	02
TL141170	TransGrid 132 kV- TL fitting crossarms	04
TL915215	CWOREZ Project Light Suspension Tower RSR electrical clearance diagram	A2
TL-915243/1	CWOREZ Project Light Strain Tower RWA electrical clearance diagram	A1
TL915248	CWOREZ Project Heavy Strain Tower RWC electrical clearance diagram	A1
TL878175	EnergyConnect- 330 kV Guyed light suspension tower RSG	A0
TL878176	EnergyConnect- 330 kV Guyed light suspension tower RSG	A0

3.2 Basis of Design – Study Parameters

The baseline parameters used for the assessment in this report are taken from the basis of design report for the VNI West transmission line project, as summarised below in Table 4.

3.2.1 VNI Transmission Lines – System Definition:

Table 4: VNI West transmission lines – study parameters

Parameters	Requirements
VNI West 500 kV double circuit transmission line	
Phase Conductors	Orange ACSR/GZ
Phase Sub-Conductors / Bundle Spacing	4 / 460 mm
Earth wires ³	Heavy
Minimum Ground Clearance	12.5 metres ⁴ [B5]
Phase to Phase (V)	550 kV, 1.1 p.u
Phase to Neutral (V)	317.54 kV, 1.1 p.u
Current Rating	4255 A (summer daytime) 1848 A (Time-weighted average - TWA ⁵)
Observation Zone	1 metre (Maximum height of child, or seated adult), 2 metres (Maximum standing height of adult)

³ Lemon ACSR/GZ 30/7/3.0mm (heavy) earth wires (2 off) have been considered for all models in this assessment. There is opportunity to use light earth wires and OPGWs in certain areas of the line, further analysis is required during latter stages to confirm conduction selection/configuration.

⁴ The absolute minimum ground clearance 12.5 metres determined from VNI West – Electric and Magnetic Field Study has been used to approximate the average conductor heights used for this study.

⁵ The time weighted average gives a typical daily average load and both circuits in service.

Parameters	Requirements
Transmission Line Easement	70 metres wide easement (35 metres from centreline) ⁶
System Frequency	50 Hz
Altitude	120 metres
Phasing Arrangement	Circuit 1 (Left) - RWB and Circuit 2 (Right) - BWR
Preferred Transmission Line Alignment	As per GIS information provided by Transgrid [B2]
Line 51 330 kV Double Circuit Transmission Line	
Phase Conductors	Olive ACSR/GZ ⁷
Phase Sub-Conductors / Bundle Spacing	2 / 380 mm
Earth Wires ⁸	Grape ACSR/GZ
Minimum Ground Clearance	8 metres ⁹ [B1]
Phase to Phase (V)	363 kV, 1.1 p.u
Phase to Neutral (V)	209.58 kV, 1.1 p.u
Current Rating	3500 A (Maximum – Summer daytime) 1575 A (TWA)
Transmission Line Easement	60 metres wide easement (30 metres from centreline)
Observation Profile	1 metre (Maximum height of child, or seated adult), 2 metres (Maximum standing height of adult)
System Frequency	50 Hz
Altitude	380 metres
Phasing Arrangement	Circuit 1 (Left) – RWB and Circuit 2 (Right) – BWR
Preferred Transmission Line Alignment	As per GIS information provided by Transgrid [B5]

3.2.2 Existing Nearby Services (Parallel Lines) – System Definition

Along some sections of the VNI West transmission lines, planned assets will parallel other existing transmission lines. The wideband AN emission from both transmission lines will contribute to the total wideband AN.

The identified parallel services include:

- Yanco Delta 330 kV double circuit transmission line (parallel to VNI West 500 kV double circuit transmission line)
- EnergyConnect (NSW Eastern Section) project, L2 project (Dinawan to Buronga) 330 kV double circuit transmission line referred to by this report as EnergyConnect Line 2 330 kV double circuit transmission line (parallel to VNI West 500 kV double circuit transmission line)

⁶ The transmission line between the NSW/Victorian border and the future Dinawan substation would be located within an easement approximately 70 metres wide, except at two transposition locations, requiring a 110-metre easement for approximately 1 kilometre in length at each location.

⁷ Actual conductor is ZTACIR/AS-Olive cable, the conductor cable electrical properties have been modelled are similar to ZTACIR/AS-Olive cable.

⁸ Grape ACSR/GZ 30/7/2.5 mm (heavy) earth wires (2 off) have been considered for all models in the Line 51 330 kV double circuit transmission line assessment

⁹ The absolute minimum ground clearance 8.0 metres determined from VNI West – Electric and Magnetic Field Study has been used to approximate the average conductor heights used for this study.

- HumeLink 500 kV double circuit transmission line (parallel to Line 51 330 kV double circuit transmission line)

The baseline parameters used in this report for the identified parallel services, were provided by Transgrid (unless otherwise noted) and summarised below in Table 5.

Table 5: Identified nearby service (transmission lines) – Study parameters

Parameters	Requirements
Yanco Delta 330 kV Double Circuit Transmission Line	
Phase Conductors	Olive ACSR/GZ
Phase Sub-Conductors / Bundle Spacing	3 / 460 mm
Earth Wires ¹⁰	Opal AAAC
OPGW	18 mm, 28 Core OPGW (Type B).
Minimum Ground Clearance	9 metres
Phase to Phase (V)	363 kV, 1.1 p.u
Phase to Neutral (V)	209.58 kV, 1.1 p.u
Current Rating	2000 MVA, 3500 A (Maximum – Summer daytime)
Transmission Line Easement	60 metres wide easement (30 metres from centreline)
System Frequency	50 Hz
Transmission Line Alignment	As per GIS information provided by Transgrid [B8]
EnergyConnect Line 2 330 kV Double Circuit Transmission Line	
Phase Conductors	Mango ACSR/GZ
Phase Sub-Conductors / Bundle Spacing	2 / 380 mm
Earth Wires ¹¹	Grape ACSR
Minimum Ground Clearance	9 metres
Phase to Phase (V)	363 kV, 1.1 p.u
Phase to Neutral (V)	209.58 kV, 1.1 p.u
Current Rating	800 MVA, 1400 A (Maximum – Summer daytime)
Transmission Line Easement	80 metres wide easement (40 metres from centreline)
System Frequency	50 Hz
Transmission Line Alignment	As per GIS information provided by Transgrid [B9]
Humelink 500 kV Double Circuit Transmission Line	
Phase Conductors	Orange ACSR/GZ
Phase Sub-Conductors / Bundle Spacing	4 / 460 mm
Earth Wires ¹²	Heavy

¹⁰ Opal AAAC earth wires (2 off) have been considered for all models in this assessment.

¹¹ Opal AAAC earth wires (2 off) have been considered for all models in this assessment.

¹² Lemon ACSR/GZ 30/7/3.0mm (heavy) earth wires (2 off) have been considered for all models in this assessment. There is opportunity to use light earth wires and OPGWs in certain areas of the line, further analysis is required during latter stages to confirm conduction selection/configuration.

Parameters	Requirements
Minimum Ground Clearance	13 metres ¹³
Phase to Phase (V)	550 kV, 1.1 p.u
Phase to Neutral (V)	317.54 kV, 1.1 p.u
Current Rating ¹⁴	4255 A (Maximum – Summer daytime)
Transmission Line Easement	70 metres wide easement (35 metres from centreline)
System Frequency	50 Hz
Phasing Arrangement	Circuit 1 (Left) – RWB and Circuit 2 (Right) – BWR
Transmission Line Alignment	As per GIS information provided by Transgrid [B7]

3.2.3 Minimum Ground Clearance

The absolute limits for minimum ground clearance specified in the EMF report ([B5]) for the new VNI west transmission lines, as listed below, have been considered for the assessment of AN and RFI limits:

- A threshold for minimum ground clearance of 12.5 metres for the VNI West 500 kV double circuit transmission line.
- A threshold for minimum ground clearance of 8.0 metres for the Line 51 330 kV double circuit transmission line.

Based on the outcomes of this investigation, Transgrid will design, construct and operate the line to ensure the minimum ground clearance is compliant to within these bounds, or better.

¹³ The actual ground clearance is expected to be no lower than 13 metre as per (HumeLink study) and therefore the results of this assessment for this parallel alignment are considered to be conservative.

¹⁴ The Transgrid HumeLink 500 kV double circuit current rating is assumed to be equal to (not greater than) the VNI West 500 kV double circuit transmission line specifications.

3.3 Structure Geometry

There are four structure types proposed along the length of VNI West 500 kV double circuit transmission line:

- VTU – Light Tension Tower
- VTV – Medium Tension Tower
- VTW – Heavy Tension Tower
- VSU – Suspension Tower

There are three structure types proposed along the length of Line 51 330 kV¹⁵ double circuit transmission line:

- RSR – Light Suspension Tower
- RWA – Light Strain Tower
- RWC – Heavy Strain Tower

The structure outline drawings referenced in Table 3 define the phase/bundle conductor arrangements considered in the assessment. Actual design dimensions may vary from the concept dimensions used. Differences are likely to be small, but reconfirmation of the calculated values may be required if designs vary significantly. The referenced drawings are also included in Appendix A and Appendix B.

3.4 Weather Data (Precipitation)

Long-term historical weather data from the Bureau of Meteorology (BoM) was gathered and processed to determine nominal and peak rain rates over 24-hour periods at nominated sites along the preferred transmission line alignment for transmission line considered in this study. The results of this analysis are summarized in Table 6 and Table 7.

From the tables below, the highest recorded rain-fall rate (highlighted yellow) for each respective transmission line alignment considered in this study, shall be used as a weather correction factor in SES-Enviro Version 19.0¹⁶ for calculation methods.

Table 6: Calculated nominal rainfall parameters along VNI West 500 kV double circuit transmission line

Location	BoM Station	Rain Rate (mm/hr)	
		Mean	STD
Swan Hill	77094	0.26	0.30
Deniliquin	74258	0.29	0.30
Griffith	75041	0.30	0.34
Yanco	74037	0.30	0.34

¹⁵ RWA and RWC tower drawings show both heavy and light insulators, the assessment considers an insulator length of 3.427 metres. Refer to TL-903581 and manufacturer catalogues.

¹⁶ The SESEnviroPlus software package (part of the CDEGS suite) is an electromagnetic environmental impact assessment analysis (EEIA) tool. For a technical description of the software and its functionality, see: <https://www.sestech.com/en/Product/Package/SESEnviroPlus>

Table 7: Nominal rainfall parameters along Line 51 330 kV double circuit transmission line

Location	BoM Station	Rain Rate (mm/hr)	
		Mean	STD
Wagga Wagga	72150	0.35	0.39
Kapooka (Defence)	74272	0.23	0.36

4. AN and RFI Assessment Criteria

The following section identifies the assessment criteria and limits of the AN and RFI study considered in this report.

4.1 Surface Voltage Gradient

The source of the corona discharges on transmission line conductors is the high electric field strength near the surface of each conductor, which is referred to as the conductor Surface Voltage Gradient (SVG). Other factors, such as the accumulation of pollution and water droplets on the conductor surface influence the level of corona discharge. It is, however, the unperturbed electric field strength that is used as the reference field for the corona calculations. The effect of pollution and rain on the corona performance is then determined by adding empirical correction factors (environmental factors) to the reference performance.

The TLDM identifies a maximum conductor SVG of 16 kV/cm¹⁷ being generally accepted as a design criteria for sizing conductors and determining bundle sizes. This is in line with recommendations of AS/NZS 7000 for limiting the generation of corona discharges. The intention of this design criteria is to minimise the impact of AN and RFI on the local environment.

The corona performance of a transmission line is primarily dependent¹⁸ on the average maximum Surface Voltage Gradient (SVG) on the phase conductor bundles.

The study of these phenomena depends on factors relating to the system definition, i.e. phase conductor and bundle arrangements, system operating conditions and structure/line configurations for conductor heights relative to an observation point and weather conditions.

4.2 Audible Noise

Audible noise performance of a transmission line is primarily determined by the noise generation function, and the propagation of noise away from the source (i.e. line) is not affected by any particular line configuration¹⁹. Conductor corona generates two forms of audible noise - a wideband, random crackling sound and very narrowband tones - the most significant of which is the 100 Hz tone. The wideband noise is the dominant component of the emitted sound energy; however, the narrowband tonal component may become particularly significant on new conductors with a hydrophobic surface under wet conditions.

Transgrid's requirements (TLDM-MNB) state that audible noise calculations ($L_{50 \text{ wet}}$) for any conductor is assessed for a 50 dB(A) noise limit using the EPRI semi-empirical calculation method. This limit applies at the edge of the 70 metres easement in wet conditions.

The NSW Noise Policy for Industry (NPfI) addresses the impact of noise from industrial sources scheduled under the Protection of the Environment Operations Act 1997. While transmission line easements are not 'scheduled premises' under the Act (i.e. NPfI does not necessarily apply), the NPfI does provide a framework

¹⁷ Per TLDM-MNB (Rev 2) – Section 10.11, higher values of SVG may be accepted by Transgrid where acceptable AN and RFI performance is demonstrated.

¹⁸ The line's corona performance is less influenced by secondary factors such as altitude and pollution. Severe pollution may however have a more significant effect on the corona performance of a transmission line and is generally specific to a particular area (e.g. seasonal insect swarms or severe dust storms).

¹⁹ EPRI AC Transmission Line Reference Book – 200 kV and Above- third edition

for assessing the transmission line noise emissions. The residential receptor intrusive criterion²⁰ and residential amenity criteria defined in the NPfI have been used as a guide for determining whether the level of transmission line Audible Noise (AN) is acceptable.

For the residential receptor intrusiveness criteria, the EPA states in Section 2.3 of the NPfI that the LEQ level of noise intrusion from wideband noise sources may be up to 5 dB above the L₉₀ background noise level at the receptor without being considered intrusive. The residential amenity criteria summarised in Table 8 are based on Table 2.2 in the NPfI. They are defined as recommended LEQ industrial noise levels that under normal circumstances should not be exceeded. The intention of these limits is to prevent successive developments near residential areas progressively increasing the background noise level by less than 5 dB each time with no upper tolerable limit. The limits apply at the location of the sensitive receivers (i.e. the residential dwellings or places of work).

Table 8: Project noise trigger levels adopted for transmission lines considered in this study

Receiver Location	Assessment / Receiver Type	Project Noise Trigger Levels (dBA _{Leq,15min})		
		Day ²¹	Evening ²²	Night ²³
Rural residential	Intrusiveness ²⁴	40	35	35
	Amenity ²⁵	48	43	38
	PNTL – Residential	40	35	35
Passive recreation	Amenity ²⁶	48		
Industrial premises	Amenity	68		
Edge of easement	TLDM-MNB	50		

The wet conductor AN emissions also have a very narrowband tonal characteristic (100 Hz tone). Modifying factor corrections for tonal noise are specified by *Table C1* in Fact Sheet C of the NPfI of 5 dB. This factor is a correction to account for the additional annoyance of the noise source. This correction factor is to be applied where the one-third octave band associated with corona (100 Hz) exceeds the level of the adjacent bands on both sides by 15 dB or more.

4.3 Radio Frequency Interference

Limits for electromagnetic interference (radio disturbance) from the transmission lines considered in this study, are established in AS 2344 in the frequency band 0.15 MHz to 3000 MHz. A satisfactory level of radio reception, as defined by the International Telecommunication Union (ITU), can be expected for broadcast, navigation, safety-of-life and other radio communication services in areas where the emissions from the transmission line are below these limits. These limits are generally applied at the boundary of the respective line easement.

²⁰ EPA states in Section 2.3 of the NPfI that the L_{EQ} level of noise intrusion from wideband noise sources may be up to 5 dB above the L₉₀ background noise level at the receptor without being considered intrusive.

²¹ Day-time is defined as the period from 7:00 am to 6:00 pm Monday to Saturday or 8:00 am to 6:00 pm on Sundays and public holidays

²² Evening is defined as the period from 6:00 pm to 10:00 pm.

²³ Night-time is defined as the period outside of day-time and evening.

²⁴ The existing background noise level has been determined by VNI west Technical Paper 7 -Noise and Vibration by WSP Rev B in accordance with Noise Category R1, Appendix A, AS1055.1:1997.

²⁵ $L_{Aeq,15min} = L_{Aeq,period} + 3 \text{ dB}$

²⁶ When in use

New South Wales falls into ITU Region 3, Zone C. The applicable RFI emission limits for this zone and the (mostly) rural environments along the VNI West transmission line alignment are summarised in Table 9.

Compliance with the limits is verified by testing in accordance with CISPR TR 18-2. The measured levels at an appropriate location must comply with the limits for at least 80% of the time with a confidence level of at least 80% (80/80 rule). The only variability considered in the calculations was that between fair and wet weather conditions (and rainfall rate), the effects of wind, temperature, relative humidity and pollution will be negligible in comparison.

Table 9: RFI limits applied at the edge of the transmission line easements

Frequency (MHz)	Field Strength (dBμA/m)		Field Strength (dBμV/m)
	Urban Areas ²⁷	All Other Areas	
0.15 – 0.3	-1.5	-1.5	n/a
0.3 – 0.5	-15.5	-15.5	n/a
0.5 – 1.7	-1.5	-15.5	n/a
1.7 – 3	-15.5	-15.5	n/a
3 – 30 ²⁸	-15.5 to -28.5	-15.5 to -28.5	n/a
30 – 230	n/a	n/a	30
230 – 1 000	n/a	n/a	37
1 000 – 3 000	n/a	n/a	60

The RFI limits defined in AS 2344 are derived for a signal to noise protection ratio of 30 dB considering region 3 as applicable to NSW Australia.

It is noted that these limits are defined for the protection of broadcast and communication reception against the subjective annoyance caused by the interference from transmission line RFI, specifically for perceived annoyance to music listeners. Higher RFI emission levels may be tolerable for less sensitive receivers (e.g. receivers located close to the relevant transmitter or receivers that use more sophisticated modulation techniques) or where there is greater tolerance for reduced intelligibility or increased annoyance.

The TLDM-MNB specifies that the “Class” defining the quality of reception using the CIGRE scale should not be worse than Class 3 for wet conductors

²⁷ Applicable to areas having a population of greater than 2000 people that are serviced by local broadcast stations

²⁸ The limit decreases linearly with the logarithm of the frequency from 3 MHz to 30 MHz

5. Surface Voltage Gradient

The AN and RFI performance of the transmission lines are correlated to the average maximum surface voltage gradient (corona discharge) on the conductor bundles.

The average maximum SVG was calculated using SES-Enviro Version 19.0 for the baseline parameters, structure/line configuration and phasing arrangements for each structure outlined in Section 3.

The results are summarised in Table 10 and Table 11 for the various structure types proposed for the transmission lines considered in this study.

Table 10: Calculated average maximum SVG on VNI West 500 kV double circuit transmission line structures.

500 kV Structure Type	Average Maximum Surface Voltage Gradient (kV/cm)		
	Phase A	Phase B	Phase C
VTU	15.8	15.7	15.9
VTV	15.8	15.7	15.9
VTW	15.6	15.9	15.6
VSU	15.9	15.6	16.1

Table 11: Calculated average maximum SVG on Line 51 330 kV double circuit transmission line structures.

330 kV Structure Type	Average Maximum Surface Voltage Gradient (kV/cm)		
	Phase A	Phase B	Phase C
RSR	15.5	15.9	15.7
RWA and RWC	15.6	15.9	15.8

For the VNI west 500 kV double circuit transmission line – it is observed that the highest SVG values are associated with the VSU structure types along the line, while relatively uniform SVG values are observed for other structures. This is attributed mostly to the smaller circuit spacing for the VSU geometry, as the phase spacings for all structures considered are consistent.

For the Line 51 330 kV double circuit transmission line– relatively uniform SVG values are observed across all the structure types along the line.

The reported values reflect the unperturbed electric field strength that is used as the reference field for the corona calculations. The effect of pollution and rain on the corona performance is determined by adding empirical correction factors (environmental factors) to the reference performance.

6. Audible Noise Performance

6.1 Methodology

6.1.1 Wet Weather (Precipitation)

The AN and RFI emissions from a transmission line increase significantly under wet conductor conditions due to the formation of water droplets on the outer surface of the conductors. The Southwire²⁹ SVG plots in Figure 2 illustrate how droplets of different nominal diameters form on the outer surface of the conductor create a higher, localised SVG adjacent to the droplet and therefore increase corona activity. In these plots, the maximum calculated SVG on the round outer wire strands without a water droplet was 26.1 kV/cm as illustrated in Figure 3. The droplet increases the localised SVG by up to 50%, depending on its size.

The standard AN and RFI evaluation methods do not consider the actual distribution of SVG around each outer strand wire but rather, simplifies the analysis by calculating the SVG around a smooth cylindrical conductor of outer radius equal to the outer radius of the stranded round wire conductor. For reference, as illustrated in Figure 3, the SVG for the smooth cylindrical equivalent to the stranded round wire conductor was calculated to be 18.5 kV/cm.

It is reasonable to suggest that more droplets will form on the surface of a conductor with larger diameter (i.e. larger surface area) and on bundles with more sub-conductors so will therefore be subject to more corona sources under wet-weather conditions.

There are complex relationships between the AN and RFI performance of a transmission line and the equivalent smooth conductor's surface voltage gradient, rain rate, sub-conductor number and diameter.

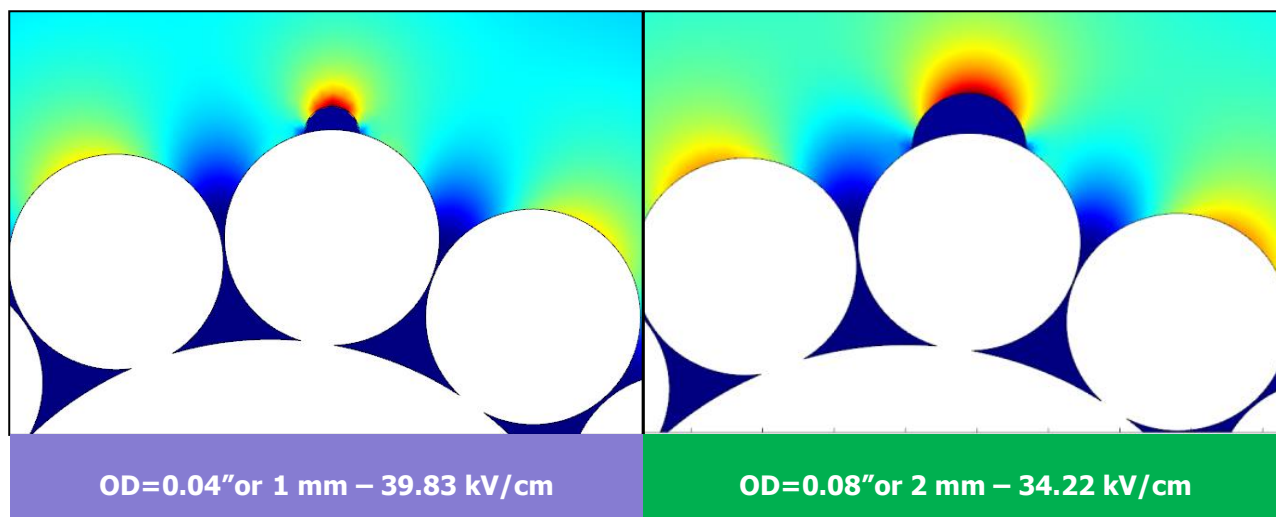


Figure 2: Surface voltage gradient plots for different water droplet sizes [A3] – Southwire

The increase in AN and RFI levels from a transmission line with increasing rain rates subsides at a maximum value for heavy rain rates that are exceeded only 5% of the time (i.e. the L_5 exceedance level). This level is used to represent the maximum AN and RFI performance of a transmission line. However, the AN and RFI performance of a line is generally described by the average wet weather levels. The average wet weather level

²⁹ Southwire Energy Division, "Corona Effects on Bare Overhead Conductors", Oncor Presentation, 2015

is the level derived for rain rates exceeded 50% of the time for a particular region (i.e. the L_{50} exceedance level).

The general approach to predicting the L_{50} AN and RFI performance of a line (which is adopted by the semi-empirical calculation methods) is to calculate the heavy rain L_5 level and then apply a correction factor to determine the L_{50} average wet conductor level. This correction factor is a function of the equivalent smooth conductor surface voltage gradient, sub-conductor diameter and sub-conductor number.

One weather condition that can cause particularly noticeable AN is mist or fog³⁰. This is because the mist or fog forms at night and early morning under light wind conditions which have relatively low background AN level (ambient) and therefore less attenuation. The measurement of AN performance in these conditions is identified with the L_{50} level (wet weather) but should be assessed for residential areas with low levels of ambient noise.³¹

6.1.2 Evaluation Methods

There are numerous evaluation methods available for predicting the AN performance of a transmission line. These methods generally only consider the wideband components' sound pressure level, although the pure tone component observed at 100 Hz may also be derived. Generally, the evaluation methods are divided into two distinct types, empirical and semi-empirical methods.

6.1.3 Altitude

Air density affects the generation of corona sources and the resulting AN and RFI emissions. At higher altitudes above sea level, corona inception occurs at lower conductor surface gradients. VNI west transmission lines structures will be exposed to various altitude, this study considered an altitude of 120 metres for VNI west 500 kV double circuit transmission line and 380 meter altitude for Line 51 330 kV double circuit transmission line.

Increased altitudes should also be considered in the specification and testing of line hardware.

Empirical calculation formulas are derived from field test data recorded at test locations adjacent to operating transmission lines or full-scale test spans. Through regression analysis of the test data, strong correlation between the computed wideband AN level (sound pressure) for each phase of the transmission is identified to be a function of the main parameters, surface voltage gradient (g), sub-conductor number (n), sub-conductor diameter (d) and distance between the conductors and the measurement point (R).

This may be mathematically expressed as:

Equation 1:

$$AN = AN_0 + k_1 f_1(g) + k_2 f_2(n) + k_3 f_3(d) + k_4 f_4(R) + K$$

where AN_0 is a reference noise level, k_1 to k_4 are empirical constants, f_1 to f_4 are functions of the independent main parameters and K is an adjustment factor of the regression analysis.

While the empirical formulas only consider the primary dependencies on the four identified variables, there is also a strong correlation with weather and pollution conditions that is not accounted for, as well as less significant dependencies on other variables that are not considered. Given that the empirical calculation

³⁰ Typical conditions for mist or fog are low, non-zero wind conditions, an ambient temperature below the dew point temperature and a relative humidity of at least greater than 95% without any recorded rainfall over the 24-hour period.

³¹ Further acoustic investigations should be carried out to determine the actual level of ambient noise (background noise) present in the identified (potential) risk zones.

formulas are derived from a discrete, and often limited number of operational transmission lines, they are specific to the characteristics of the line design philosophy for the respective utility or group of utilities who've developed it, as well as the characteristic weather of the region. It is therefore not surprising that the methods developed by individual transmission utilities and national industry bodies have different empirical constants.

An example of a less significant dependency is that of the outer strand diameter. All empirical formulas are based on a derived correlation between the emission levels and the outer diameter of a smooth cylinder with radius equal to the outer diameter of a stranded conductor. The SVG plots published by Southwire³² illustrate in Figure 3 how the actual SVG is much higher at discrete points around the circumference (or fringes) of a round wire conductor. In between those discrete points, in the troughs between adjacent outer strands, the SVG is much lower.

For trapezoidal wire (TW) conductors, the peak SVG is lower than that of the round wire (RW) conductor but has a larger distribution around the circumference of the TW conductor. RW conductors that have a high strand-to-conductor radius ratio will have a higher peak SVG over a smaller surface area, whereas conductors with a low strand-to-conductor radius ratio will have the opposite effects, similar to the TW conductors. The available empirical formulas do not consider this dependency and the sensitivity of the calculated AN level to the strand-to-conductor radius ratio is implicit to the empirical constants in Equation 1. This empirical constant will therefore vary for the various methods which are derived for different types of bundles with many small-diameter sub-conductors (e.g. Hydro Quebec – IREQ method) to those derived by utilities that use bundles with fewer large-diameter sub-conductors (e.g. EPRI method).

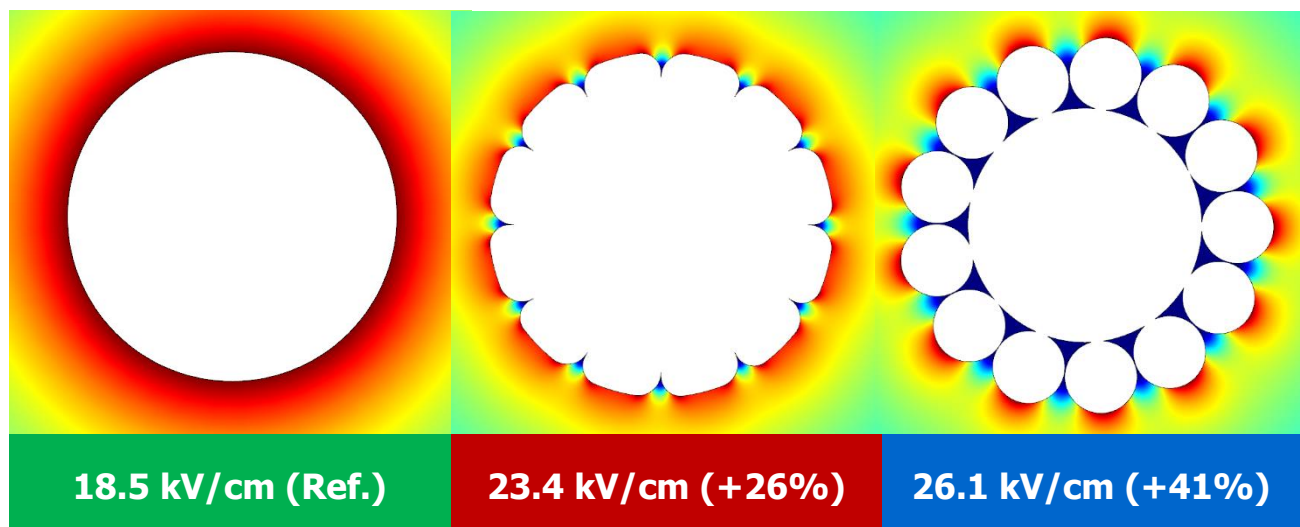


Figure 3: Surface voltage gradient plots for different conductor types [Southwire]

The empirical formulas are also generally derived for average rain conditions (i.e. L_{50} exceedance levels). Given that the maximum AN level is dependent on the rain rate, the formulas are therefore specific to the range of average rain rates for locations specific to the lines included in the regression analysis.

For example, the empirical EPRI formula was derived from measured data on the full-scale test span. The L_{50} natural rainfall intensity for the derived formula was 0.75 mm/hr at the Pittsfield, Massachusetts project test facility. The corresponding rainfall rates derived in Section 3.4 for the transmission lines considered in this study are observed to be higher than this value (according to BoM) and will therefore require correction factors

³² Southwire Energy Division, "Corona Effects on Bare Overhead Conductors", Oncor Presentation, 2015

for a defined rate to ensure parity for this analysis. Using the EPRI calculation formula without a rainfall rate correction factor, would produce misleading AN calculation results.

Several published empirical calculation methods for AC transmission lines were compared in an IEEE committee report³³, which concluded that results obtained from applying the different methods to as many of the test configurations/methods as possible (even when some methods were outside the domain of validity) would provide significant variation. The paper strongly suggests taking care to use a particular method within the specified range for which the method was researched or developed. Further, for the methods included in SES-Enviro Version 19.0 (six empirical methods), the results compare favorably with experimental results.

Beca have reviewed details for the transmission lines tested in developing the methods used in SES-Enviro Version 19.0, as the IEEE Committee suggests. Some methods may be applicable only when particular conditions apply i.e. based on the empirical data obtained under different test conditions. In this case, the domain of validity for all the available methods³⁴ is technically applicable to the transmission lines considered in this study, however, may not be appropriate to produce the most accurate results specific to the topography and configuration.

Semi-empirical calculation formulas and the experimental data are generally derived from tests on three phase and single-phase lines, or within outdoor test cages. The conductor bundle under test is surrounded by a cage of earthed wires that replicate the average maximum SVG on the bundle with much reduced ground clearances. The test conductor is tensioned over a shorter length to negate the impact of the catenary shape on the generated noise. This scaled down test facility allows numerous different conductors to be tested, including concept bundle designs, over a wide range of SVGs. Water sprinkler systems are attached to the cage that allows testing of the bundles under controlled rain rates. Semi-empirical formulas generally predict the heavy rain L₅ exceedance level, which represents the upper limit of the AN emissions, but provide correction factors for different rain rates. Experimental data is independent of the transmission line geometry, so correction factors also account for the SVG and bundle geometry dependencies to produce more accurate assessment of AN for different rainfall rates. Additionally, new conductors can be monitored over time to determine the impact of new conductor effects associated with grease and drawing oil on the outer surface of the conductor which causes hydrophobic effects.

At a first instance, the experimental data from the test cage / laboratory is used to derive a per unit length line generated noise source i.e. quantity A, defined as the A-weighted³⁵ generated acoustic power density. Acoustic transmission theory is then used to determine the sound pressure propagating AN level at an observation point from the line sources, called AN generation functions, applied to the phase conductor bundles.

The **EPRI (USA) semi-empirical method** is considered the most appropriate for assessing the AN performance of the transmission lines considered in this study and is also the preferred method per Transgrid's requirements (TLDM-MNB). The EPRI method also provides an SVG-dependent rainfall rate correction factor, a method of calculating the sound pressure level at the 100 Hz tone and a correction factor for new conductor effects.

EPRI (semi-empirical) calculation methods were used in SES-Enviro Version 19.0 to determine the wideband AN levels for the lines considered in this study. Results calculated using the BPA method are included for

³³ IEEE Committee Report, "A Comparison of Methods for Calculating Audible Noise of High Voltage Transmission Lines", IEEE Trans., Vol. PAS-101, October 1982, pp. 4090-4099

³⁴ There are six available empirical methods introduced in SES-Enviro for AC voltages: IREQ method (Canada), General Electric method (USA), BPA method (USA), EdF method (France), ENEL method (Italy), and FGH method (Germany).

³⁵ The A-weighted level is a widely used noise measure that takes into account the entire frequency spectrum of the noise, but which gives more weight to the mid-frequencies (500-3000 Hz). Human hearing is most sensitive at this range.

comparison purposes only. The EPRI calculations considered a rainfall rate of 0.34 mm/hr for the VNI West 500 kV double circuit transmission line and a rainfall rate of 0.39 mm/hr for the Line 51 330 kV double circuit transmission line (refer to Section 3.4). The BPA calculations provide $L_{50 \text{ wet}}$ exceedance levels for an unspecified rainfall rate.

SES-Enviro Version 19.0 does not provide sound pressure level calculations for the 100 Hz pure tones. Modifying factors for tonality may need to be considered at sensitive receivers identified within the AN risk zone.

6.2 AN Levels

The wideband AN performance of the transmission lines considered in this study is calculated for all proposed structure types using for the baseline parameters, structure/line configuration and phasing arrangements outlined in Section 3.

The calculated wideband AN levels are assessed at observation height of 1 metre and 2 metres above ground for average rain ($L_{50 \text{ wet}}$) and average fair weather ($L_{50 \text{ dry}}$) conditions.

The results are summarised below for the VNI West 500 kV double circuit transmission line and Line 51 330 kV double circuit transmission line in Table 12 and Table 13 respectively.

Table 12: Calculated wideband AN levels at the edge of 70 metres easement.

Structures	Observation Height	EPRI, dB(A)		BPA, dB(A)		Limit
		$L_{50 \text{ wet}}$	$L_{50 \text{ dry(adj)}}$	$L_{50 \text{ wet}}$	$L_{50 \text{ dry}}$	
VTU	1 metre	47.0	19.7	46.3	21.3	50
	2 metres	47.1	19.8	46.3	21.3	50
VTV	1 metre	47.0	19.7	46.2	21.2	50
	2 metres	47.0	19.8	46.3	21.3	50
VTW	1 metre	46.6	19.3	45.9	20.9	50
	2 metres	46.7	19.4	46.0	21.0	50
VSU	1 metre	47.3	20.1	46.5	21.5	50
	2 metres	47.4	20.2	46.6	21.6	50

The maximum sound pressure level ($L_{50 \text{ wet}}$) at the edge of the 70 metres easement is identified as 47.4 dB(A) which is less than the 50 dB(A) limit as required by Transgrid's TLDM-MNB. Fair weather AN levels³⁶ will be within the project noise trigger level of 35 dB(A) within or close to the edge of the line easement.

³⁶ EPRI method $L_{50 \text{ dry}}$ sound pressure level with fair weather correction factor of 15 dB applied, based on long-term audible noise measurements conducted in clean environments, which show that during fair weather (dry) conditions the AN level is about 25 dB(A) less than that of the L_{50} AN levels during measurable rain. See $L_{50 \text{ dry(adj)}}$ reported results.

Table 13: Calculated wideband AN levels at the edge of 60 metres easement.

Structures	Observation Height	EPRI, dB(A)		BPA, dB(A)		Limit
		L ₅₀ wet	L ₅₀ dry(adj) ³⁷	L ₅₀ wet	L ₅₀ dry	
RSR	1 metre	47.6	23.6	46.7	21.7	50
	2 metres	47.7	23.7	46.8	21.8	50
RWA and RWC	1 metre	47.8	23.8	46.9	21.9	50
	2 metres	47.9	23.8	47.0	22.0	50

The maximum sound pressure level (L_{50 wet}) at the edge of the 60 metres easement is identified as 47.9 dB(A) which is less than the 50 dB(A) limit as required by Transgrid's TLDM-MNB. Fair weather AN levels³⁸ will be within the project noise trigger level of 35 dB(A) within or close to the edge of the line easement.

6.3 100 Hz Tonality

The sound pressure level produced by transmission line corona include pure tones, the most significant of which occurs at twice the power frequency i.e. at the 100 Hz tone. The sound pressure (AN) is correlated to the voltage phase angle of the phase conductor bundle that generates it. The total pressure is determined by six direct and six reflected wave fronts with these phase correlations that are correlated at the observation point. The vector total of these wave fronts results in the observed sound pressure level of the 100 Hz tone at the observation point. Variations in observation height and distance from the line's easement will result in a standing wave pattern of constructive and destructive interference.

The hum is particularly noticeable in similar conditions to that which produces a large amount of corona loss i.e. heavy rain. The hum noise is only slightly attenuated by the natural landscape, i.e. trees, air, so at larger distance from the line and/or at residential zones it may become more noticeable. In addition, the resulting hum is dependent on the location of the measuring point, including its height above ground.

Modifying factors for tonality may need to be considered at sensitive receivers identified within the AN risk zone.

6.4 Parallel Transmission Lines

6.4.1 VNI West 500 kV Double Circuit // Yanco Delta 330 kV Double Circuit Transmission Line

The new VNI West 500 kV double circuit transmission line alignment is identified to parallel a planned 330 kV double circuit transmission line, supplying the adjacent Yanco Delta double circuit transmission line. The parallel section is identified between spans, from Tower 24 to Tower 46. The assessment considers both parallel easements to share a boundary line, without encroaching – for a centre-to-centre distance of 65 metres³⁹.

³⁷ It is noted that the calculated EPRI fair weather AN levels are much higher than the equivalent BPA levels, whereas there was only a marginal variance between the calculated EPRI and BPA average rain AN levels. The EPRI reference book indicates that the fair weather AN levels are extremely variable as they are very dependent on surface pollution (i.e. dust particles, insects and other aerosols).

³⁸ EPRI method L_{50dry} sound pressure level with fair weather correction factor of 15 dB applied, based on long-term audible noise measurements conducted in clean environments, which show that during fair weather (dry) conditions the AN level is about 25 dB(A) less than that of the L₅₀ AN levels during measurable rain.

³⁹ The measured minimum distance between the centre points of each respective easement.

Calculate the total wideband AN emissions relative to the parallel line sections, assessed at observation heights of 1 metre and 2 metres above ground for average rain ($L_{50 \text{ wet}}$) and average fair weather ($L_{50 \text{ dry}}$) conditions. The results are summarised below relevant to the VNI West 500 kV double circuit transmission line in Table 14 and see Appendix E for the plot.

The assessment has considered the system definition for both modelled systems as per Section 3 of this report.

Table 14: Calculated wideband AN levels at the edge of easement of 70 m line easement for VTW tower⁴⁰.

Structures	Observation Height	EPRI, dB(A)		BPA, dB(A)		Limit
		$L_{50 \text{ wet}}$	$L_{50 \text{ dry(adj)}}$	$L_{50 \text{ wet}}$	$L_{50 \text{ dry}}$	
VTW	1 metre	48.7	21.3	46.3	21.3	50
	2 metres	48.8	21.3	46.3	21.3	50

The maximum sound pressure level ($L_{50 \text{ wet}}$) at the edge of the 70 metres easement is identified as 48.8 dB(A) which is less than 50 dB(A) limit as required by Transgrid's TLDM-MNB. Fair weather AN levels will be within the project noise trigger level of 35 dB(A) within or close to the edge of the line easement

6.4.2 Line 51 330 kV Double Circuit Replacement // Humelink 500 kV Double Circuit

The Line 51 330 kV double circuit transmission line runs parallel with the Humelink 500 kV double circuit transmission line between Ivydale Road (south of the existing Wagga 330 kV substation) and the future Gugaa 500 kV substation. The parallel section is identified between spans, from Tower HL conn.1 to Tower HL conn.2. The assessment considers both parallel easements to share a boundary line, without encroaching – for a centre-to-centre distance of 65 metres⁴¹.

Calculate the total wideband AN emissions relative to the parallel line sections, assessed at observation heights of 1 metre and 2 metres above ground for average rain ($L_{50 \text{ wet}}$) and average fair weather ($L_{50 \text{ dry}}$) conditions. The results are summarised below relevant to the Line 51 330 kV double circuit transmission line in Table 15 and see appendix E for the plot.

The assessment has considered the system definition for both modelled systems as per Section 3 of this report.

Table 15: Calculated wideband AN levels at the edge of easement of 60 m line easement for RWA and RWC tower⁴²

Structures	Observation Height	EPRI, dB(A)		BPA, dB(A)		Limit
		$L_{50 \text{ wet}}$	$L_{50 \text{ dry(adj)}}$	$L_{50 \text{ wet}}$	$L_{50 \text{ dry}}$	
RWA and RWC	1 metre	51.5	25.8	49.6	24.6	50
	2 metres	51.5	25.9	49.7	24.7	50

The maximum sound pressure level ($L_{50 \text{ wet}}$) at the edge of the 60 metres easement is identified as 51.5 dB(A) which is above the 50 dB(A) limit as required by Transgrid's TLDM-MNB. Fair weather AN levels will be within the project noise trigger level of 35 dB(A) within or close to the edge of the line easement

⁴⁰ Only a single tower/line configuration has been modelled parallel assessment, as VTW tower produces worst RFI limits

⁴¹ The measured minimum distance between the centre points of each respective easement.

⁴² Only a single tower/line configuration has been modelled parallel assessment, as RWA and RWC tower produces worst RFI limits

6.4.3 VNI West 500 kV Double Circuit // EnergyConnect project Line 2 330 kV Double Circuit

The VNI West 500 kV double circuit transmission line alignment is identified to parallel with EnergyConnect Project Line 2 330 kV double circuit transmission line. The parallel section is identified between spans, from Tower 1 to Tower 24. The assessment considers both parallel easements to share a boundary line, without encroaching – for a centre-to-centre distance of 75 metres⁴³.

Calculated the total wideband AN emissions relative to the parallel line sections, assessed at observation heights of 1 metre and 2 metres above ground for average rain ($L_{50 \text{ wet}}$) and average fair weather ($L_{50 \text{ dry}}$) conditions. The results are summarised below relevant to the VNI West 500 kV double circuit transmission line in Table 16 and see Appendix E for the plot.

The assessment has considered the system definition for both modelled systems as per Section 3 of this report.

Table 16: Calculated wideband AN levels at the edge of easement of 70 metres line easement for VTW tower⁴⁴.

Structure	Observation Height	EPRI, dB(A)		BPA, dB(A)		Limit
		$L_{50 \text{ wet}}$	$L_{50 \text{ dry(adj)}}$	$L_{50 \text{ wet}}$	$L_{50 \text{ dry}}$	
VTW	1 metre	50.8	27.2	50.1	25.1	50
	2 metres	50.8	27.2	50.1	25.1	50

The maximum sound pressure level ($L_{50 \text{ wet}}$) at the edge of the 70 metres easement is identified as 50.8 dB(A) which is less than 50 dB(A) limit as required by Transgrid's TLDM-MNB. Fair weather AN levels will be within the project noise trigger level of 35 dB(A) within or close to the edge of the line easement

6.5 New Conductor Effects

The BPA method of calculating AN levels is defined for aged (i.e. weathered) conductors and not newly strung conductors. Grease applied to the steel core strands for corrosion protection, or residual drawing oil from the cable manufacturing process will create a hydrophobic surface on the outer strands of the conductor and in the valleys between adjacent outer strands. During rain or mist/fog conditions, the hydrophobic nature of the conductor surface causes moisture on the conductor surface to form small droplets that do not move downwards to the under surface of the conductor under the normal forces of gravity and capillary action. Small droplets collecting around the conductor surface act as sources of concentrated corona activity that vibrate at harmonic frequencies of 50 Hz (most notably 100 Hz and 200 Hz).

The sun's UV and chemical pollution break down these residual oil and grease layers over time, resulting in a hydrophilic outer conductor surface. The hydrophilic surface opposes the formation of droplets on the conductor surface and results in conductors with minimal corona sources. The observed period of conductor ageing may be as long as 3 years in low-pollution regions, as reported in the EPRI reference book.

Grease near the conductor core will migrate to the surface and fill the valleys between adjacent surface strands due to mechanical torsion forces on the conductor. This further prevents the conductor from shedding surface water and results in increased AN generation. This process can continue for many years.

The residual drawing oil on the newly strung conductors will increase AN levels under the line above the calculated levels reported in Section 6.2 to Section 6.4, for the first few years of operation. Research conducted by EPRI correlates a higher increase in initial AN level for conductors operating at lower surface voltage

⁴³ The measured minimum distance between the centre points of each respective easement.

⁴⁴ Only a single tower/line configuration has been modelled parallel assessment, as VTW tower produces worst RFI limits

gradient. For the surface voltage gradients at which the transmission lines considered by this study will operate, the increased AN levels attributed to surface hydrophobicity on the new conductors are likely to be less than 2 dB (for the first few months).

Conductors exhibiting hydrophilic conditions have better audible-noise performance than those exhibiting a hydrophobic surface condition.

Transgrid requires a dulled, non-specular finish on all new conductors. This will reduce the hydrophobicity of the new conductor surfaces and thereby also new conductor effects on the overall AN emissions from the new transmission lines. The increase in AN levels due to new conductor effects is expected to be less than 2 dB and is not considered significant in the risk assessment.

6.6 AN Risk Assessment

The distance from the centre of the transmission line easement at which the AN is likely to be above 35 dBA at nighttime during average rain conditions (i.e. potential to impact residential dwellings) is summarised in Table 17 (for VNI West 500 kV double circuit transmission line) and Table 18 (for Line 51 330 kV double circuit transmission line) for the different structure types on both lines considered by this study. The AN emissions from the transmission lines do not exceed the night-time noise limits under fair weather conditions.

Table 17: distance from the centre of the of 70 metres easement at which AN may impact residential dwellings.

Structure Types / Geometry	Evaluation Methods	Distance (m)
VTU	EPRI	376
	BPA	449
VTV	EPRI	373
	BPA	445
VTW	EPRI	355
	BPA	417
VSU	EPRI	395
	BPA	478

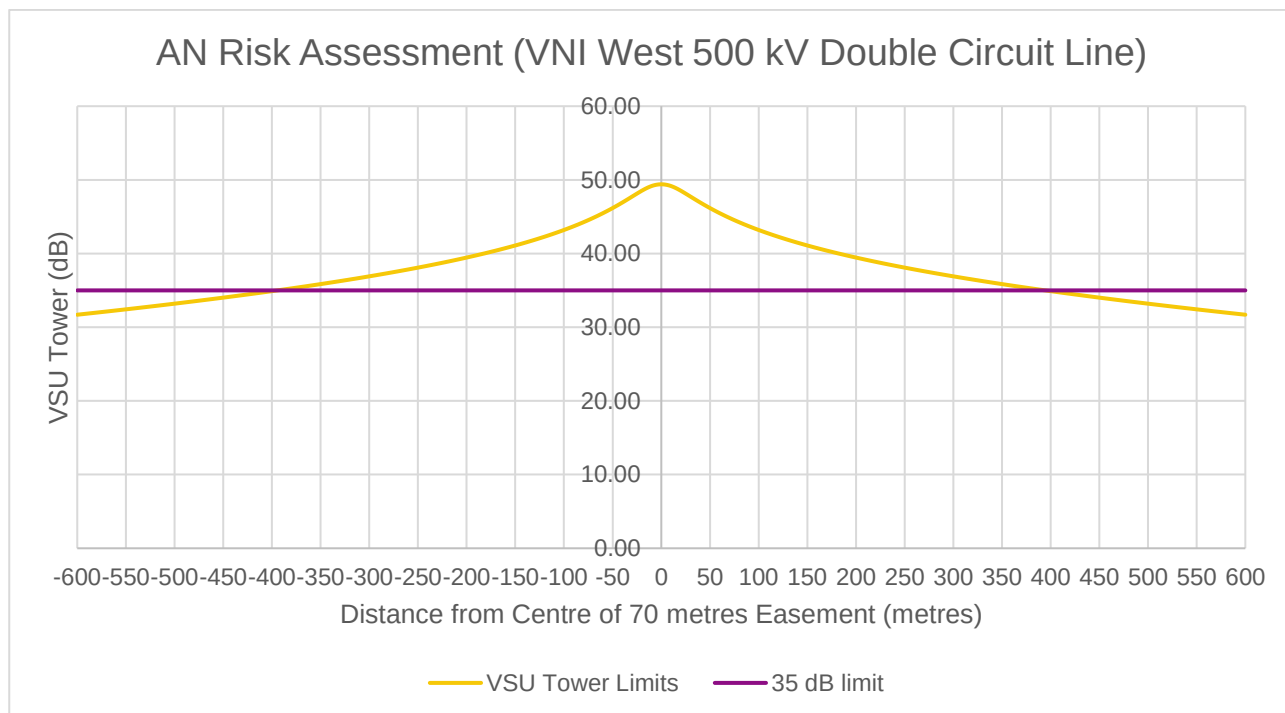


Figure 4: Distance at which AN may impact residential dwellings – VSU Tower (500 kV Line)

Table 18: Distance from the centre of the line of 60 m easement at which AN may impact residential dwellings.

Structure Types / Geometry	Evaluation Methods	Distance (m)
RSR	EPRI	355
	BPA	399
RWA/RWC	EPRI	359
	BPA	405

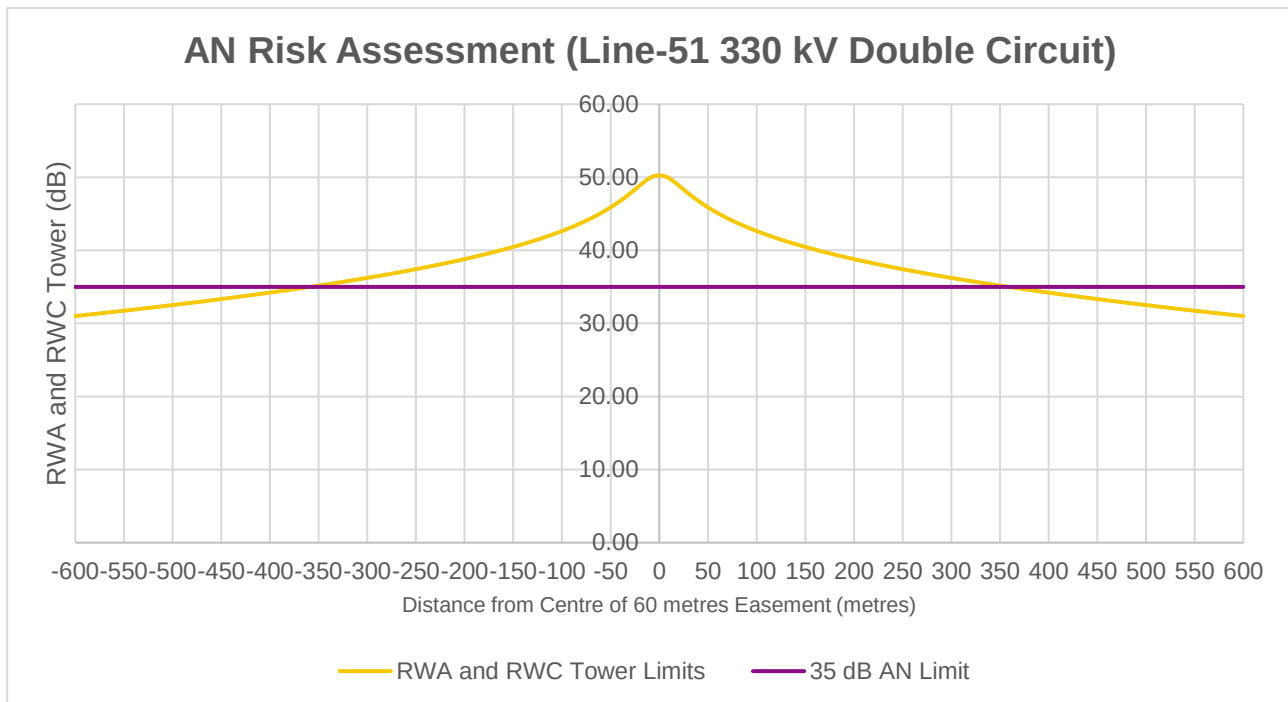


Figure 5: Distance at which AN may impact residential dwellings – RWA and RWC Structures (330 kV Line).

Further investigations should be carried out to identify sensitive receivers in the identified (potential) AN risk zones which extend 395 metres either side of the VNI West 500 kV double circuit transmission line and 359 metres either side of the Line 51 330 kV double circuit transmission line.

A statistical based audible noise study ⁴⁵ concluded that the risk of public noise complaints for a transmission line was low for a wideband AN level less than 52 dB(A) at the sensitive receiver. This study has been the basis of subsequent studies which have verified the validity of the guideline level. The New York State Public Service Commission adopted the recommended 52 dB(A) $L_{50 \text{ wet}}$ limit at the edge of transmission line easement as a reasonable standard^{46, 47}. The Commission concluded that 35 dB(A) is an appropriate maximum limit in a bedroom to address the impact of sleep disturbance. Given that the noise occurs only during rainy conditions, the limit is increased to 36.5 dB(A) to account for background noise. For a reasonable attenuation factor of 15.5 dB for the high frequency noise source through a partially open window, the audible noise limit outside the house is 52 dB(A).

The AN emissions from the transmission lines considered by this study are below 52 dB(A) at the edge of the 70 metres wide easement and 60 m wide easement, for the VNI West 500 kV double circuit and Line 51 330 kV double circuit respectively. Beca are not aware of any comparable guidelines in Australia⁴⁸, but the referenced publications are considered a valid basis for assessing the risk of public noise complaints.

⁴⁵ D.E. Perry, "An Analysis of Transmission Line Audible Noise Levels Based upon Field and Three-Phase Test Line Measurements", IEEE Trans., Vol. PAS-91, May/June 1972, pp. 857-865

⁴⁶ State of New York Public Service Commission, Opinion and Order Determining Health and Safety Issues, Imposing Operating Conditions, and Authorizing, in Case 26529, Operation Pursuant to those Conditions, Opinion No. 78-13, June 19, 1978.

⁴⁷ State of New York Public Service Commission, Agreement between New York State Public Service Commission and Power Authority of State of New York Concerning Operation of Massena-Marcy 765kV Transmission Line February 7, 1980

⁴⁸ There is a noise study [A2] that was carried out in Australia that looked at noise reduction through facades with open windows which concluded that the tested residencies, despite variations in construction, all achieved reductions ranging from 5 dBA and up to 15 dBA in some cases.

7. Radio Frequency Interference Performance

7.1 Evaluation Methods

Similarly to AN evaluation methods, empirical and semi-empirical methods have been developed to calculate the RFI performance of a transmission line. The same advantages and disadvantages discussed in Section 6.1 for these methods apply to the RFI calculations.

In line with this, a worldwide joint CIGRE/IEEE comparison of RFI calculation methods was documented in an IEEE committee report ⁴⁹. The comparison concluded that RFI predictions made with calculation methods developed in one country could be out by more than 10 dB from the measured performance of a constructed line in another country. The selection of an appropriate method is therefore critical for the RFI risk assessment.

RFI levels are traditionally measured using a quasi-peak (QP) detector that provides a weighting function which better accounts for the degradation in radio reception quality. The international CISPR measurement standard for QP RFI levels specifies a 500 kHz centre frequency and 9 kHz bandwidth. The American ANSI measurement standard specifies a 1 MHz centre frequency and 10 kHz bandwidth for QP RFI levels. The frequency spectrum for positive corona streamer pulses, which are the main source of RFI from a transmission line is flat from 0 Hz to approximately 1.59 MHz ⁵⁰[8], after which it decreases with increasing frequency.

The narrowband measurements at 0.5 MHz and 1 MHz represent the maximum receiver interference level at all frequencies.

The joint CIGRE/IEEE comparison study included a comparison of measured and calculated RFI for a number of test transmission lines operating at varying voltage levels up to 750 kV. For lines with comparable conductor bundles and surface voltage gradients, it is observed that the semi-empirical EPRI method produces calculations significantly lower than the measured RFI levels under both fair weather (approximately 8 dB) and wet weather (approximately 5 dB) conditions. The empirical CIGRE calculations more accurately predicted the measured levels.

The CIGRE method is the recommended method for both transmission lines considered by this study, based on the joint CIGRE/IEEE comparison and per Transgrid's TLDM requirements. The CIGRE (empirical) calculation method was used in SES-Enviro Version 19.0 to determine the RFI levels at 500 kHz and 1 MHz. Results calculated using the EPRI (semi-empirical) calculation method are included for comparison purposes only.

Both methods predict heavy rain (i.e. L5 exceedance levels) and have fixed correction factors for calculating average rain and average fair-weather levels. Both the CIGRE and EPRI calculation methods provide formulas for calculating the RFI level at higher frequencies⁵¹ for the assessment of interference to various forms of communications identified adjacent to the preferred transmission line alignments.

⁴⁹ IEEE Committee Report, "Comparison of Radio Noise Prediction Methods with CIGRE/IEEE Survey Results", IEEE Trans., Vol. PAS-92, May/June 1973, pp. 1029-1042.

⁵⁰ P. S. Maruvada, Corona Performance of High-Voltage Transmission Lines, Research Studies Press, 2000, pp. 116 - 117.

⁵¹ Per the EPRI reference book, the most complete empirical method for predicting TVI above 30 MHz is the method developed by the BPA, a method which was first developed to predict TVI from overhead lines during rain but has since expanded.

7.2 RFI Levels

The RFI performance of the transmission lines considered in this study at 0.5 MHz and 1.0 MHz, is calculated for all proposed structure types for the baseline parameters, structure/line configuration and phasing arrangements outlined in Section 3.

The calculated RFI levels are assessed at observation height of 1 metre and 2 metres above ground for average rain ($L_{50 \text{ wet}}$) and average fair weather ($L_{50 \text{ dry}}$) conditions. The results are summarised below for structures on the VNI West 500 kV double circuit transmission line and Line 51 330 kV double circuit transmission line, in Table 19/Table 20 and Table 21/

Table 22 respectively.

All the outputs related to RFI are normalized to CISPR values (bandwidth of 9 kHz and measuring frequency of 0.5 MHz and 1 MHz).

Table 19: Calculated RFI levels at the edge of 70 metres easement @ 0.5 MHz

Structure Type / Geometry	Observation Height	Radio Frequency Interference @ 0.5MHz (dBμA/m)				
		CIGRE method		EPRI method		Limits
		L ₅₀ wet	L ₅₀ dry	L ₅₀ wet	L ₅₀ dry	
VTU	1 metre	0.6	-17.5	3.8	-13.7	-15.5
	2 metres	0.9	-17.2	3.8	-13.7	-15.5
VTV	1 metre	0.6	-17.5	3.7	-13.8	-15.5
	2 metres	0.8	-17.3	3.8	-13.7	-15.5
VTW	1 metres	0.8	-17.3	3.4	-14.1	-15.5
	2 metres	1.1	-17.0	3.5	-14.0	-15.5
VSU	1 metre	0.8	-17.3	4.3	-13.2	-15.5
	2 metres	1.0	-17.1	4.3	-13.2	-15.5

Table 20: Calculated RFI levels at the edge of 70 metres easement @ 1.0 MHz

Structure Type / Geometry	Observation Height	Radio Frequency Interference @ 1.0MHz (dBμA/m)				
		CIGRE (dBμA/m)		EPRI (dBμA/m)		Limits
		L _{50 wet}	L _{50 dry}	L _{50 wet}	L _{50 dry}	
VTU	1 metre	-3.5	-21.6	-2.2	-19.7	-15.5
	2 metres	-3.2	-21.3	-2.2	-19.7	-15.5
VTV	1 metre	-3.5	-21.6	-2.4	-19.9	-15.5
	2 metres	-3.3	-21.4	-2.3	-19.8	-15.5
VTW	1 metres	-3.3	-21.4	-2.6	-20.1	-15.5
	2 metres	-3.0	-21.4	-2.5	-20.0	-15.5
VSU	1 metre	-3.3	-21.4	-1.8	-19.3	-15.5
	2 metres	-3.0	-21.1	-1.8	-19.3	-15.5

Table 21: Calculated RFI levels at the edge of 60 metres easement @ 0.5 MHz

Structure Type / Geometry	Observation Height	Radio Frequency Interference @ 0.5MHz (dBµA/m)				
		CIGRE (dBµA/m)		EPRI (dBµA/m)		Limits
		L ₅₀ wet	L ₅₀ dry	L ₅₀ wet	L ₅₀ dry	
RSR	1 metre	5.7	-12.4	5.0	-12.5	-15.5
	2 metres	6.0	-12.1	5.1	-12.4	-15.5
RWA/RWC	1 metre	5.9	-12.2	5.5	-12.0	-15.5
	2 metres	6.2	-11.9	5.6	-11.9	-15.5

Table 22: Calculated RFI levels at the edge of 60 metres easement @ 1.0 MHz

Structure Type / Geometry	Observation Height	Radio Frequency Interference @ 1.0MHz (dBµA/m)				
		CIGRE (dBµA/m)		EPRI (dBµA/m)		Limits
		L ₅₀ wet	L ₅₀ dry	L ₅₀ wet	L ₅₀ dry	
RSR	1 metre	1.6	-16.5	-1.2	-18.7	-15.5
	2 metres	1.9	-16.2	-1.1	-18.6	-15.5
RWA/RWC	1 metre	1.8	-16.3	-0.7	-18.2	-15.5
	2 metres	2.1	-16.0	-0.6	-18.1	-15.5

7.3 Interference at Typical Broadcast Frequencies

A list of both national and local AM radio stations (and respective transmitters/receivers) that have coverage through the preferred line alignments for the lines considered in this study, is included^{52,53} in Table 23 and Table 24. These sites are identified using the public databases available through The Australian Communications and Media Authority (ACMA)⁵⁴.

The summary included in Table 23 and Table 24 is a comparison of the calculated maximum RFI levels⁵⁵ with the AS 2344 RFI limits, as well as the limits associated with a Class 3 rating for the quality of reception on the CIGRE scale.

⁵² Digital Audio Broadcasting (DAB+) stations are not included since the digital receiver's audio codec results in reception that is more immune to noise.

⁵³ Frequency modulated (FM) stations and Digital TV broadcast services are not included, since there is a lack of background material available on the determination of limits to protect their respective service reception i.e. the limits do not express the protection required for services operating in the typical bands from 30 MHz to 1 GHz, and is largely an overstatement of what is expected to be actually required when compared with CISPR general product limits. Instead (for completeness), RFI emissions at typical broadcast frequencies for these services have been calculated against the limits of Table 9, near the preferred VNI West transmission line alignment.

⁵⁴ Website Source: https://web.acma.gov.au/pls/radcom/site_proximity.main_page/

⁵⁵ Maximum RFI levels calculated at transmitter frequency is associated with RWA/RWC Line 51 330 kV double circuit transmission line tower geometry.

Table 23: National and local AM radio stations along VNI West 500 kV double circuit transmission line

Coverage Area	AM Radio	Transmittal location	Frequency (KHz)	Observation profile	CIGRE method (dB μ A/m)	EPRI method (dB μ A/m)	Limit (dB μ A/m)	
					L _{50 wet}	L _{50wet}	AS 2344	CIGRE Class 3
Deniliquin	2QN Deniliquin	Broadcast Site Cnr Cobb Hwy & Cal Col Rd Deniliquin	1521 kHz	1 metre	-3.3	-2.6	-15.5	-3.5
				2 metres	-3.0	-2.5		
Swan Hill	3SH Swan Hill	Broadcast Site Murray Valley Hwy 8km SSE of Swan hill	1332 kHz	1 metre	-3.3	-2.6	-15.5	-3.5
				2 metres	-3.0	-2.5		

Table 24: National and local AM radio stations along Line 51 330 kV double circuit transmission line.

Coverage Area	AM Radio	Transmitter Location	Frequency (kHz)	Observation Profile	CIGRE method (dB μ A/m)	EPRI method (dB μ A/m)	Limit (dB μ A/m)	
					L _{50wet}	L _{50wet}	AS 2344	CIGRE Class 3
Wagga Wagga	2WG Wagga Wagga	Radio 2WG AM 111m Mast Riverina Bcers Site Olympic Hwy 2km SSE of BRUCEDALE	1521 kHz	1 metre	1.8	-0.7	-15.5	-3.5
				2 metres	2.1	-0.6		

7.3.1 Quasi-Peak & RMS Detectors

The quasi-peak (QP) detector was developed to provide a measure of the interference effect of pulsative noise on analogue AM radio reception (it has also been applied to analogue TV reception) and has historically demonstrated through subjective listening tests to correlate well with the subjective evaluation of interference impacts on quality due to RFI.

Although an RMS measurement of the noise to reception of all other communication services (including navigation, aeronautical, safety-of-life, amateur radio and citizen band (CB) radio) may be more appropriate⁵⁶, as they are considered necessary in first establishing an absolute noise power measurement. Furthermore, QP detectors do not alone provide suitable data for evaluating interference to all of the various types of receivers and therefore rely on an RMS measurement to quantify an estimation of the noise interference (both methods are considered as per Section 7.3.2).

⁵⁶ IEEE Committee Report, "Review of Technical Considerations on Limits of Interference from Power Lines and Stations", IEEE Trans., Vol. PAS-99, January/February 1980, pp. 365-388

The vast majority of data available for power lines, however, fall under the QP category – as very few RMS measurements have been made on actual power transmission lines (with respect to latest measurement equipment).

The worst case RFI levels measured in an RMS receiver, for the base measurements at 500 kHz and 1.0 MHz, are summarised in Table 25 through Table 28.

Table 25: Calculated RFI levels at the edge of the 70 m line easement for VTW structures with RMS detector.

Transmission Line	Operating Case / Structure Option	Radio Frequency Interference @ 0.5MHz (dBµA/m)			
		CIGRE method	EPRI method	Limit	
		L ₅₀ wet	L ₅₀ wet	AS 2344	CIGRE Class 3
VNI West 500 kV double circuit transmission line	1 metre	4.4	7.4	-15.5	-3.5
	2 metres	4.7	7.5		

Table 26: Calculated RFI levels at the edge of the 70 m line easement for VTW structure with RMS detector.

Transmission Line	Operating Case / Structure Option	Radio Frequency Interference @ 1.0 MHz (dBµA/m)			
		CIGRE method	EPRI method	Limit	
		L ₅₀ wet	L ₅₀ wet	AS 2344	CIGRE Class 3
VNI West 500 kV double circuit transmission line	1 metre	0.3	1.4	-15.5	-3.5
	2 metres	0.6	1.5		

Table 27: Calculated RFI levels at the edge of the 60 m line easement for RWA and RWC structures with RMS detector.

Transmission Line	Operating Case / Structure Option	Radio Frequency Interference @ 0.5MHz (dBµA/m)			
		CIGRE method	EPRI method	Limit	
		L ₅₀ wet	L ₅₀ wet	AS 2344	CIGRE Class 3
Line 51 330 kV double circuit transmission line	1 metre	9.8	9.4	-15.5	-3.5
	2 metres	10.1	9.4		

Table 28: Calculated RFI levels at the edge of the 60 m line easement for RWC and RWA structures with RMS detector

Transmission Line	Operating Case / Structure Option	Radio Frequency Interference @ 1.0MHz (dBµA/m)			
		CIGRE method	EPRI method	Limit	
		L ₅₀ wet	L ₅₀ wet	AS 2344	CIGRE Class 3
Line 51 330 kV double circuit transmission line	1 metre	5.7	3.2	-15.5	-3.5
	2 metres	6.0	3.2		

7.3.2 TVI for Commercial Broadcasts above 30 MHz

The corona RFI emissions (for a CISPR quasi-peak detector) at typical broadcast frequencies for commercial FM radio (90 MHz), aeronautical VHF (128 MHz), UHF CB (477 MHz) and Digital TV (600 MHz) were calculated to the transmission lines considered in this study. The calculated wet conductor conditions results are compared to the limits summarised in Table 29 and Table 30. The fair weather RFI levels will be significantly⁵⁷ below the stated wet conductor levels.

The CIGRE RFI frequency correction factors are defined for frequencies only up to 30 MHz. For frequencies above 30 MHz, the correction factors specified in the EPRI reference book (third edition) have been used⁵⁸ to assess interference to sensitive receivers operating at commercial broadcast frequencies.

Table 29: Corona RFI emission (for a CISPR quasi-peak detector) at typical broadcast frequencies for VNI West 500 kV double circuit transmission line.

Broadcast / Service	Observation Height	RFI @ 1.0MHz (dB μ V/m) CISPR Addition Method		RFI @ 1.0MHz (dB μ V/m) RMS Addition Method		Limits	
		CIGRE Method	EPRI Method	CIGRE Method	EPRI Method	AS2344	CIGRE Class 3
		L ₅₀ wet	L ₅₀ wet	L ₅₀ wet	L ₅₀ wet		
Commercial FM radio - 90 MHz	1 metre	9.61	10.63	12.92	12.58	30	N/A
	2 metres	10.67	10.92	13.43	12.87	30	N/A
Aeronautical VHF - 128 MHz	1 metre	6.55	7.57	9.86	9.52	30	N/A
	2 metres	7.61	7.86	10.37	9.81	30	N/A
UHF CB - 477 MHz	1 metre	-4.88	-3.85	-1.56	-1.91	37	N/A
	2 metres	-3.82	-3.57	-1.05	-1.62	37	N/A
Digital TV - 600 MHz	1 metre	-6.87	-5.85	-3.56	-3.90	37	N/A
	2 metres	-5.81	-5.56	-3.04	-3.61	37	N/A

⁵⁷ EMI calculations performed by EPRI (third edition) predict the average fair-weather noise levels by a subtraction of 21.6 dB (+/- 5 dB for calculation error which is consistent with fair-weather noise variability).

⁵⁸ Per the EPRI reference book, the most complete empirical method for predicting TVI above 30 MHz is the method developed by the BPA, a method which was first developed to predict TVI from overhead lines during rain but has since expanded.

Table 30: Corona RFI emissions (for a CISPR quasi-peak detector) at typical broadcast frequencies for Line 51 330 kV double circuit transmission line.

Broadcast / Service	Observation Height	RFI @ 1.0MHz (dBµV/m) CISPR Addition Method		RFI @ 1.0MHz (dBµV/m) RMS Addition Method		Limits	
		CIGRE Method	EPRI Method	CIGRE Method	EPRI Method	AS234 4	CIGRE Class 3
		L ₅₀ wet	L ₅₀ wet	L ₅₀ wet	L ₅₀ wet		
Commercial FM radio - 90 MHz	1 metre	15.68	11.71	18.79	14.46	30	N/A
	2 metres	16.42	11.96	19.37	14.69	30	N/A
Aeronautical VHF - 128 MHz	1 metre	12.36	8.65	15.73	11.40	30	N/A
	2 metres	13.37	8.90	16.31	11.63	30	N/A
UHF CB - 477 MHz	1 metre	1.20	-2.77	4.30	-0.03	37	N/A
	2 metres	1.94	-2.52	4.89	0.21	37	N/A
Digital TV - 600 MHz	1 metre	-0.79	-4.76	2.31	-2.02	37	N/A
	2 metres	-0.05	-4.52	2.89	-1.79	37	N/A

7.4 Parallel Transmission Lines

The only potential RFI issues associated with parallel transmission lines was AM radio reception during rain conditions. For AM radio reception, QP detectors are used to assess the impact of the RFI on the quality of reception.

Where there are two sources of RFI at a receiver location (e.g. parallel transmission lines), the measured QP level will not be significantly affected by the second source if the RFI level from that source is more than 3 dB⁵⁹ below the RFI level of the first source.

RFI calculations were carried out for the existing (or planned) 330kV (Yanco Delta) and 500 kV (Humelink) transmission lines that parallel the transmission lines considered in this study. The RFI from these secondary sources was more than 3 dB below the RFI from the primary sources i.e. lines considered in this study. The contributions from the existing transmission lines does not therefore affect the results in Section 7.3.

7.5 Point-to-Point (P2P)

A summary of point-to-point communication links i.e. microwave beams, operating in the vicinity of the preferred VNI West transmission line alignment is illustrated in Figure 6. These sites are identified using the public databases available through ACMA [A2].

⁵⁹ A difference of 3 dB corresponds to about twice or half the power. If the second source is more than 3 dB below the first, its contribution to the overall interference level would be minor compared to the dominant source.



Figure 6: P2P communication links for VNI west 500 kV double circuit transmission line alignment

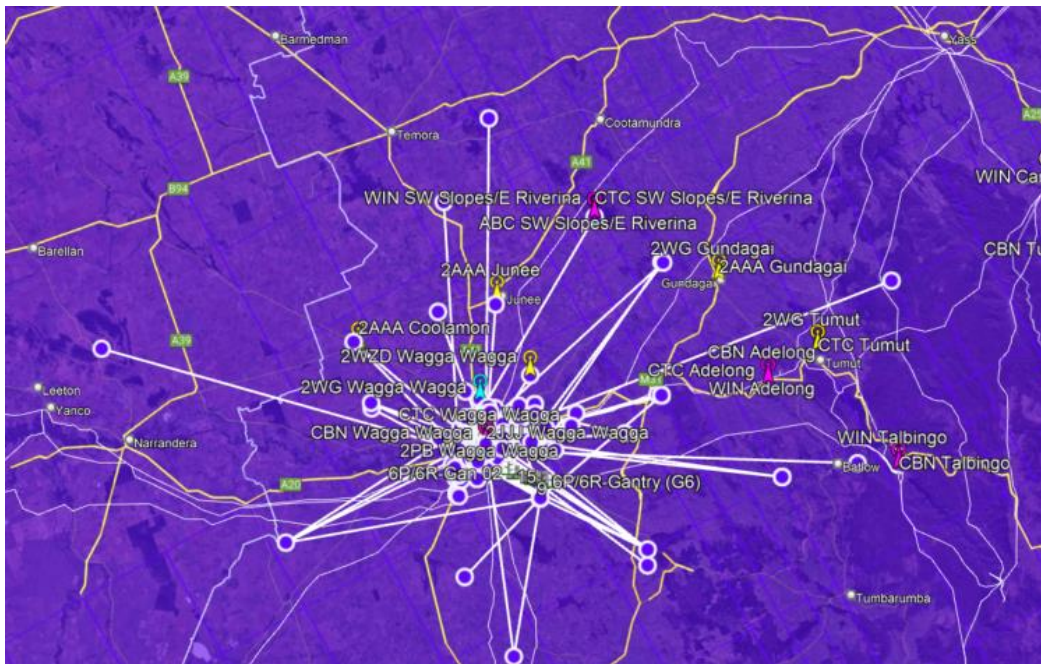


Figure 7: P2P communication links for Line 51 330 kV double circuit transmission line alignment

Microwave is a line-of-sight wireless communication technology which utilises high frequency beams of radio waves to provide high-speed wireless connections which allows for a multitude of telecommunication services.

The concept of a Fresnel Zone in radio communications defines one of a number of concentric ellipsoids (volumes) in the radiation pattern of a circular pattern i.e. Each zone is a result of diffraction where the first Fresnel Zone is circular, and the subsequent ones are annular.

The concept of Fresnel Zone clearance may be used to analyse interference by obstacles (i.e. transmission structures) near the line-of-sight of a radio beam. The first zone must be kept largely free from obstructions to avoid interfering with the radio reception.

It is recommended that the respective Fresnel Zone for the identified point-to-point links and the perceived impacts on the communication services be calculated and assessed during detailed design when final locations of structures are determined.

7.6 New Conductor Effects

As discussed in Section 6, the new conductor effects will not significantly increase the RFI levels near the new VNI West transmission lines as these effects will not impact results presented in Section 7.

7.7 RFI Risk Assessment

The distance from the edge of the transmission line easement at which the RFI is likely to negatively impact commercial AM radio reception during rain conditions is limited to 122 metres from the edge of the easement for VNI West 500 kV double circuit transmission line and 141 metres from the edge of the easement for Line 51 330 kV double circuit transmission line. For all other communication devices, the quality of reception will at least be better than Class 3 on the CIGRE scale under average rain conditions outside of the transmission line easement.

It is recommended that investigations are undertaken to identify any sensitive receivers impacted by the preferred transmission line. The impact to each receiver should be assessed for compliance with the 80/80 rule in accordance with AS 2344.

8. Mitigation Options

Where project noise trigger levels are exceeded, mitigation strategies should be assessed in accordance with NPfI. Mitigation options for consideration may include, but are not limited to, the following:

- Increased buffer distances between the transmission line and sensitive receivers, however, this is often impractical due to other constraints and considerations.
- A minimum quad Peach ACSR conductor bundle (500 kV line option) or Twin Xenon conductor bundle (330 kV line option) would need to be strung to pro-actively reduce the AN levels, however, it is worth noting these very large conductor size requirements are not considered to be feasible to implement given the significantly higher costs, constructability challenges, significantly larger structures and foundations.
- Application of acoustic treatment and/or installing mechanical ventilation in affected houses, in consultation with landowners.
- Supplying the affected dwelling with a high-performance, active AM antenna (e.g. Tecsun AN100 AM Loop Antenna).

9. Results and Recommendations

Surface Voltage Gradients of Conductors

The presence of high surface voltage gradients (SVG) on the transmission line conductors lead to ionisation of the air surrounding the conductor surfaces, resulting in corona discharge. This corona discharge generates AN and RFI emissions. Transgrid and Australian standards recommend that the conductor SVG be limited to less than 16 kV/cm to minimise the impact of AN and RFI. Higher values of SVG may be used where acceptable AN and RFI performance is demonstrated. The following have been observed:

- For the VNI West 500 kV double circuit transmission line, the maximum SVG for the smooth cylindrical equivalent to the stranded round wire conductor is calculated to be 16.1 kV/cm.
- For the Line 51 330 kV double circuit transmission line, the maximum SVG for the smooth cylindrical equivalent to the stranded round wire conductor is calculated to be 15.9 kV/cm.

Audible Noise

The EPRI (semi-empirical) calculation method was determined to be the most appropriate method that is available in the SES-Enviro Version 19.0 software tool for calculating the wideband AN level from the VNI West transmission lines. The following has been observed:

- The wideband AN levels from the transmission lines considered in this study, will achieve the NSW Noise Policy for Industry limits at a distance of 395 metres from the centre of the transmission line easement.
- Fair weather AN levels will be within the project noise trigger level of 35 dB(A) within or close to the edge of the line easement.

For the both transmission lines considered in this study, the maximum observed AN limits under the wet weather conditions are as summarised in Table 31 below.

Table 31: Maximum AN Limits:

Transmission Line	Easement width (m)	Max. Observed AN Levels ⁶⁰ dB(A)	TLDM-MNB Limit dB(A)	Identified AN Risk Zone
VNI West 500 kV double circuit transmission line.	70 metres	47.4	50	395 metres
VNI West 500 kV double circuit transmission line // Yanco Delta 330 kV double circuit transmission line section.	70 metres	48.8	50	N/A
VNI West 500 kV double circuit transmission line // EnergyConnect project Line 2 330 kV double circuit transmission line section.	70 metres	50.8	50	N/A
Line 51 330 kV double circuit transmission line.	60 metres	47.9	50	359 metres
Line 51 330 kV double circuit transmission line // HumeLink 500 kV double circuit transmission line section.	60 metres	51.5	50	N/A

⁶⁰ Maximum AN limits observed for observation height of 1 metres and 2 metres for wet weather conditions for considered double circuit transmission lines.

The AN risk assessment was based on a 35 dB noise limit at all rural dwellings. This limit is very low. A number of international studies and legal proceedings have confirmed that 35 dBA is an appropriate maximum limit in a bedroom to address the impact of sleep disturbance. These studies have however also considered a reasonable attenuation factor for the high frequency AN source through a partially open window, which increased the AN limit outside the house to 52 dB(A). This was not considered for the either case study in this assessment, which is therefore considered to be conservative. The AN emissions from the VNI West lines are below 51 dB(A) at the edge of the 70 m wide easements.

Radio Frequency Interference

The RFI limits in AS 2344 (*Limits of electromagnetic interference from overhead a.c. powerlines and high voltage equipment installations in the frequency range 0.15 MHz to 3000 MHz*) are defined for the protection of radio and television reception for perceived annoyance to music listeners. The International Council on Large Electric Systems (CIGRE) empirical calculation was determined to be the most appropriate method available in the SES-Enviro Version 19.0 software tool for calculating the RFI levels. This method was used to determine the RFI levels for the VNI West transmission lines. It is found that:

- The calculated emission levels applicable to AM reception (500 kHz – 1.6 MHz) exceed the AS 2344 limits at the edge of the transmission line easement during L₅₀ wet conditions for all lines considered and assessed in this report.
- For VNI West 500 kV double circuit transmission line, the distance from the edge of the transmission line easement at which the RFI is likely to negatively impact commercial AM radio reception during rain conditions is limited to 122 metres from the centre of the easement.
- For Line 51 330 kV double circuit transmission line, the distance from the edge of the transmission line easement at which the RFI is likely to negatively impact commercial AM radio reception during rain conditions is limited to 141 metres from the centre of the easement.
- Transmission lines identified to parallel to the VNI West 500 kV Double Circuit Transmission line and TL51 result in RFI levels more than 3 dB below that of the evaluated transmission line and do not significantly affect the results.

Other forms of communication are not noticeably affected by RFI at the edge of the transmission line easement.

Recommendations and Next Steps

The following next steps and recommendations are proposed:

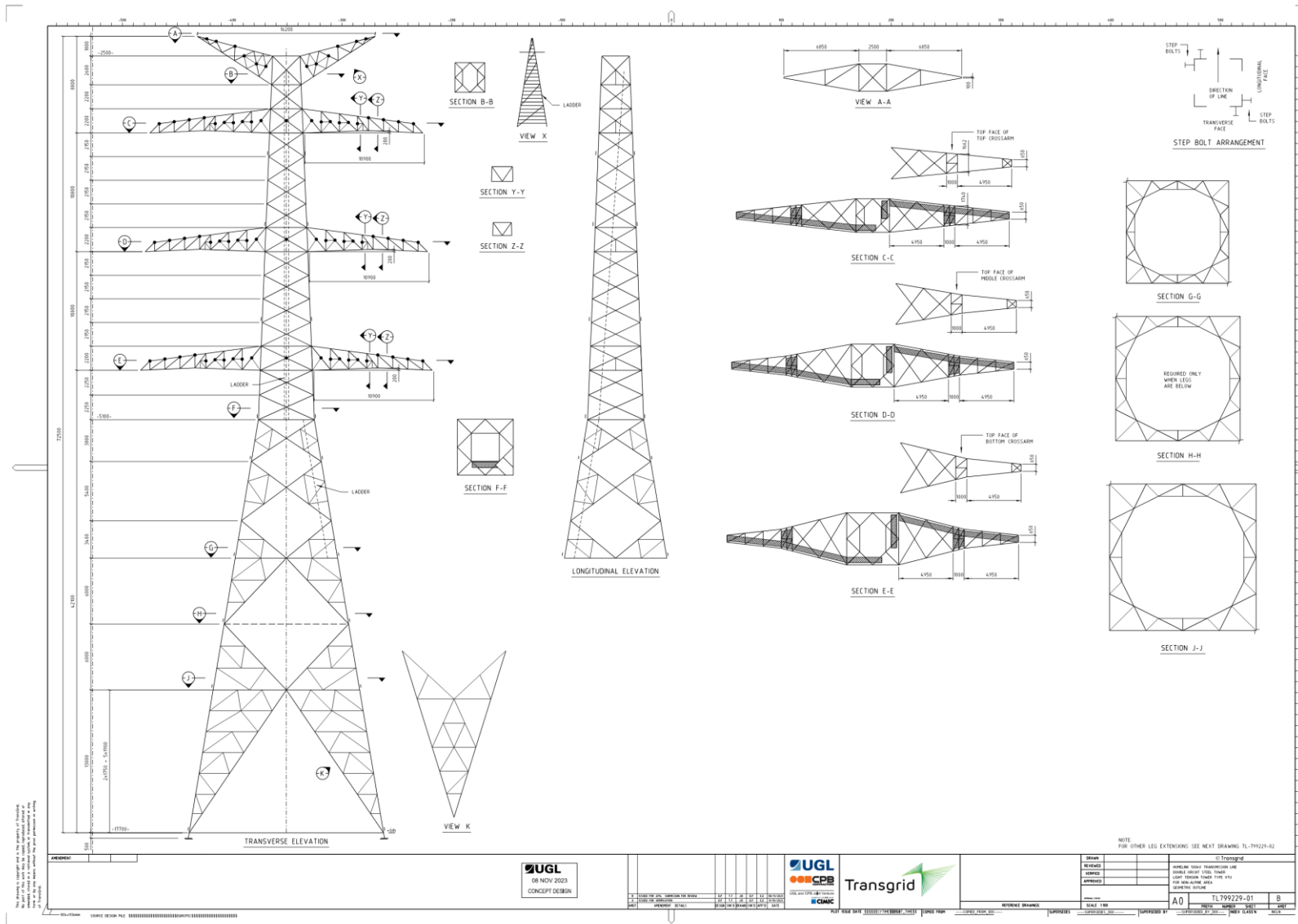
- Noise measurements are undertaken to determine the level of ambient noise (background noise) present in the identified (potential) AN risk zones, as low levels of ambient noise would be susceptible to the increased perception of disruption to amenity levels.
- Investigations are carried out to identify sensitive receivers (e.g. residential dwellings and places of work, education, or worship) within 395 metres of the centre of the VNI West 500 kV double circuit transmission line easement and within 359 metres of the centre of the Line 51 330 kV double circuit transmission line easement. In addition to identifying existing sensitive receivers, publicly available council Local Environmental Plans (LEP) should be reviewed to identify any authorised, but not yet constructed developments. Modifying factors for tonality may need to be considered at sensitive receivers identified within the AN risk zone.
- RFI investigations to be undertaken to identify any sensitive receivers within 122 metres from the centre VNI West 500 kV double circuit transmission line easement and 141 metres from the centre of Line 51

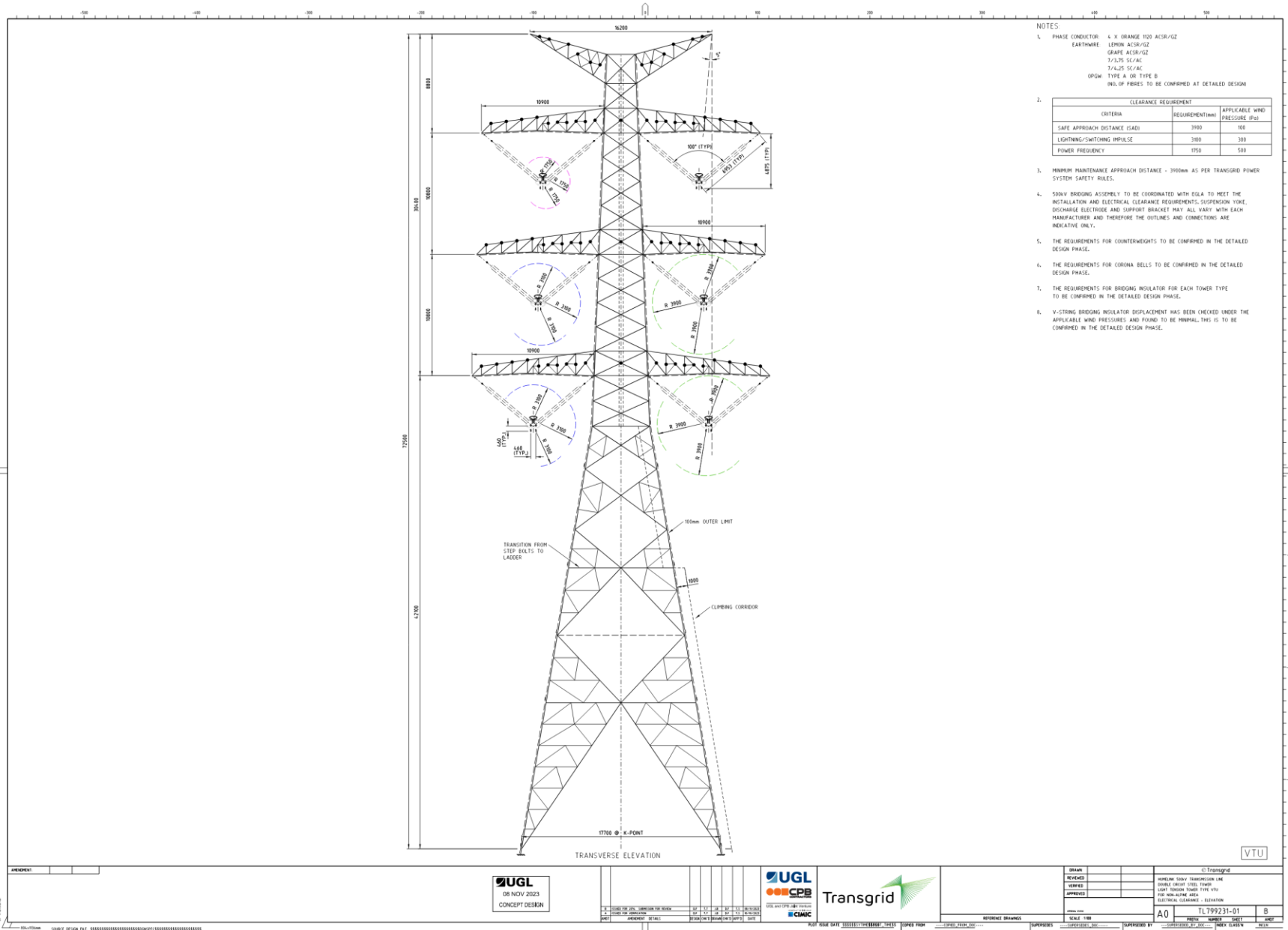
330 kV double circuit transmission line easement. The impact to each receiver should be assessed for compliance with the 80/80 rule in accordance with AS 2344.

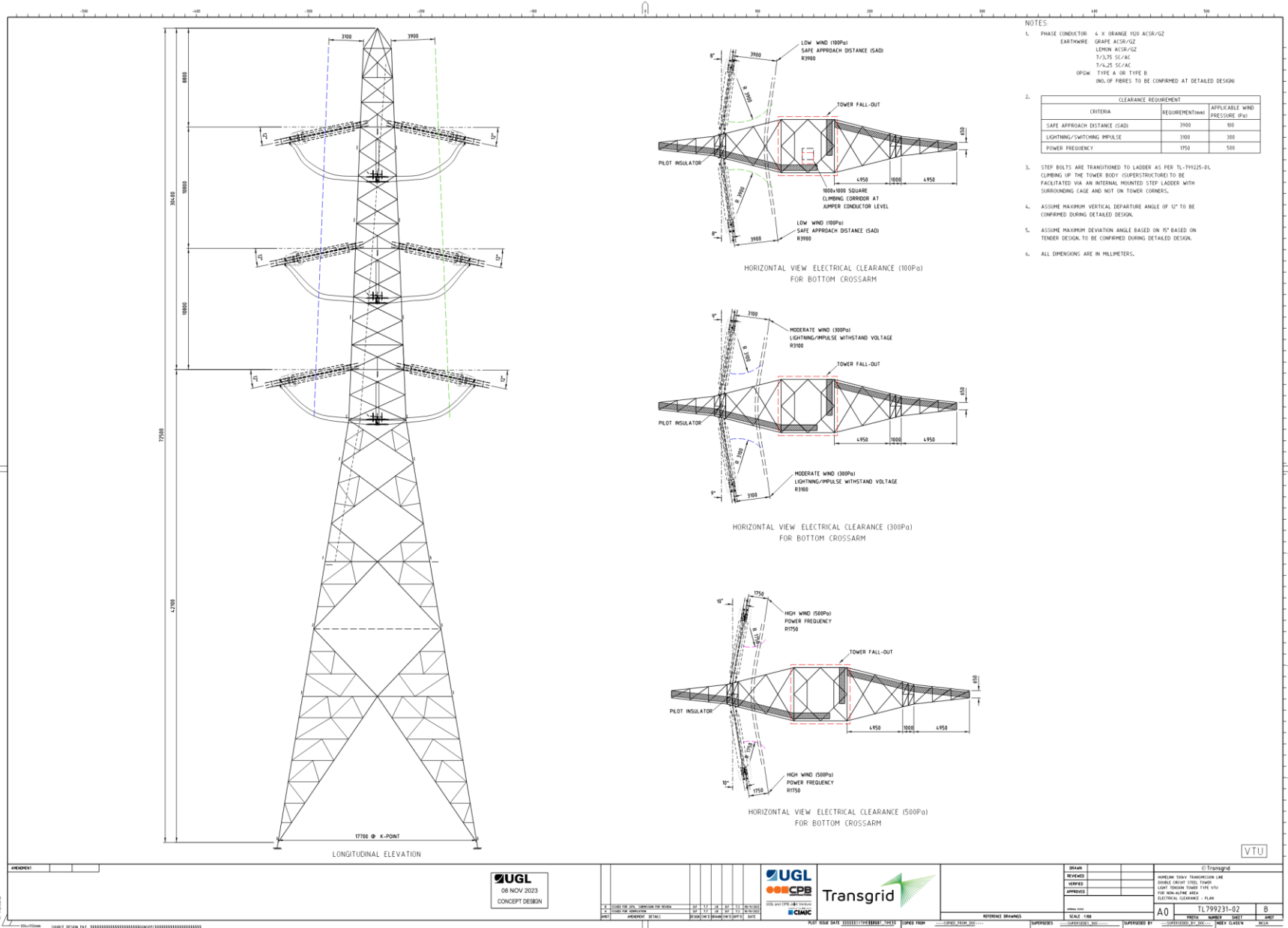
- Perceived impacts on point-to-point communication links i.e. microwave beams operating in the vicinity of the VNI West 500 kV double circuit transmission line and Line 51 330 kV double circuit transmission line alignment should be assessed during detailed design.

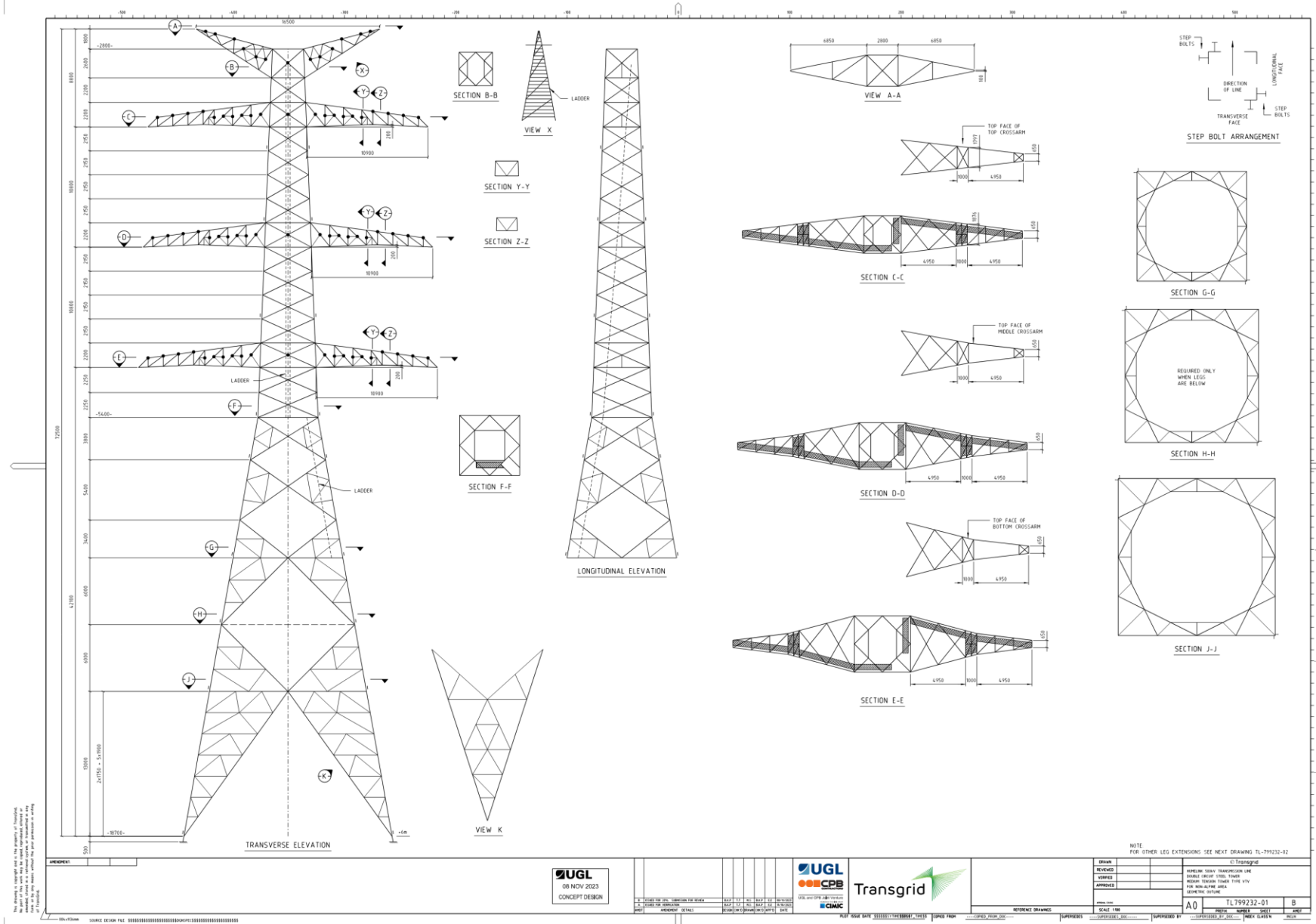
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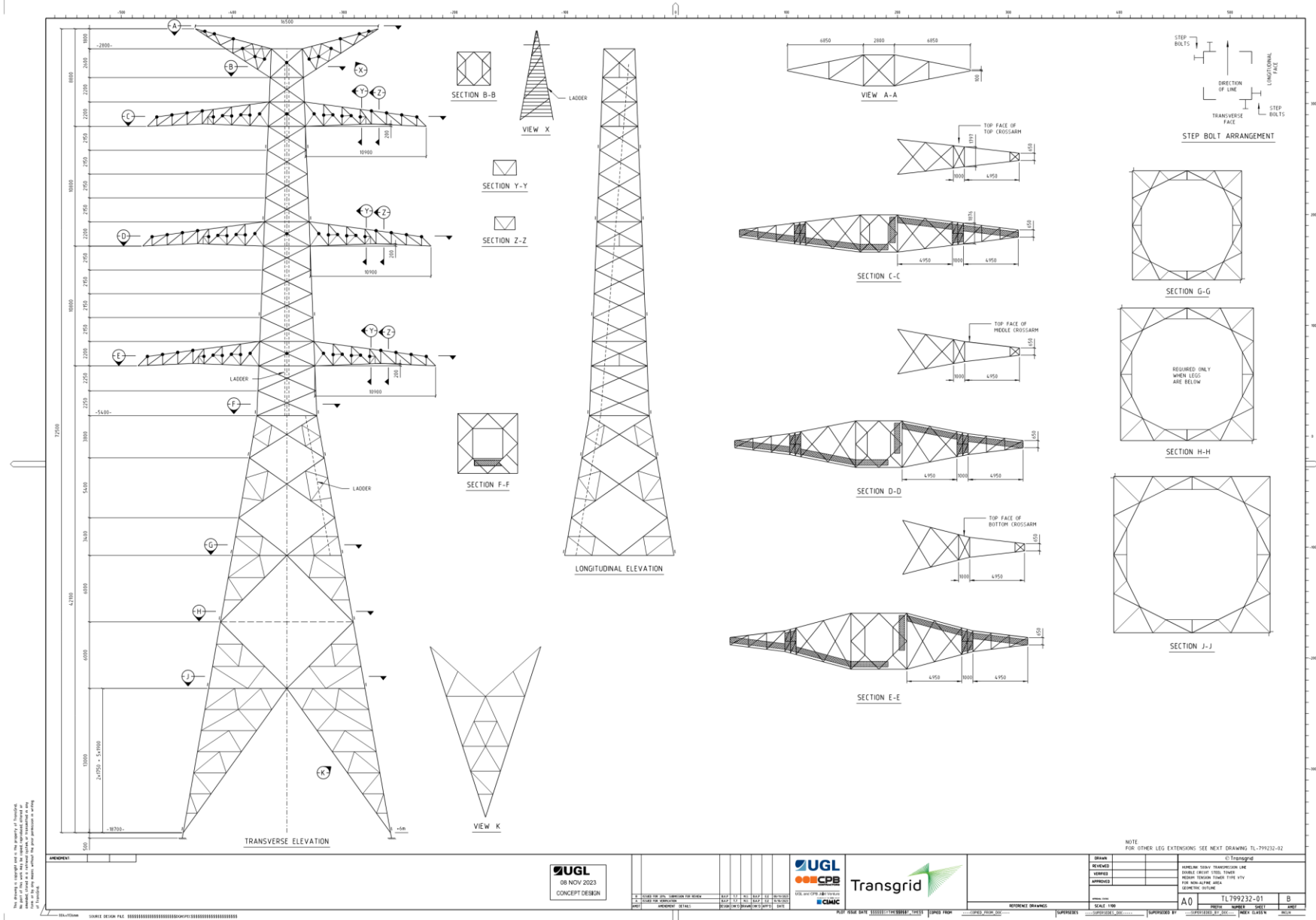
Appendix A– VNI West 500 kV Double Circuit Transmission Line Tower Structure Drawings









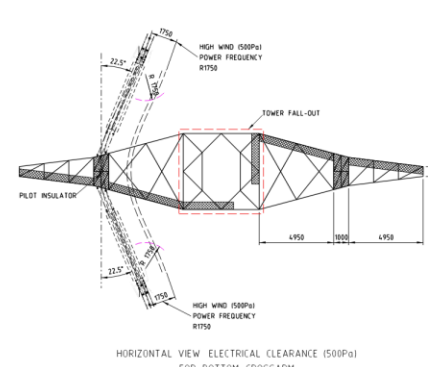
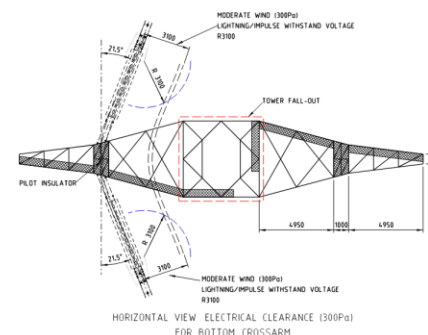
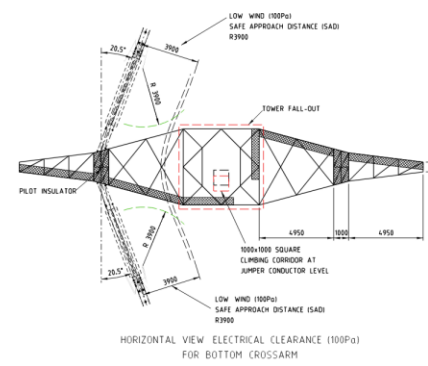
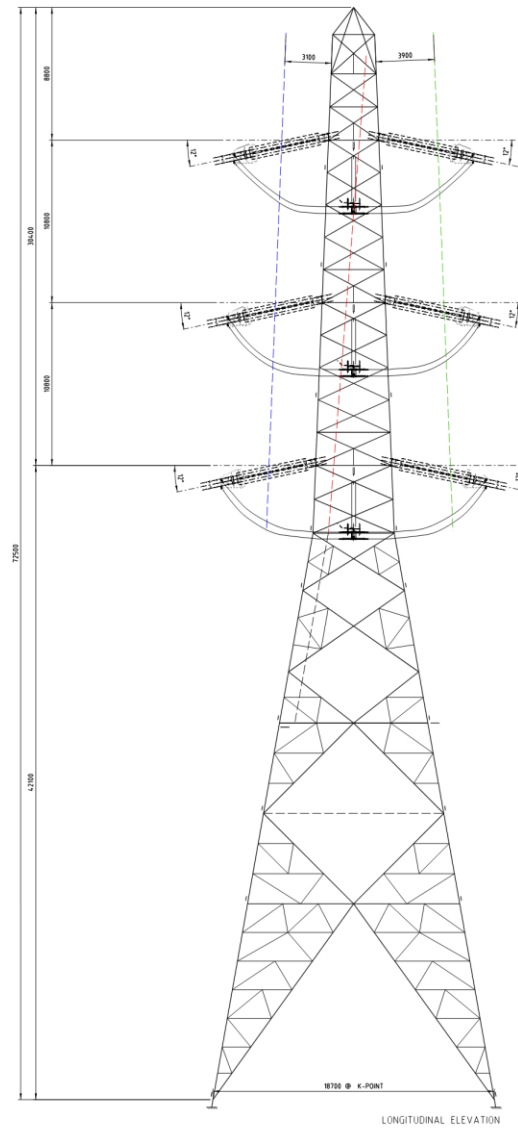


NOTES

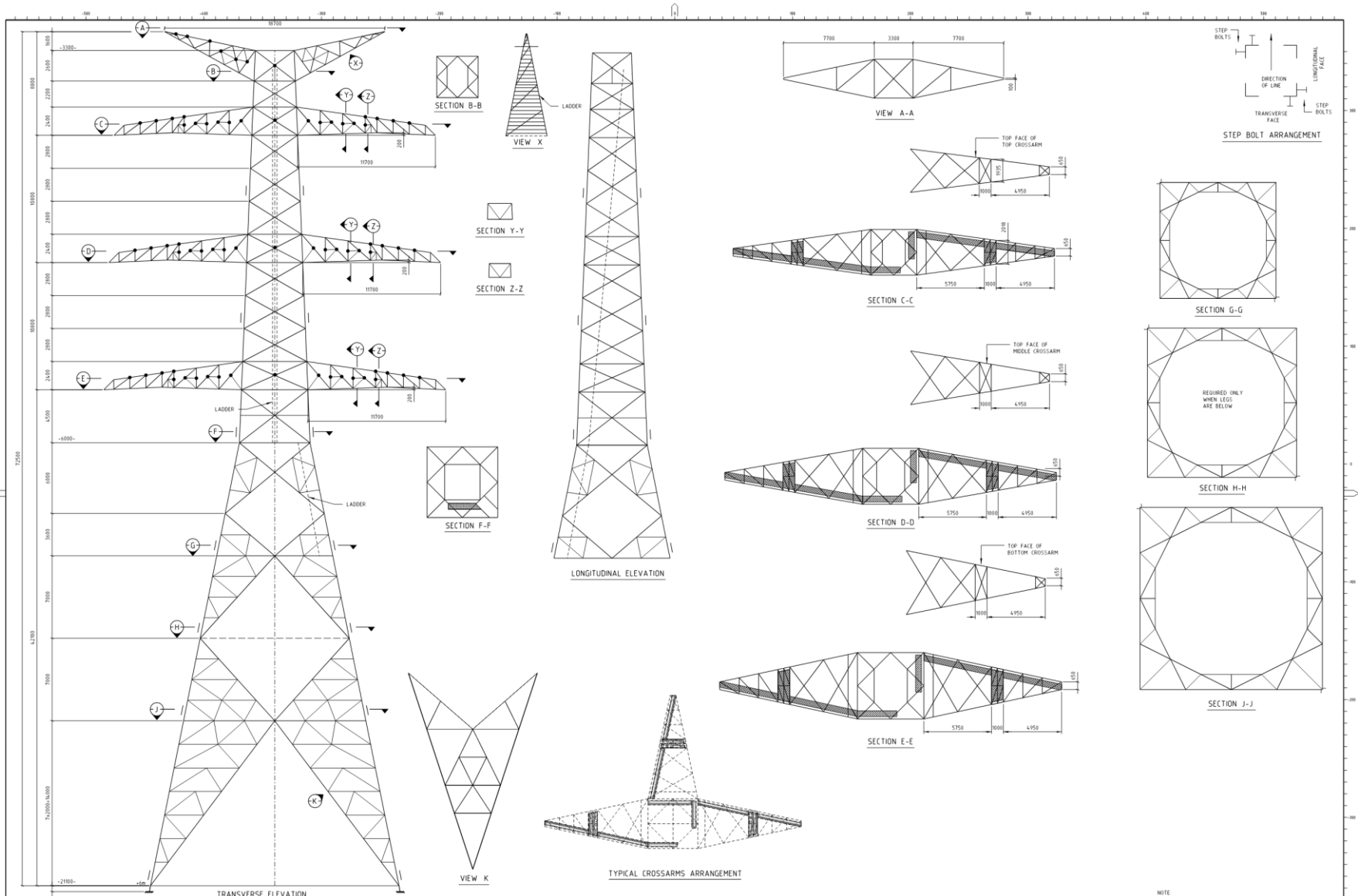
1. PHASE CONDUCTOR: 4 X ORANGE 110 AC58/GZ
EARTHWIRE: GRAPE AC58/GZ
LEADIN AC58/GZ
7/3.75 SC/AL
7/3.75 SC/AL
OPGW: TYPE A OR TYPE B
INCL OF FIBRES TO BE CONFIRMED AT DETAILED DESIGN

CLEARANCE REQUIREMENT		
CRITERIA	REQUIREMENT(mm)	APPLICABLE WIND PRESSURE (Pa)
SAFE APPROACH DISTANCE (SAD)	3900	100
LIGHTNING/SWITCHING IMPULSE	3100	300
POWER FREQUENCY	1750	500

2. STEP BOLTS ARE TRANSFORMED TO LADDER AS PER TL-79925-01. CLIMBING UP THE TOWER BODY (SUPERSTRUCTURE) TO BE FACILITATED VIA AN INTERNAL MOUNTED STEP LADDER WITH SURROUNDING GAGE AND NOT ON TOWER CORNERS.
3. ASSUME MAXIMUM VERTICAL DEPARTURE ANGLE OF 12° TO BE CONFIRMED DURING DETAILED DESIGN.
4. ASSUME MAXIMUM DEVIATION ANGLE BASED ON 4.2° BASED ON TOWER DESIGN TO BE CONFIRMED DURING DETAILED DESIGN.
5. ALL DIMENSIONS ARE IN MILLIMETERS.



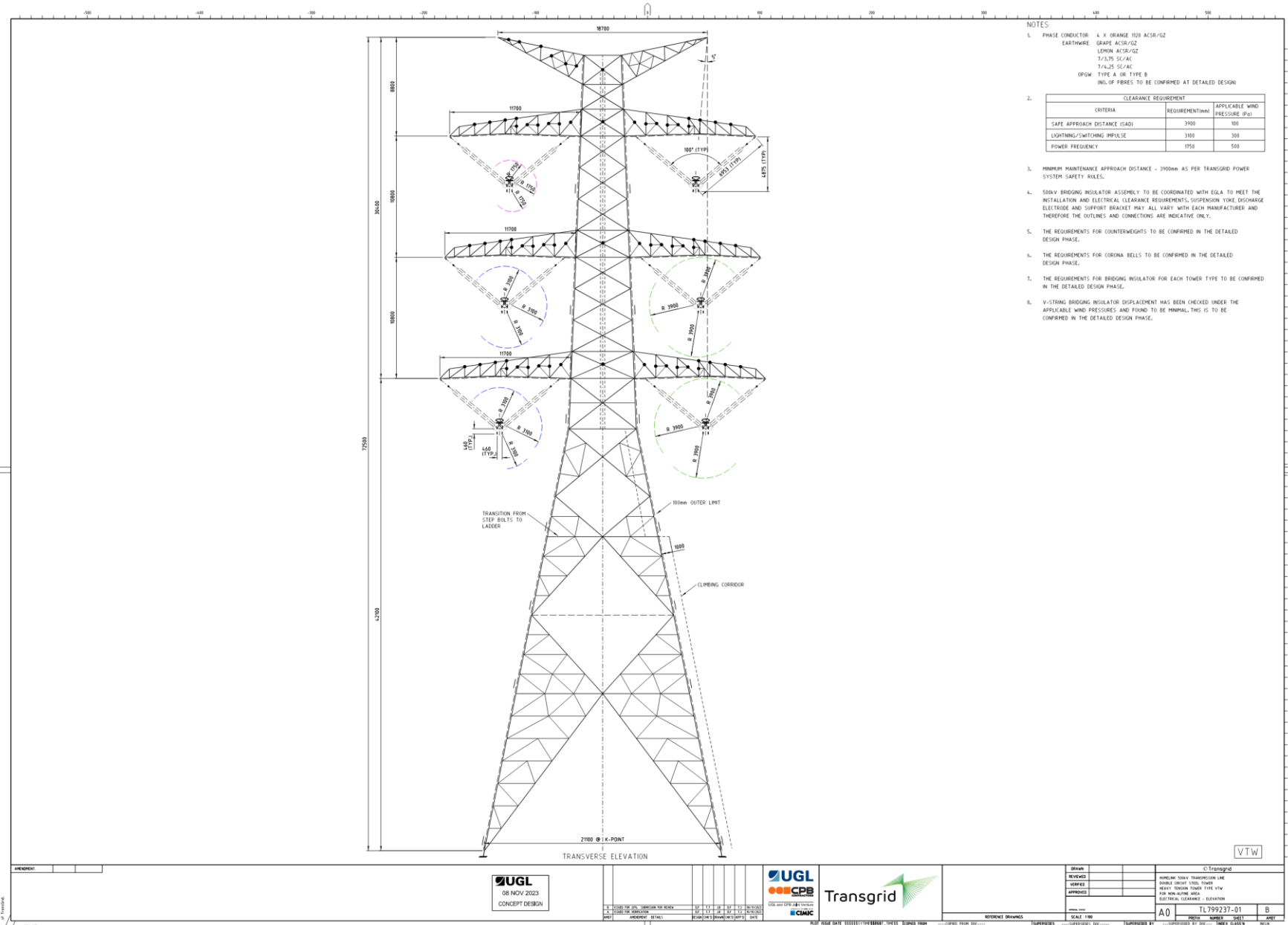
Drawn		© Transgrid
Reviewed		HUMBLE DUNN TRANSMISSION LINE
Approved		SIMPLE DUNN TRANSMISSION LINE
Scale	1:100	FOR NON-AREA AREA
Sheet	A0	TL799234-02
Block	B	

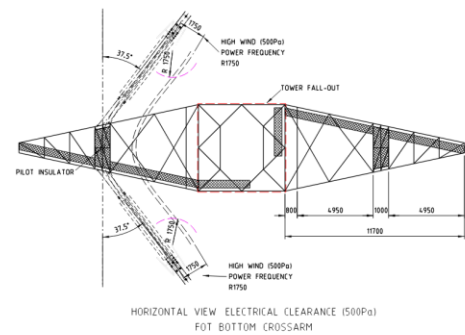
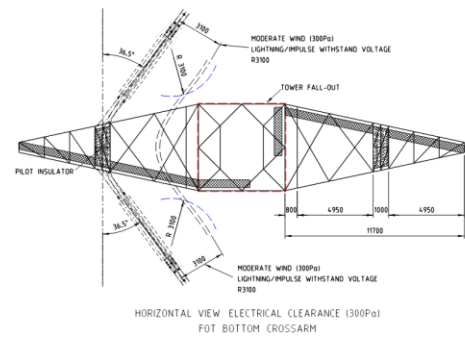
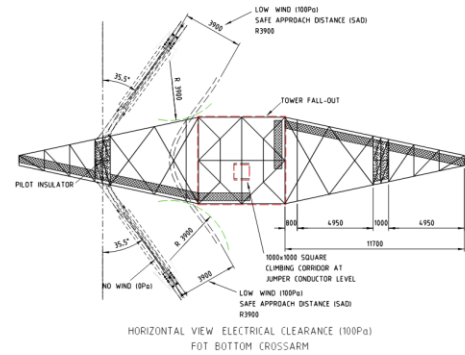
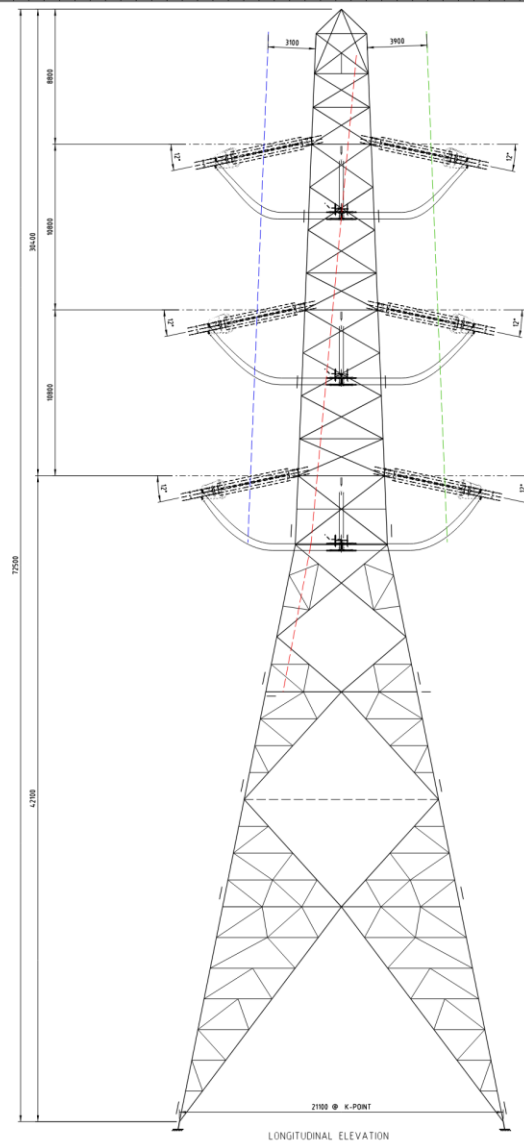


This drawing is a conceptual sketch. The geometry of the structure is not final and may be subject to change. It is not intended for construction. It is for information only.

NOTE
FOR OTHER LEG EXTENSION SEE NEXT DRAWING TL-799235-02

UGL 08 NOV 2023 CONCEPT DESIGN		UGL CPB CMC Transgrid		DRAWN: [] REVISED: [] CHECKED: [] APPROVED: []		© Transgrid HIGH VOLTAGE TRANSMISSION LINE TOWER DESIGN STUDY TOWER LEG EXTENSION TOWER LEG EXTENSION TYPE XTH TOWER LEG EXTENSION AREA LEG EXTENSION OUTLINE	
PROJECT: [] DRAWING: [] SHEET: []		SCALE: 1:100 DATE: []		A0 TL799235-01 B		INDEX CLASS: [] SHEET: []	





NOTES:

- PHASE CONDUCTOR: 4 X ORANGE 1120 ACSSR/GZ
EARTHWIRE: GRAYE ACSSR/GZ
LENNH ACSSR/GZ
7/3.75 SC/AL
7/3.75 SC/AL
OPGW: TYPE A OR TYPE B
NO. OF FIBRES TO BE CONFIRMED AT DETAILED DESIGN

CLEARANCE REQUIREMENT		
CRITERIA	REQUIREMENT (mm)	APPLICABLE WIND PRESSURE (Pa)
SAFE APPROACH DISTANCE (SAD)	3000	100
LIGHTNING/SWITCHING IMPULSE	3000	300
POWER FREQUENCY	1750	500

- STEP BOLTS ARE TRANSITIONED TO LADDER AS PER TL-799225-01. CLIMBING UP THE TOWER BODY IS SUPERSTRUCTURED TO BE FACILITATED VIA AN INTERNAL MOUNTED STEP LADDER WITH SURROUNDING CAGE AND NOT ON TOWER CORNERS.
- ASSUME MAXIMUM VERTICAL DEPARTURE ANGLE OF 12° TO BE CONFIRMED DURING DETAILED DESIGN.
- ASSUME MAXIMUM DEVIATION ANGLE BASED ON 70° BASED ON TOWER DESIGN TO BE CONFIRMED DURING DETAILED DESIGN.
- ALL DIMENSIONS ARE IN MILLIMETERS.

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APPROVED: _____

UGL
08 NOV 2023
CONCEPT DESIGN

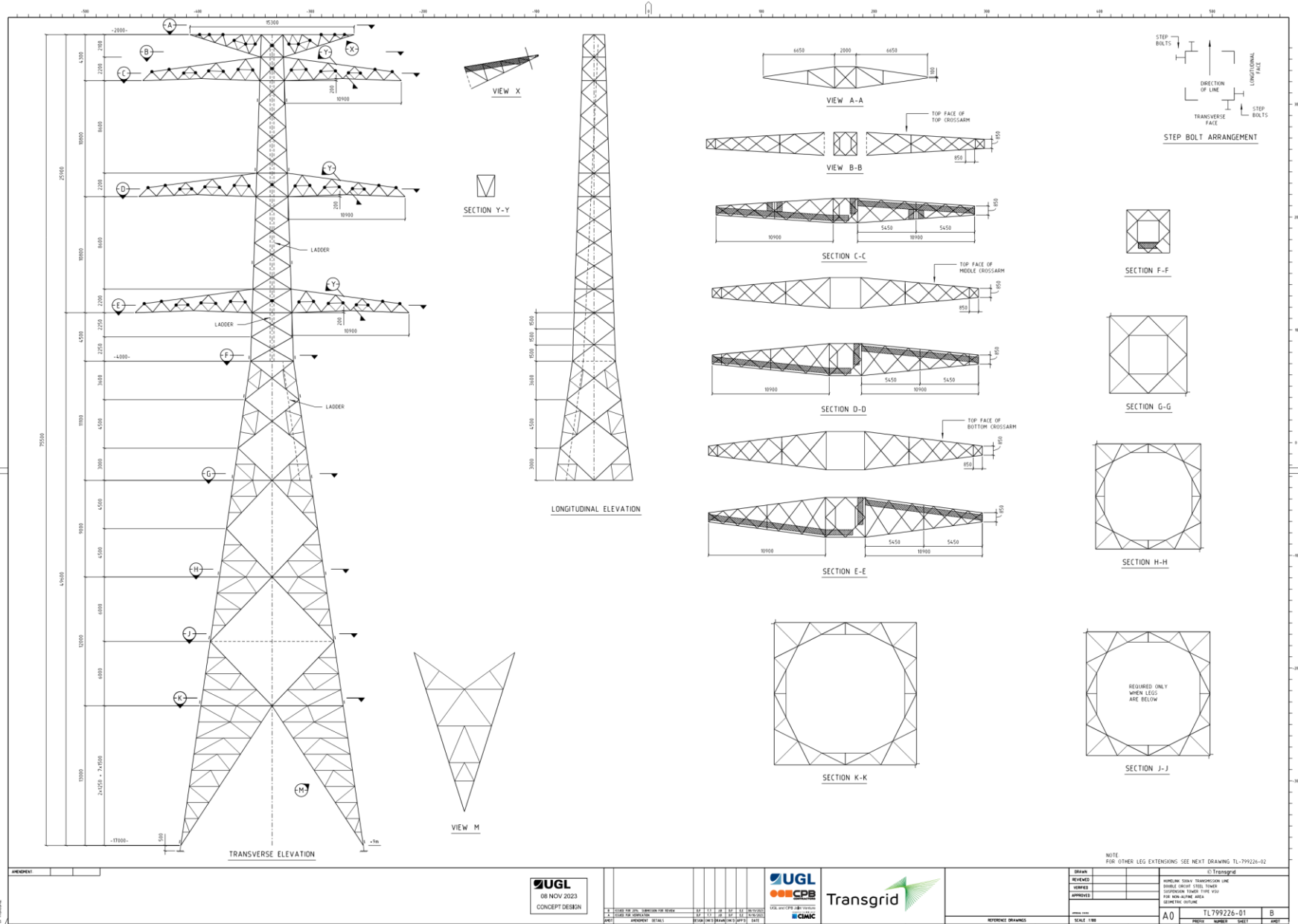
NO.	REVISION	DATE	BY	CHKD	APPD
1	ISSUED FOR DESIGN	08 NOV 2023	_____	_____	_____
2	FOR CONSTRUCTION	08 NOV 2023	_____	_____	_____

UGL
CPB
ECMC

Transgrid

REVISIONS		SCALE		PROJECT	
NO.	REVISION	SCALE	PROJECT	NO.	REVISION
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2	FOR CONSTRUCTION			2	FOR CONSTRUCTION

VTW



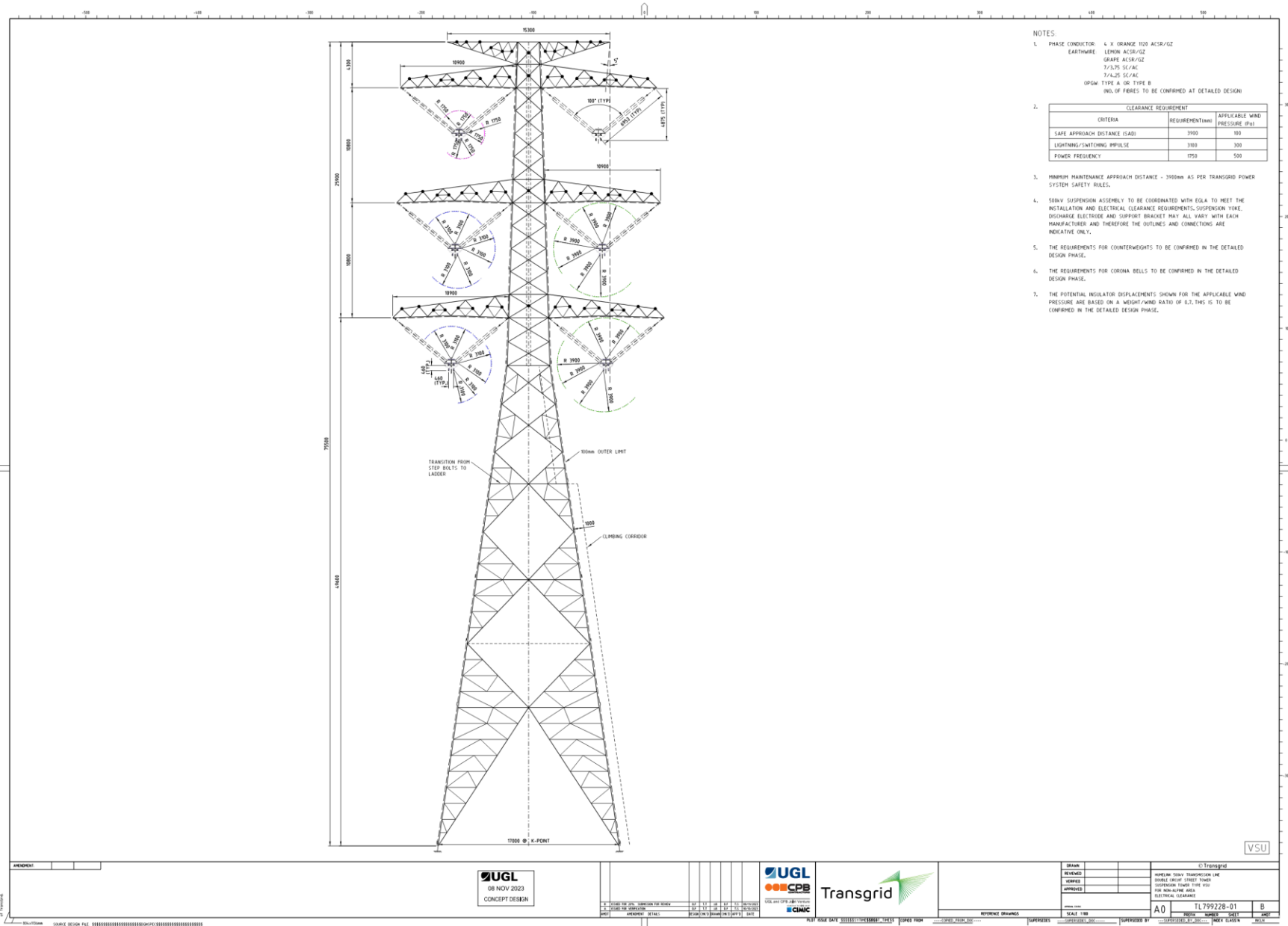
Not for construction. This drawing is for informational purposes only. It is not to be used for construction or for any other purpose without the written approval of the Transgrid Engineering Department.

UGL
08 NOV 2023
CONCEPT DESIGN

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CPE
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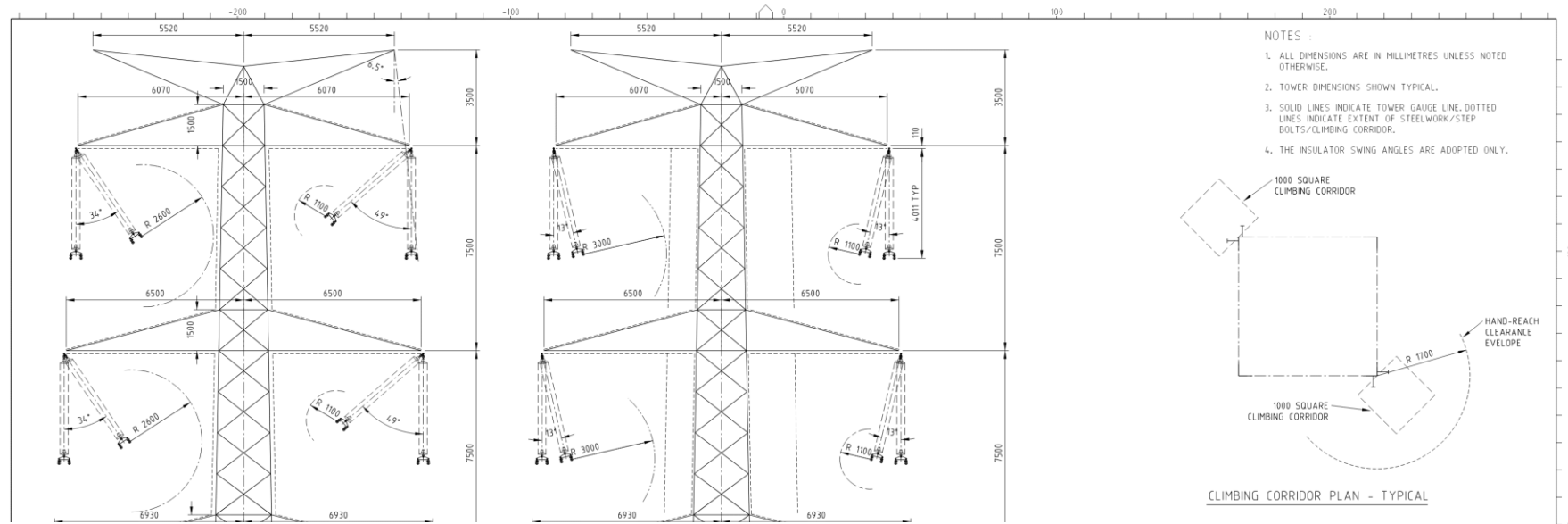
Transgrid

DESIGN		© Transgrid
REVIEWED		APPROVED FOR CONSTRUCTION
APPROVED		APPROVED FOR CONSTRUCTION
DATE		DATE
SCALE	1:100	SCALE
PROJECT	TL799226-01	PROJECT
SHEET	B	SHEET
TITLE		TITLE



B

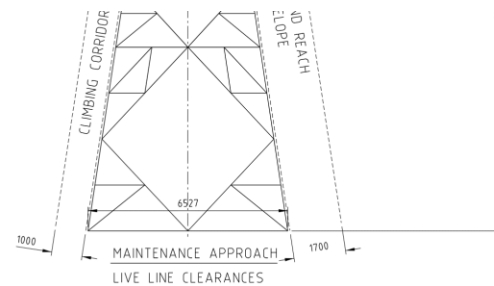
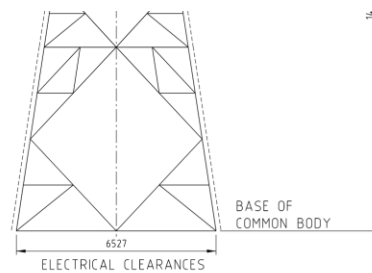
Appendix B— Line 51 330 kV Double Circuit Transmission Line Tower Structure Drawings



UL CLEARANCE REQUIREMENTS		
APPLICABLE WIND PRESSURE (Pa)	REFERENCE	LEGEND
300 (MODERATE WIND)	AS/NZS 7000 TABLE 3.4	---
500 (HIGH WIND)	AS/NZS 7000 TABLE 3.4	---
ALL	AS/NZS 7000 CLAUSE 3.3.2 & 3.3.3	NOT CRITICAL
100 (LOW WIND)	EN 50300 TABLE 2	---
100 (LOW WIND)	AS/NZS 7000 FIGURE 3.1	---

1/E AC/SR/GZ
DEGREE

SUSPENSION INSULATOR ARRANGEMENT	TL-903581 (HEAVY) 4011mm
WIND SPAN (m)	450
WEIGHT SPAN (m)	676
WEIGHT SPAN (m)	178
WIND SPAN (m)	230
LINE ANGLE (°)	0



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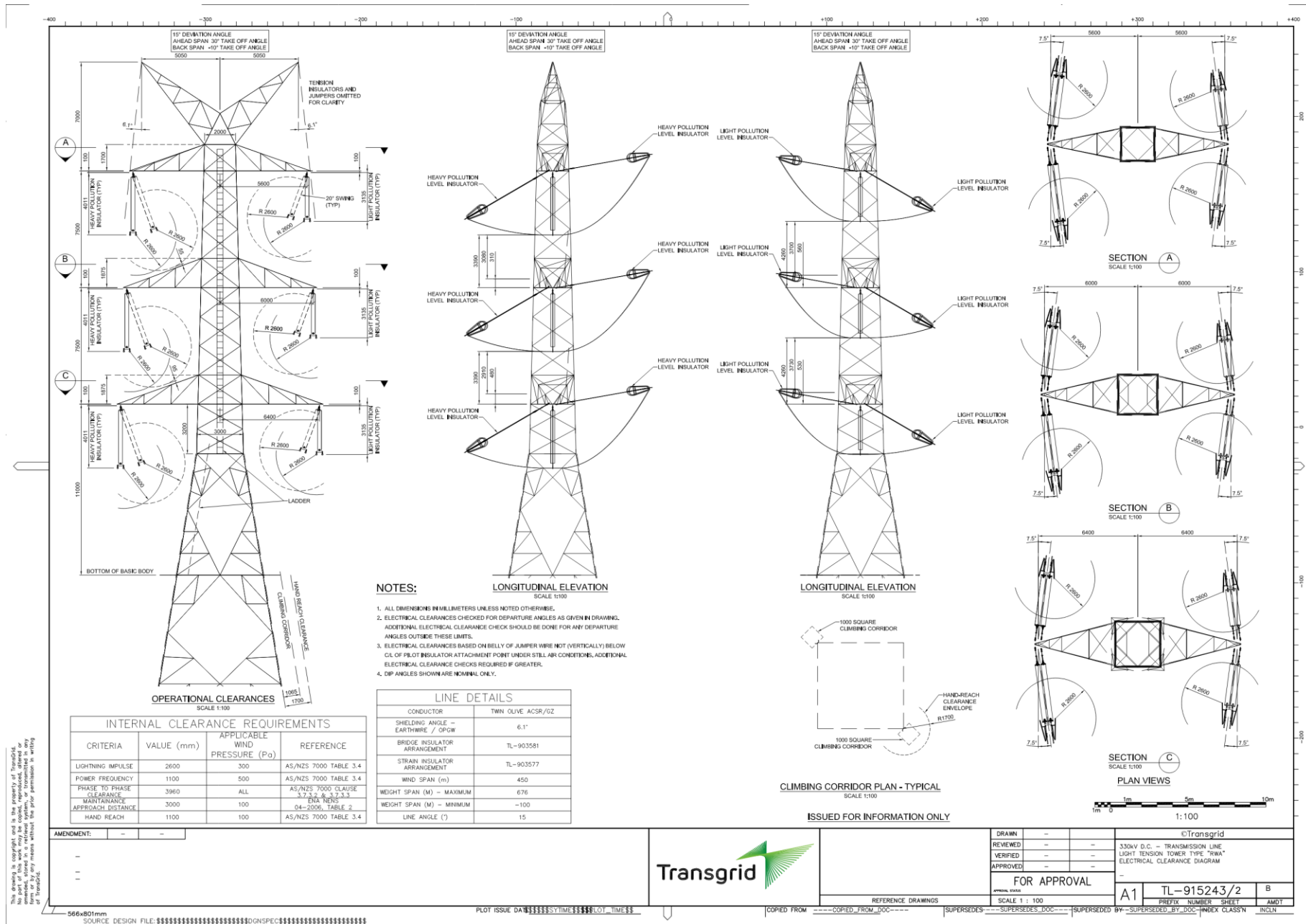
AMENDMENT		
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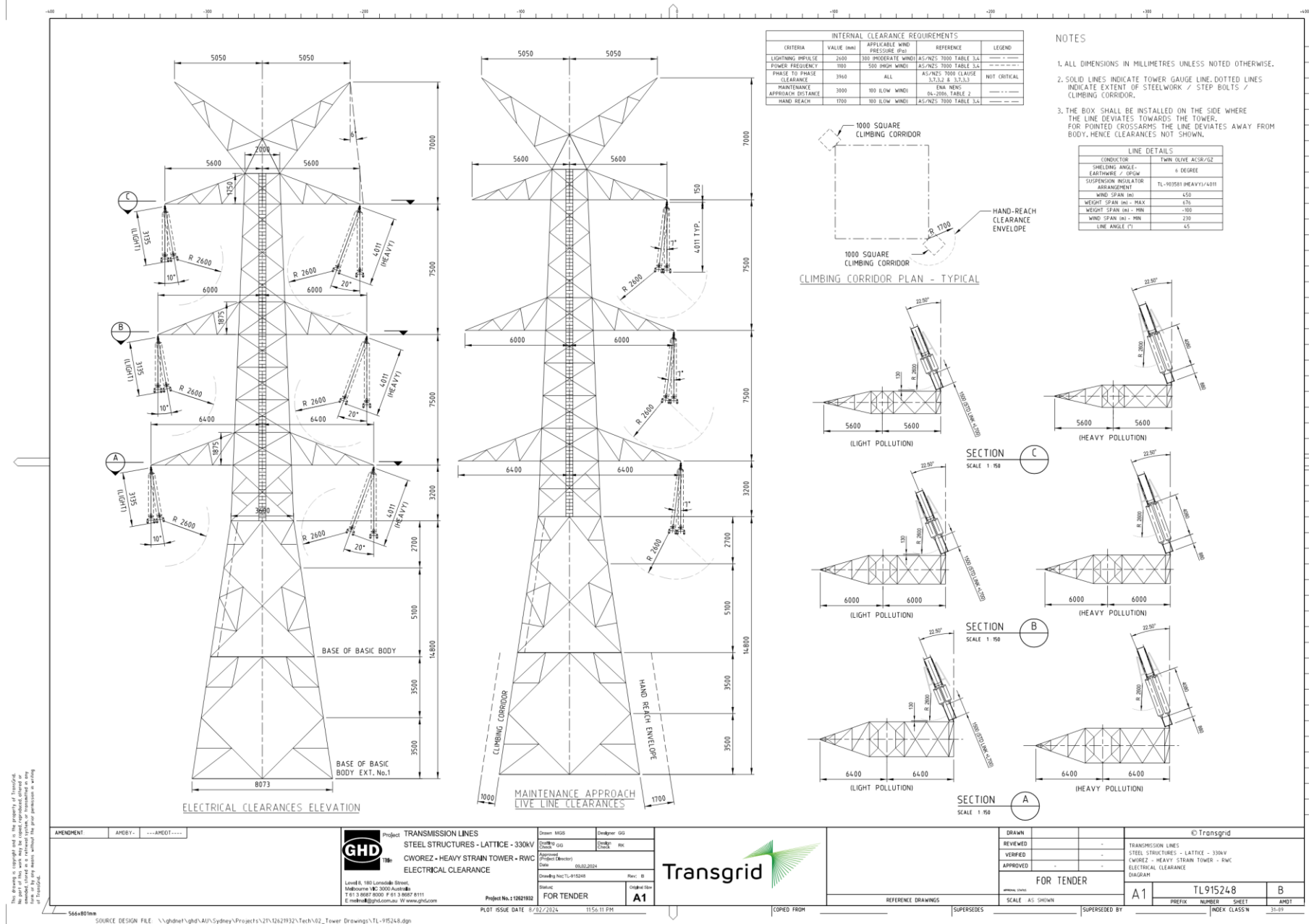
TL-915216 LIGHT SUSPENSION TOWER OUTLINE
TL-903581 SINGLE SUSPENSION GLASS INSULATOR STRING

DRAWN: WJ
REVIEWED:
VERIFIED:
APPROVED:
ISSUED FOR TENDER
APPROVAL STATUS:
SCALE:

©Transgrid		
TRANSMISSION LINES STEEL STRUCTURE - LATTICE - 330KV C/WIREZ - LIGHT SUSPENSION TOWER RSR ELECTRICAL CLEARANCE DIAGRAM		
A2	TL915215	00 C
INDEX	NUMBER	SHEET
		30-09

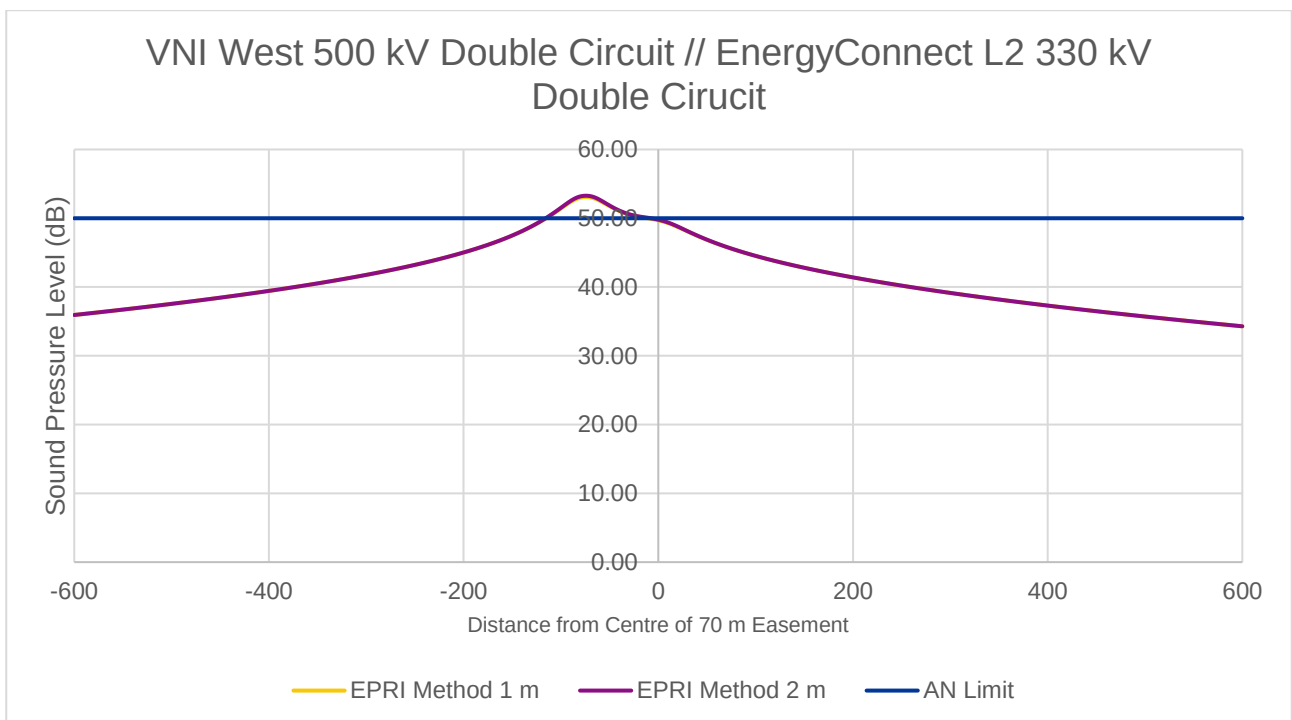
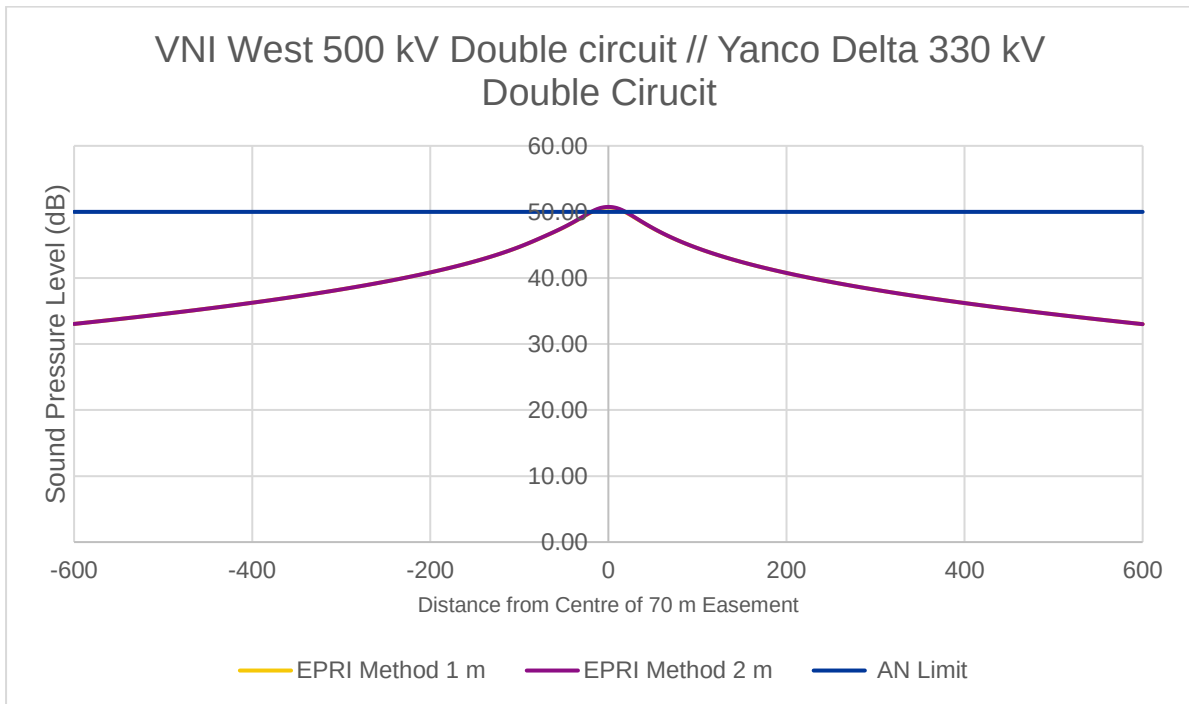


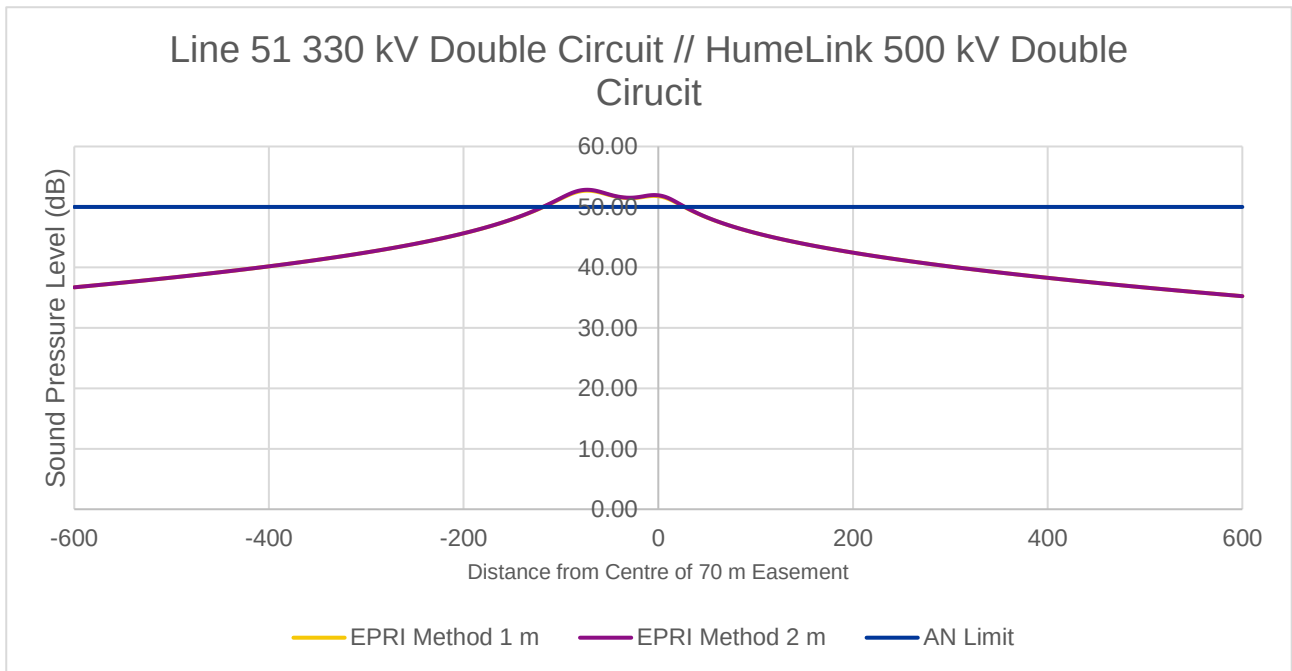
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C

Appendix C—Parallel Assessment





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