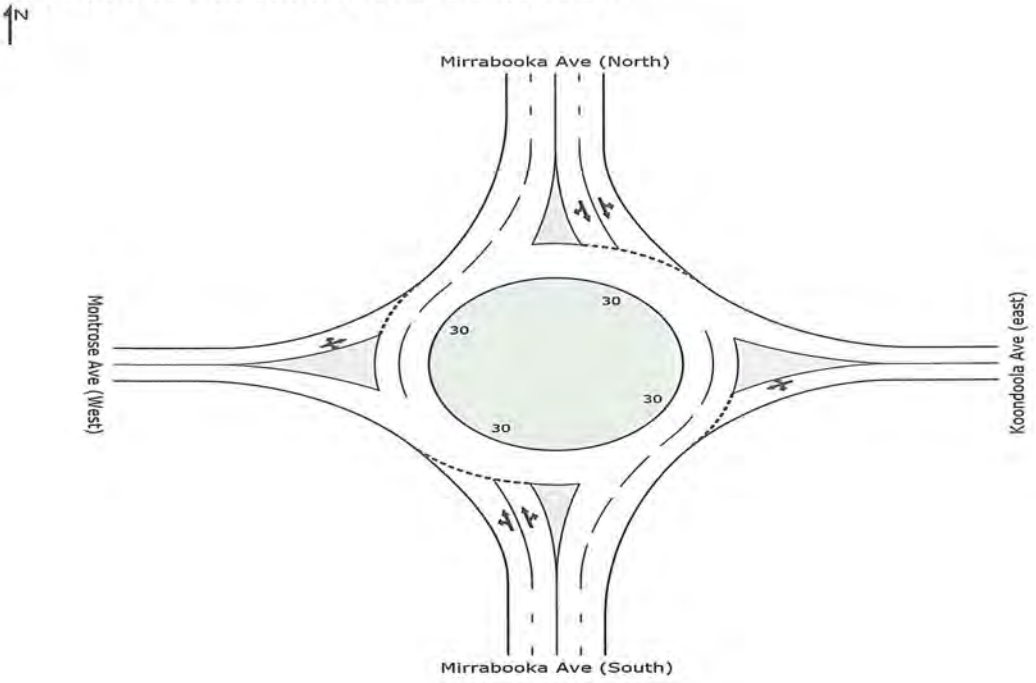
Appendix E - Summary of Sidra analysis - 2031 no LHS, existing geometry

Sidra Analysis with NO LHS 2031

This technical note provides the Sidra analysis and output for the Existing Intersection Geometry for full development (2031) with No LHS.

Mirrabooka/Koondoola Intersection 2031



Mirabooka Koondoola 2031 No LHS am Existing Geometry
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	68	4.0	0.334	6.5	LOS A	2.4	17.5	0.44	0.56	49.5
2	T	764	4.0	0.334	5.3	LOS A	2.4	17.5	0.45	0.48	49.8
3	R	109	4.0	0.334	12.4	LOS B	2.3	16.7	0.47	0.78	46.3
Approach		941	4.0	0.334	6.2	LOS A	2.4	17.5	0.45	0.52	49.3
East: Koondoola Ave (east)											
4	L	140	4.0	0.585	15.2	LOS B	3.7	26.8	0.87	1.04	42.3
5	T	74	4.0	0.585	14.2	LOS B	3.7	26.8	0.87	1.02	42.5
6	R	75	4.0	0.585	21.1	LOS C	3.7	26.8	0.87	1.09	39.9
Approach		289	4.0	0.585	16.5	LOS B	3.7	26.8	0.87	1.05	41.7
North: Mirrabooka Ave (North)											
7	L	56	4.0	0.587	6.9	LOS A	5.2	37.5	0.55	0.60	49.0
8	T	1563	4.0	0.587	5.8	LOS A	5.2	37.5	0.57	0.52	49.1
9	R	52	4.0	0.587	12.9	LOS B	5.0	36.5	0.59	0.80	46.4
Approach		1671	4.0	0.587	6.1	LOS A	5.2	37.5	0.57	0.54	49.0
West: Montrose Ave (West)											
10	L	40	4.0	0.194	8.3	LOS A	0.8	6.0	0.62	0.72	47.7
11	T	32	4.0	0.194	7.3	LOS A	0.8	6.0	0.62	0.65	47.7
12	R	75	4.0	0.194	14.2	LOS B	0.8	6.0	0.62	0.92	44.7
Approach		147	4.0	0.194	11.1	LOS B	0.8	6.0	0.62	0.81	46.1
All Vehicles		3048	4.0	0.587	7.4	LOS A	5.2	37.5	0.57	0.59	48.1

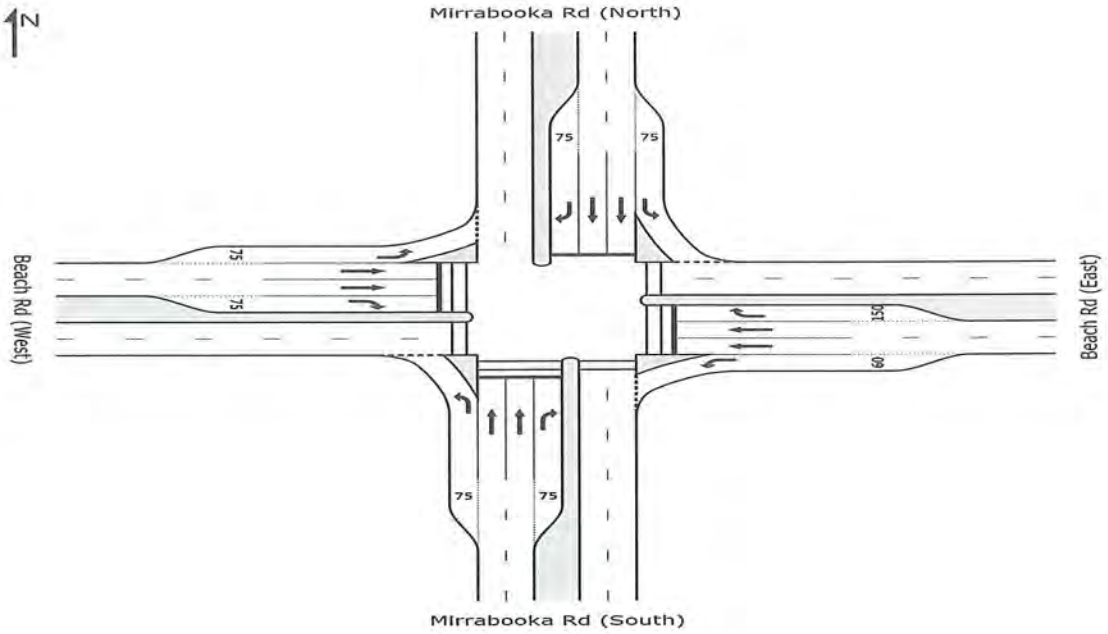
Mirabooka Koondoola 2031 No LHS pm Existing Geometry
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	116	4.0	0.560	6.5	LOS A	5.0	36.6	0.48	0.55	49.4
2	T	1448	4.0	0.560	5.4	LOS A	5.0	36.6	0.49	0.49	49.6
3	R	99	4.0	0.560	12.5	LOS B	4.9	35.7	0.52	0.78	46.5
Approach		1663	4.0	0.560	5.9	LOS A	5.0	36.6	0.49	0.51	49.3
East: Koondoola Ave (east)											
4	L	94	4.0	0.268	8.5	LOS A	1.2	8.7	0.64	0.73	47.6
5	T	17	4.0	0.268	7.5	LOS A	1.2	8.7	0.64	0.67	47.5
6	R	95	4.0	0.268	14.3	LOS B	1.2	8.7	0.64	0.93	44.5
Approach		206	4.0	0.268	11.1	LOS B	1.2	8.7	0.64	0.82	46.1
North: Mirrabooka Ave (North)											
7	L	47	4.0	0.315	6.5	LOS A	2.1	15.4	0.42	0.56	49.7
8	T	799	4.0	0.315	5.4	LOS A	2.1	15.4	0.44	0.48	50.0
9	R	44	4.0	0.315	12.4	LOS B	2.0	14.8	0.45	0.82	46.6
Approach		890	4.0	0.315	5.8	LOS A	2.1	15.4	0.44	0.50	49.8
West: Montrose Ave (West)											
10	L	65	4.0	0.330	11.3	LOS B	1.6	11.8	0.79	0.90	45.6
11	T	29	4.0	0.330	10.3	LOS B	1.6	11.8	0.79	0.88	45.8
12	R	83	4.0	0.330	17.2	LOS B	1.6	11.8	0.79	0.98	42.4
Approach		177	4.0	0.330	13.9	LOS B	1.6	11.8	0.79	0.93	44.0
All Vehicles		2936	4.0	0.560	6.7	LOS A	5.0	36.6	0.50	0.55	48.9

The above analysis indicates that the existing roundabout will accommodate forecast traffic volumes to 2031 with no LHS.

Beach Road/Mirrabooka Road Intersection 2031
Existing Geometry



Beach Rd/Mirrabooka Ave 2031 No LHS Existing Geometry AM
Signals - Fixed Time Cycle Time = 116 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Rd (South)											
1	L	111	5.0	0.187	14.7	LOS B	2.1	15.6	0.42	0.69	43.0
2	T	550	5.0	0.512	37.5	LOS D	13.1	95.4	0.89	0.76	28.3
3	R	117	5.0	0.390	52.5	LOS D	5.8	42.5	0.91	0.78	24.7
Approach		778	5.0	0.512	36.5	LOS D	13.1	95.4	0.83	0.75	29.1
East: Beach Rd (East)											
4	L	133	5.0	0.297	18.4	LOS B	3.2	23.4	0.51	0.71	40.0
5	T	450	5.0	0.658	48.6	LOS D	12.1	88.4	0.98	0.82	24.7
6	R	241	5.0	0.974	103.1	LOS F	19.6	142.7	1.00	1.23	15.7
Approach		824	5.0	0.974	59.7	LOS E	19.6	142.7	0.91	0.92	22.4
North: Mirrabooka Rd (North)											
7	L	369	5.0	0.538	13.0	LOS B	6.7	49.2	0.42	0.71	44.4
8	T	1041	5.0	0.970	86.9	LOS F	43.2	315.2	1.00	1.34	17.2
9	R	298	5.0	1.000 [3]	58.3	LOS E	16.8	122.4	1.00	0.85	23.2
Approach		1708	5.0	1.000	66.0	LOS E	43.2	315.2	0.87	1.12	20.9
West: Beach Rd (West)											
10	L	167	5.0	0.283	14.3	LOS B	3.2	23.3	0.42	0.70	43.3
11	T	584	5.0	0.854	58.1	LOS E	18.0	131.5	1.00	1.00	22.3
12	R	146	5.0	0.590	60.1	LOS E	8.0	58.4	0.99	0.80	22.8
Approach		897	5.0	0.854	50.3	LOS D	18.0	131.5	0.89	0.91	24.6
All Vehicles		4207	5.0	1.000	55.9	LOS E	43.2	315.2	0.88	0.97	23.2

Beach Rd/Mirrabooka Ave 2031 No LHS Existing Geometry PM
Signals - Fixed Time Cycle Time = 118 seconds (Optimum Cycle Time - Minimum Delay)

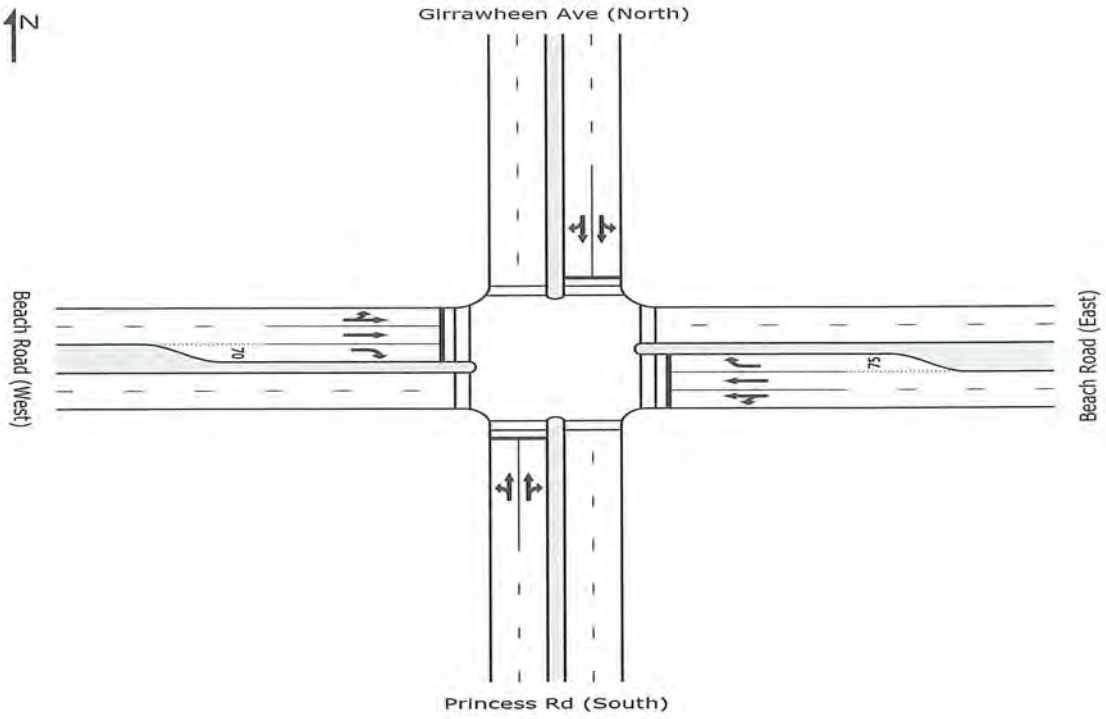
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Mirrabooka Rd (South)											
1	L	144	5.0	0.245	15.1	LOS B	2.9	21.2	0.43	0.69	42.6
2	T	925	5.0	0.876	54.0	LOS D	29.2	213.1	1.00	1.03	23.2
3	R	114	5.0	0.834	74.4	LOS E	7.3	53.0	1.00	0.94	19.8
Approach		1183	5.0	0.876	51.2	LOS D	29.2	213.1	0.93	0.98	24.2
East: Beach Rd (East)											
4	L	126	5.0	0.197	10.7	LOS B	1.6	11.7	0.29	0.66	46.5
5	T	809	5.0	0.871	56.0	LOS E	25.6	186.6	1.00	1.03	22.7
6	R	324	5.0	0.927	80.1	LOS F	23.2	169.7	1.00	1.07	18.8
Approach		1259	5.0	0.927	57.7	LOS E	25.6	186.6	0.93	1.00	22.7
North: Mirrabooka Rd (North)											
7	L	270	5.0	0.338	10.3	LOS B	3.3	24.2	0.29	0.68	46.9
8	T	555	5.0	0.525	38.7	LOS D	13.5	98.8	0.90	0.76	27.9
9	R	121	5.0	0.885	78.4	LOS E	8.0	58.4	1.00	1.02	19.1
Approach		946	5.0	0.885	35.7	LOS D	13.5	98.8	0.74	0.77	29.6
West: Beach Rd (West)											
10	L	438	5.0	1.000 [3]	27.3	LOS C	16.8	122.8	0.77	0.81	34.5
11	T	313	5.0	0.337	39.5	LOS D	7.4	54.3	0.87	0.71	27.6
12	R	76	5.0	0.254	51.4	LOS D	3.7	27.1	0.88	0.76	25.0
Approach		827	5.0	1.000	34.2	LOS C	16.8	122.8	0.82	0.77	30.6
All Vehicles		4215	5.0	1.000	46.3	LOS D	29.2	213.1	0.86	0.90	25.8

The above analysis indicates an intersection LoS of D/E to 2031 with no LHS for the current geometry. Stop rates for some movements are greater than 1 and the degree of saturation is 1. The analysis indicates that upgrade is required to improve the performance.

Girrawheen/Beach Road Intersection 2031

Existing Geometry



Girrawheen Avenue / Beach Road / Princess Rd AM 2031 Existing Geometry No LHS
Signals - Fixed Time Cycle Time = 117 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Princess Rd (South)											
1	L	199	5.0	0.900	71.8	LOS E	23.6	172.1	1.00	1.06	20.5
2	T	296	5.0	0.900	63.4	LOS E	23.6	172.1	1.00	1.06	20.6
3	R	210	5.0	0.900	71.5	LOS E	23.5	171.8	1.00	1.06	20.6
Approach		705	5.0	0.900	68.2	LOS E	23.6	172.1	1.00	1.06	20.6
East: Beach Road (East)											
4	L	422	5.0	0.918	73.6	LOS E	29.4	214.8	1.00	1.02	19.8
5	T	359	5.0	0.741	44.5	LOS D	19.3	141.2	0.98	0.87	25.9
6	R	91	5.0	0.424	61.4	LOS E	5.0	36.3	0.97	0.78	22.4
Approach		872	5.0	0.918	60.3	LOS E	29.4	214.8	0.99	0.93	22.2
North: Girrawheen Ave (North)											
7	L	98	5.0	0.895	71.1	LOS E	22.6	164.7	1.00	1.08	20.9
8	T	541	5.0	0.895	62.7	LOS E	22.7	165.8	1.00	1.08	21.1
9	R	47	5.0	0.895	70.8	LOS E	22.7	165.8	1.00	1.08	21.1
Approach		686	5.0	0.895	64.5	LOS E	22.7	165.8	1.00	1.08	21.0
West: Beach Road (West)											
10	L	30	5.0	0.578	49.5	LOS D	14.0	101.9	0.93	0.86	26.5
11	T	528	5.0	0.578	41.1	LOS D	14.0	102.4	0.93	0.79	26.9
12	R	197	5.0	0.918	81.1	LOS F	13.6	99.2	1.00	1.06	18.6
Approach		755	5.0	0.918	51.9	LOS D	14.0	102.4	0.95	0.86	24.1
All Vehicles		3018	5.0	0.918	61.0	LOS E	29.4	214.8	0.98	0.98	22.0

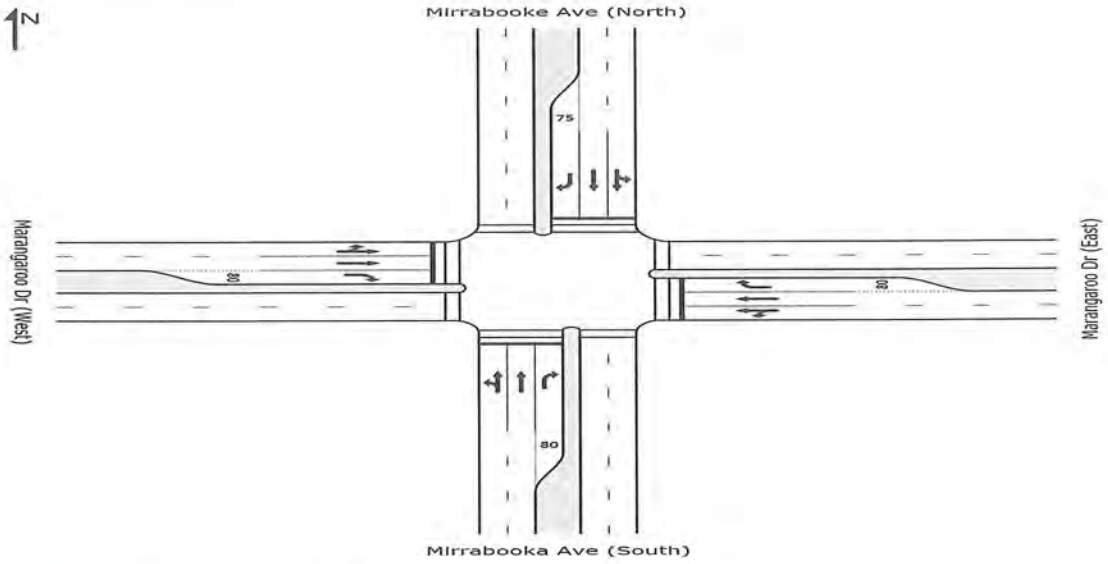
Girrawheen Avenue / Beach Road / Princess Rd PM 2031 Existing Geometry No LHS
Signals - Fixed Time Cycle Time = 160 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Princess Rd (South)											
1	L	312	5.0	0.992	125.2	LOS F	79.2	578.2	1.00	1.22	13.7
2	T	568	5.0	0.992	117.0	LOS F	79.2	578.2	1.00	1.20	13.7
3	R	483	5.0	0.992	125.4	LOS F	78.3	571.9	1.00	1.18	13.6
Approach		1363	5.0	0.992	121.9	LOS F	79.2	578.2	1.00	1.20	13.7
East: Beach Road (East)											
4	L	256	5.0	1.015	161.6	LOS F	57.0	415.9	1.00	1.31	11.1
5	T	665	5.0	1.015	152.6	LOS F	58.5	426.8	1.00	1.42	11.3
6	R	68	5.0	0.379	82.5	LOS F	5.1	37.1	0.98	0.77	18.4
Approach		989	5.0	1.015	150.1	LOS F	58.5	426.8	1.00	1.35	11.6
North: Girrawheen Ave (North)											
7	L	56	5.0	0.878	93.6	LOS F	18.4	134.2	1.00	1.01	17.2
8	T	347	5.0	0.878	85.1	LOS F	18.5	135.1	1.00	1.01	17.3
9	R	28	5.0	0.878	93.2	LOS F	18.5	135.1	1.00	1.01	17.4
Approach		431	5.0	0.878	86.8	LOS F	18.5	135.1	1.00	1.01	17.3
West: Beach Road (West)											
10	L	41	5.0	0.436	63.2	LOS E	13.0	95.2	0.90	0.85	22.6
11	T	358	5.0	0.436	54.8	LOS D	13.2	96.2	0.90	0.75	23.0
12	R	176	5.0	0.982	103.1	LOS F	15.6	114.2	1.00	0.92	15.7
Approach		575	5.0	0.982	70.2	LOS E	15.6	114.2	0.93	0.81	20.1
All Vehicles		3358	5.0	1.015	116.8	LOS F	79.2	578.2	0.99	1.15	14.1

The above analysis indicates an intersection LoS of E/F to 2031 with no LHS for the current geometry. Stop rates for most movements are greater than 1 and the degree of saturation is greater than 1 in the pm peak hour 1. The analysis indicates that upgrade is required to improve the performance.

Mirabooka/Marangaroo Ave Intersection 2031
Exiting Geometry



Marangaroo Dr / Mirrabooka Ave 2031 Existing Geometry AM
Signals - Fixed Time Cycle Time = 135 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Mirrabooka Ave (South)											
1	L	114	4.0	0.505	39.4	LOS D	18.9	136.9	0.79	0.89	29.7
2	T	677	4.0	0.505	31.1	LOS C	19.2	139.0	0.79	0.70	30.9
3	R	68	4.0	0.268	64.7	LOS E	4.1	29.4	0.93	0.76	21.7
Approach		859	4.0	0.505	34.9	LOS C	19.2	139.0	0.80	0.73	29.7
East: Marangaroo Dr (East)											
4	L	241	4.0	0.947	97.5	LOS F	22.4	162.4	1.00	1.09	16.3
5	T	306	4.0	0.947	88.5	LOS F	23.4	169.1	1.00	1.18	17.0
6	R	189	4.0	0.942	97.4	LOS F	15.5	112.2	1.00	1.09	16.4
Approach		736	4.0	0.947	93.7	LOS F	23.4	169.1	1.00	1.13	16.6
North: Mirrabooke Ave (North)											
7	L	198	4.0	0.939	74.2	LOS E	59.2	428.9	1.00	1.09	20.3
8	T	1272	4.0	0.939	65.6	LOS E	59.9	433.6	1.00	1.11	20.6
9	R	243	4.0	0.956	75.6	LOS E	16.9	122.4	1.00	0.87	19.6
Approach		1713	4.0	0.956	68.0	LOS E	59.9	433.6	1.00	1.07	20.4
West: Marangaroo Dr (West)											
10	L	96	4.0	0.611	66.6	LOS E	11.0	79.5	0.98	0.82	21.6
11	T	260	4.0	0.611	58.3	LOS E	11.3	81.7	0.98	0.81	22.1
12	R	108	4.0	0.538	71.0	LOS E	6.9	50.2	0.99	0.79	20.4
Approach		464	4.0	0.611	63.0	LOS E	11.3	81.7	0.99	0.81	21.6
All Vehicles		3772	4.0	0.956	64.9	LOS E	59.9	433.6	0.95	0.97	21.1

Marangaroo Dr / Mirrabooka Ave 2031 Existing Geometry PM
Signals - Fixed Time Cycle Time = 136 seconds (Optimum Cycle Time - Minimum Delay)

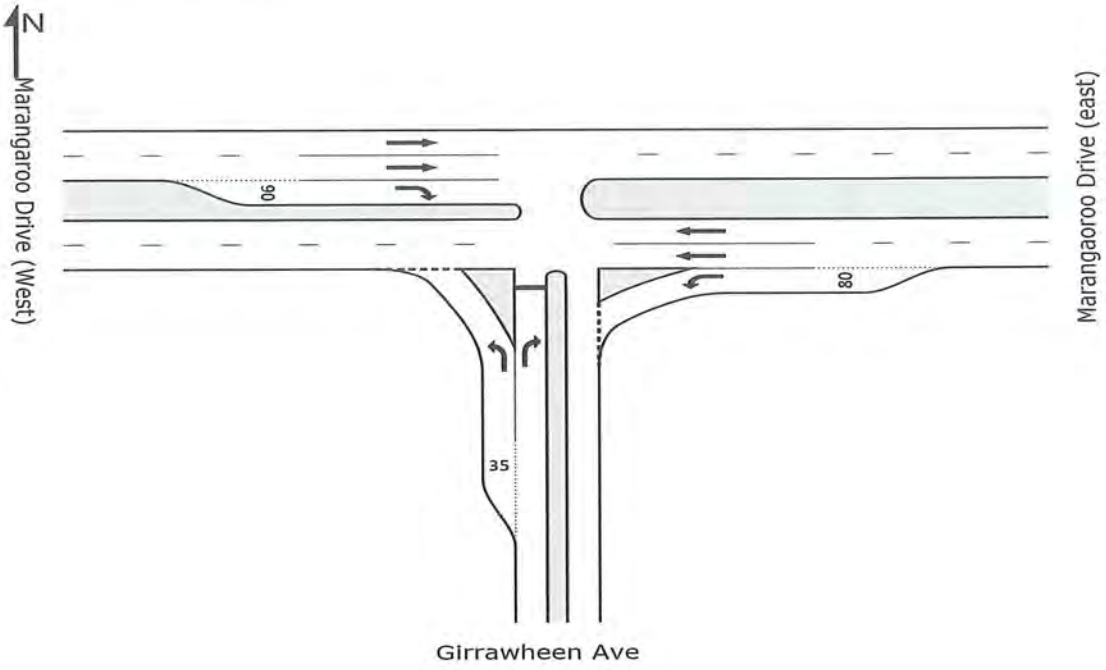
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	126	4.0	0.949	81.2	LOS F	60.5	437.9	1.00	1.14	19.1
2	T	1300	4.0	0.949	72.7	LOS E	60.9	441.0	1.00	1.15	19.3
3	R	171	4.0	0.920	91.8	LOS F	13.5	97.4	1.00	1.05	17.1
Approach		1597	4.0	0.949	75.4	LOS E	60.9	441.0	1.00	1.14	19.0
East: Marangaroo Dr (East)											
4	L	77	4.0	0.643	65.9	LOS E	12.7	92.1	0.99	0.83	21.9
5	T	332	4.0	0.643	57.5	LOS E	13.0	93.8	0.99	0.82	22.3
6	R	268	4.0	0.961	71.0	LOS E	18.1	130.9	1.00	0.84	20.4
Approach		677	4.0	0.961	63.8	LOS E	18.1	130.9	0.99	0.83	21.4
North: Mirrabooke Ave (North)											
7	L	146	4.0	0.582	42.6	LOS D	22.2	160.7	0.84	0.88	28.5
8	T	724	4.0	0.582	34.2	LOS C	22.6	163.5	0.84	0.74	29.4
9	R	178	4.0	0.958	104.6	LOS F	15.2	110.4	1.00	1.13	15.5
Approach		1048	4.0	0.958	47.3	LOS D	22.6	163.5	0.87	0.83	25.4
West: Marangaroo Dr (West)											
10	L	290	4.0	0.950	98.9	LOS F	24.8	179.7	1.00	1.07	16.1
11	T	292	4.0	0.908	76.1	LOS E	22.5	162.9	1.00	1.09	18.8
12	R	82	4.0	0.294	63.6	LOS E	4.9	35.4	0.93	0.77	21.9
Approach		664	4.0	0.950	84.5	LOS F	24.8	179.7	0.99	1.04	17.8
All Vehicles		3986	4.0	0.961	67.6	LOS E	60.9	441.0	0.96	0.99	20.6

The above analysis indicates an intersection LoS of E to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 0.9. The analysis indicates that upgrade is required to improve the performance. Queues in excess of 400m are forecast in Mirrabooka Drive.

Marangaroo Drive/Girawheen Ave Intersection 2031

Existing Geometry



Marangaroo Drive / Girrawheen Avenue Existing Geometry 2031 AM
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Girrawheen Ave											
1	L	280	4.0	0.470	14.5	LOS B	2.6	19.1	0.66	0.97	43.2
3	R	61	4.0	1.017	291.1	LOS F	8.3	60.0	1.00	1.63	6.7
Approach		341	4.0	1.017	63.9	LOS F	8.3	60.0	0.72	1.09	22.0
East: Marangaoroo Drive (east)											
4	L	160	4.0	0.182	10.2	LOS B	0.7	5.3	0.51	0.74	47.1
5	T	554	4.0	0.146	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		714	4.0	0.182	2.3	NA	0.7	5.3	0.11	0.17	56.5
West: Marangaroo Drive (West)											
11	T	398	4.0	0.105	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	449	4.0	0.556	14.0	LOS B	4.2	30.4	0.68	1.04	43.4
Approach		847	4.0	0.556	7.4	NA	4.2	30.4	0.36	0.55	49.9
All Vehicles		1902	4.0	1.017	15.6	NA	8.3	60.0	0.33	0.50	42.1

Marangaroo Drive / Girrawheen Avenue Existing Geometry 2031 PM
Stop (Two-Way)

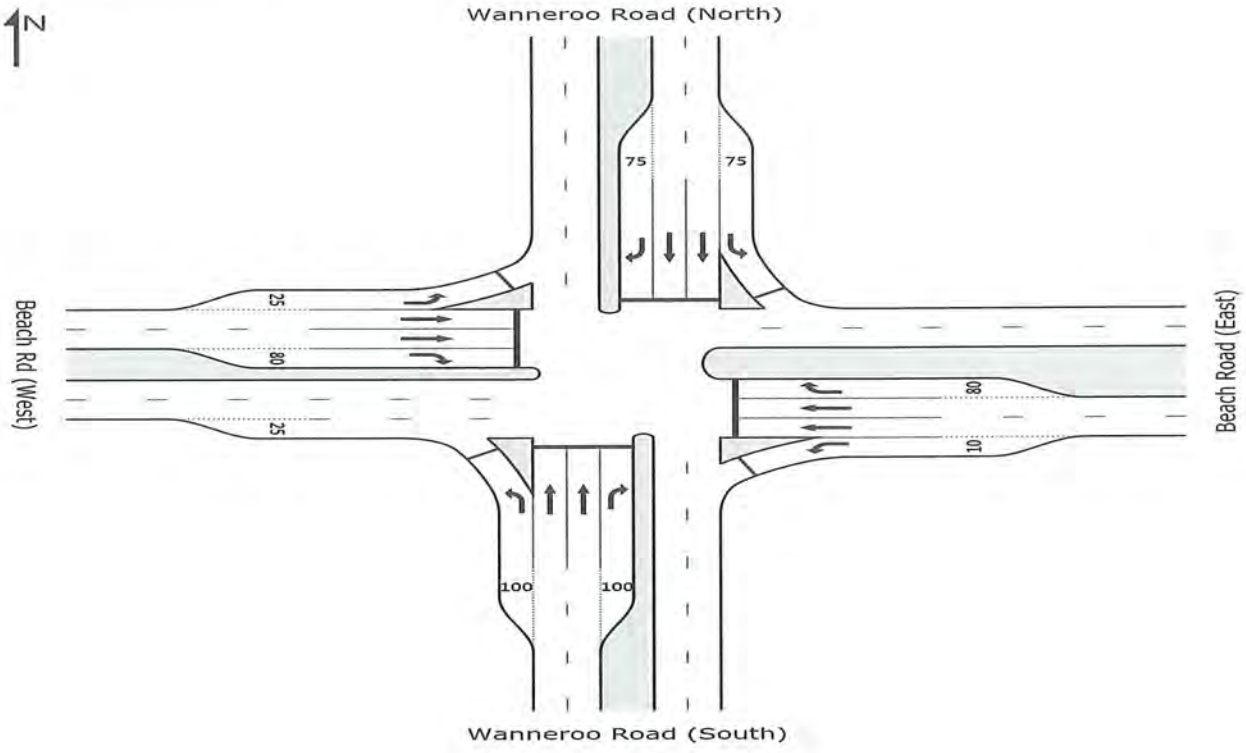
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Girrawheen Ave											
1	L	374	4.0	0.592	15.4	LOS C	4.2	30.4	0.70	1.05	42.4
3	R	115	4.0	1.743	1448.2	LOS F	67.2	486.6	1.00	4.28	1.5
Approach		489	4.0	1.743	352.4	LOS F	67.2	486.6	0.77	1.81	5.7
East: Marangaoroo Drive (east)											
4	L	74	4.0	0.064	8.6	LOS A	0.3	1.8	0.32	0.60	48.1
5	T	549	4.0	0.144	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		623	4.0	0.144	1.0	NA	0.3	1.8	0.04	0.07	58.3
West: Marangaroo Drive (West)											
11	T	607	4.0	0.160	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	217	4.0	0.267	11.5	LOS B	1.2	8.5	0.57	0.83	45.8
Approach		824	4.0	0.267	3.0	NA	1.2	8.5	0.15	0.22	55.5
All Vehicles		1936	4.0	1.743	90.6	NA	67.2	486.6	0.27	0.57	17.3

The above analysis indicates an intersection LoS of F for the right turn from Girrawheen Ave to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Girrawheen Ave. The analysis indicates that upgrade is required to improve the performance.

Beach Road/Wanneroo Road Intersection 2031

Existing Geometry



Wanneroo Beach 2031 No LHS Existing Geometry AM
Signals - Fixed Time Cycle Time = 154 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road (South)											
1	L	125	5.0	0.266	27.8	LOS C	4.7	34.5	0.55	0.72	34.3
2	T	794	5.0	0.405	23.7	LOS C	17.8	129.6	0.65	0.58	35.0
3	R	26	5.0	0.248	85.8	LOS F	1.9	14.2	0.99	0.72	18.0
Approach		945	5.0	0.405	25.9	LOS C	17.8	129.6	0.65	0.60	34.0
East: Beach Road (East)											
4	L	36	5.0	1.000 [3]	69.7	LOS E	2.2	16.3	0.97	0.72	20.8
5	T	502	5.0	0.691	62.5	LOS E	17.7	129.2	0.99	0.83	21.1
6	R	134	5.0	1.049	207.1	LOS F	17.9	130.4	1.00	1.40	9.0
Approach		673	5.0	1.049	91.7	LOS F	17.9	130.4	0.99	0.94	16.6
North: Wanneroo Road (North)											
7	L	155	5.0	0.412	28.1	LOS C	6.0	43.6	0.56	0.72	34.1
8	T	2261	5.0	1.154	351.2	LOS F	232.4	1696.3	1.00	2.32	5.6
9	R	113	5.0	1.076	249.5	LOS F	16.8	122.3	1.00	1.45	7.7
Approach		2529	5.0	1.154	326.8	LOS F	232.4	1696.3	0.97	2.18	6.0
West: Beach Rd (West)											
10	L	88	5.0	1.000 [3]	69.7	LOS E	5.6	40.8	0.98	0.77	20.8
11	T	826	5.0	1.141	348.4	LOS F	79.9	583.0	1.00	2.12	5.6
12	R	134	5.0	1.048	206.2	LOS F	17.8	130.0	1.00	1.41	9.1
Approach		1048	5.0	1.141	306.8	LOS F	79.9	583.0	1.00	1.92	6.3

All Vehicles		5195	5.0	1.154	237.6	LOS F	232.4	1696.3	0.92	1.68	7.9

Wanneroo Beach 2031 No LHS Existing Geometry PM
Signals - Fixed Time Cycle Time = 155 seconds (Optimum Cycle Time - Minimum Delay)

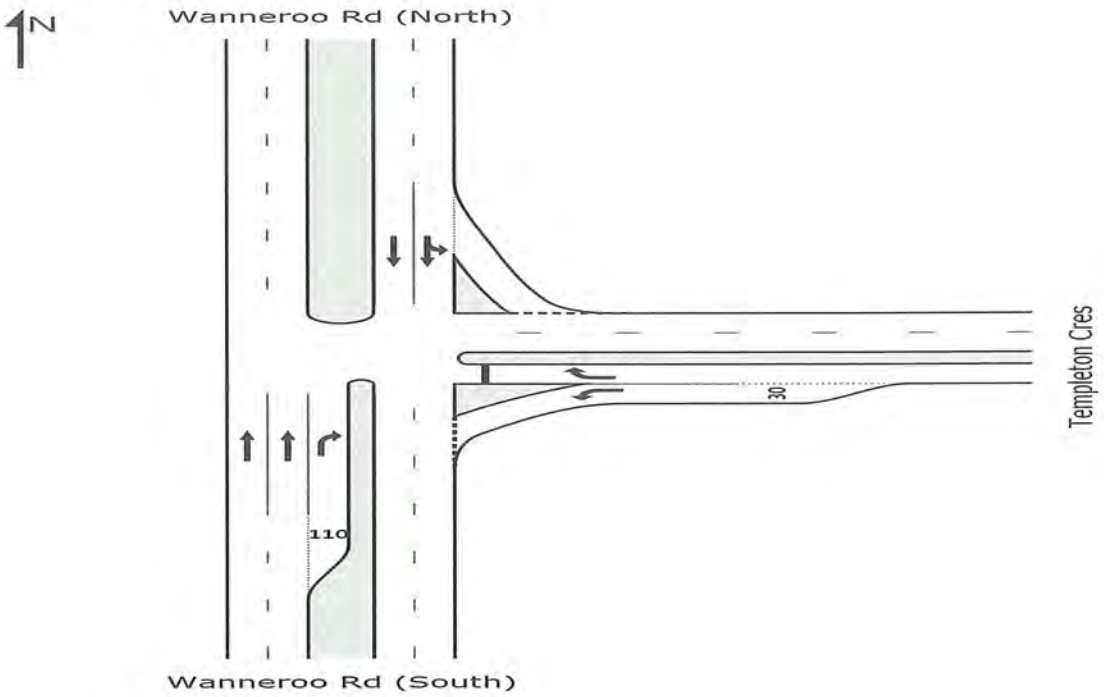
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road (South)											
1	L	232	5.0	0.526	32.7	LOS C	10.2	74.3	0.63	0.76	31.9
2	T	1980	5.0	1.083	234.2	LOS F	162.6	1187.3	1.00	1.85	8.0
3	R	48	5.0	0.377	84.9	LOS F	3.6	26.3	0.99	0.75	18.1
Approach		2260	5.0	1.083	210.3	LOS F	162.6	1187.3	0.96	1.71	8.8
East: Beach Road (East)											
4	L	35	5.0	1.000 [3]	71.2	LOS E	2.2	16.3	0.97	0.71	20.5
5	T	749	5.0	1.111	298.0	LOS F	66.1	482.9	1.00	1.93	6.4
6	R	197	5.0	1.000 [3]	108.9	LOS F	17.9	130.6	1.00	0.98	15.1
Approach		981	5.0	1.111	251.9	LOS F	66.1	482.9	1.00	1.70	7.5
North: Wanneroo Road (North)											
7	L	196	5.0	0.555	32.1	LOS C	8.4	61.3	0.62	0.74	32.1
8	T	999	5.0	0.549	29.7	LOS C	26.2	191.0	0.76	0.68	31.6
9	R	132	5.0	1.037	190.9	LOS F	16.8	122.3	1.00	1.36	9.7
Approach		1327	5.0	1.037	46.1	LOS D	26.2	191.0	0.76	0.75	25.8
West: Beach Rd (West)											
10	L	86	5.0	1.000 [3]	71.2	LOS E	5.6	40.8	0.97	0.77	20.5
11	T	612	5.0	0.915	85.7	LOS F	27.2	198.5	1.00	1.07	17.2
12	R	197	5.0	1.000 [3]	108.8	LOS F	17.9	130.6	1.00	0.99	15.2
Approach		894	5.0	1.000	89.4	LOS F	27.2	198.5	1.00	1.02	16.9
All Vehicles		5462	5.0	1.111	158.1	LOS F	162.6	1187.3	0.93	1.36	11.1

The above analysis indicates an intersection LoS of F to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 1km are forecast in Wanneroo Road. The analysis indicates that upgrade is required to improve the performance.

Wanneroo Road/Templeton Road Intersection 2031

Existing Geometry



Wanneroo Rd/ Templeton Cres 2031 No LHS Existing Geometry AM
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	1112	4.0	0.293	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	53	4.0	1.000 [3]	260.6	LOS F	5.4	38.9	1.00	1.44	7.4
Approach		1165	4.0	1.000	11.9	NA	5.4	38.9	0.05	0.07	45.3
East: Templeton Cres											
4	L	65	4.0	1.089	311.8	LOS F	10.3	74.6	1.00	1.90	6.4
6	R	100	4.0	1.661	1284.1	LOS F	57.3	414.8	1.00	2.57	1.7
Approach		165	4.0	1.661	899.0	LOS F	57.3	414.8	1.00	2.31	2.4
North: Wanneroo Rd (North)											
7	L	44	4.0	0.648	8.6	LOS A	8.3	59.9	0.33	1.27	50.6
8	T	2404	4.0	0.648	0.3	LOS A	8.3	59.9	0.16	0.00	56.9
Approach		2448	4.0	0.648	0.4	NA	8.3	59.9	0.16	0.02	56.8
All Vehicles		3778	4.0	1.661	43.2	NA	57.3	414.8	0.16	0.14	27.1

Wanneroo Rd/ Templeton Cres 2031 No LHS Existing Geometry PM
Stop (Two-Way)

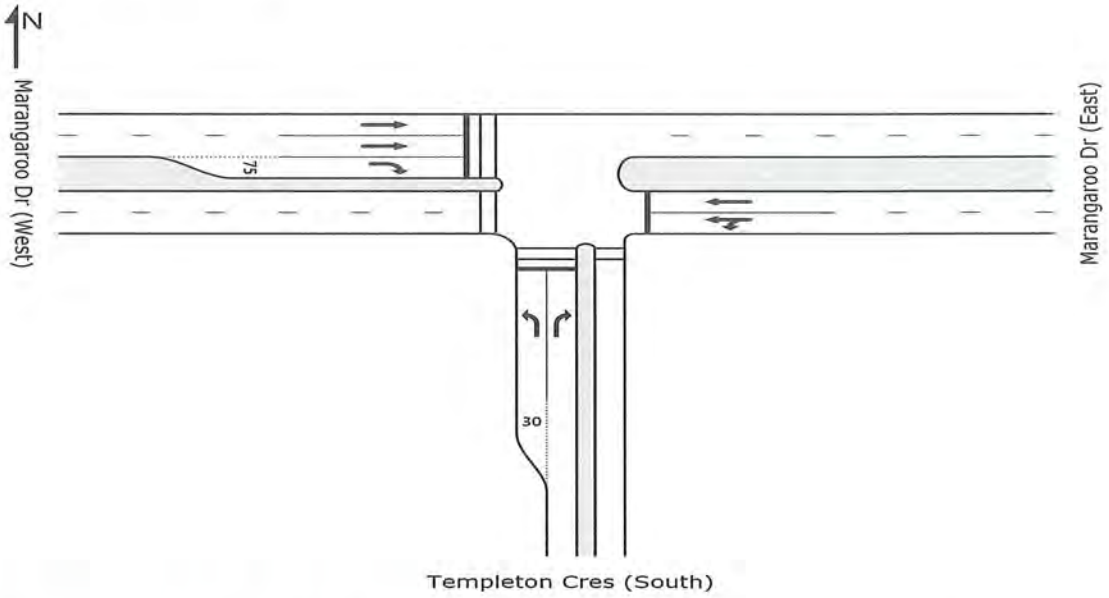
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	2401	4.0	0.632	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	249	4.0	0.836	42.4	LOS E	6.1	44.5	0.96	1.44	27.8
Approach		2650	4.0	0.836	4.0	NA	6.1	44.5	0.09	0.14	54.1
East: Templeton Cres											
4	L	87	4.0	0.432	30.5	LOS D	1.6	11.5	0.90	1.03	32.9
6	R	31	4.0	1.000[4]	276.4	LOS F	3.4	24.9	1.00	1.29	7.0
Approach		118	4.0	1.000	95.1	LOS F	3.4	24.9	0.92	1.10	16.8
North: Wanneroo Rd (North)											
7	L	52	4.0	0.350	9.6	LOS A	3.0	22.1	0.51	1.13	50.9
8	T	1242	4.0	0.350	0.8	LOS A	3.0	22.1	0.24	0.00	55.5
Approach		1294	4.0	0.350	1.1	NA	3.0	22.1	0.25	0.05	55.3
All Vehicles		4062	4.0	1.000	5.7	NA	6.1	44.5	0.16	0.13	51.1

The above analysis indicates a LoS of F for right turn movements to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Templeton Crescent. The analysis indicates that upgrade is required to improve the performance.

Marangaroo Dr/Templeton Crescent Intersection 2031

Existing Geometry



Marangaroo Drive / Templeton Crescent NO LHS Signals am 2031 AM
Signals - Fixed Time Cycle Time = 125 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Templeton Cres (South)											
1	L	35	4.0	0.284	56.1	LOS E	1.8	13.2	0.88	0.72	23.6
3	R	83	4.0	0.274	57.8	LOS E	4.5	32.4	0.91	0.77	23.2
Approach		118	4.0	0.284	57.3	LOS E	4.5	32.4	0.90	0.76	23.3
East: Marangaroo Dr (East)											
4	L	74	4.0	0.395	24.2	LOS C	14.1	102.2	0.60	0.92	37.4
5	T	776	4.0	0.395	15.9	LOS B	14.2	103.1	0.60	0.53	40.0
Approach		850	4.0	0.395	16.6	LOS B	14.2	103.1	0.60	0.56	39.7
West: Marangaroo Dr (West)											
11	T	358	4.0	0.128	5.0	LOS A	3.1	22.4	0.31	0.26	51.4
12	R	34	4.0	0.157	62.4	LOS E	1.9	13.7	0.93	0.73	22.1
Approach		392	4.0	0.157	10.0	LOS A	3.1	22.4	0.36	0.30	46.1
All Vehicles		1360	4.0	0.395	18.2	LOS B	14.2	103.1	0.56	0.51	38.9

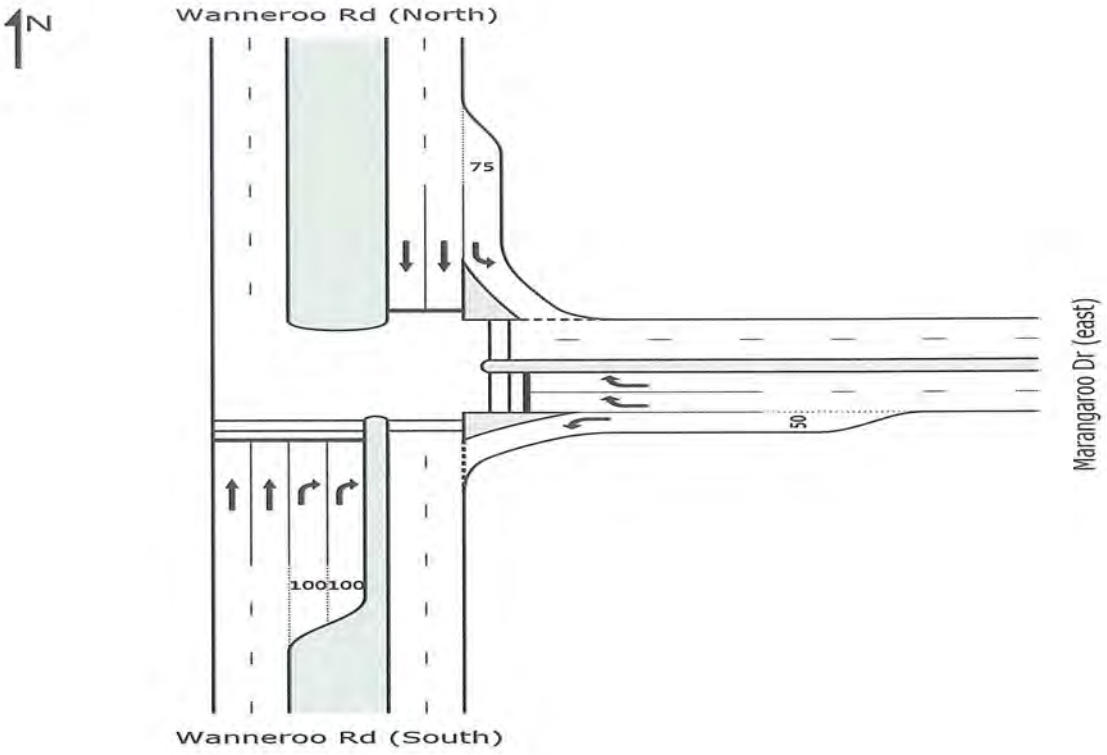
Marangaroo Drive / Templeton Crescent NO LHS Signals am 2031 PM
Signals - Fixed Time Cycle Time = 82 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Templeton Cres (South)											
1	L	74	4.0	0.371	34.1	LOS C	2.3	16.8	0.81	0.75	31.0
3	R	265	4.0	0.573	37.6	LOS D	9.5	68.5	0.92	0.83	29.5
Approach		339	4.0	0.573	36.8	LOS D	9.5	68.5	0.90	0.81	29.8
East: Marangaroo Dr (East)											
4	L	78	4.0	0.563	32.3	LOS C	11.9	86.2	0.87	0.87	33.2
5	T	648	4.0	0.563	24.0	LOS C	12.0	87.1	0.87	0.75	34.2
Approach		726	4.0	0.563	24.8	LOS C	12.0	87.1	0.87	0.76	34.1
West: Marangaroo Dr (West)											
11	T	482	4.0	0.212	8.1	LOS A	4.4	31.8	0.49	0.42	47.2
12	R	32	4.0	0.097	38.8	LOS D	1.1	7.9	0.86	0.72	29.1
Approach		514	4.0	0.212	10.0	LOS B	4.4	31.8	0.51	0.44	45.5
All Vehicles		1579	4.0	0.573	22.6	LOS C	12.0	87.1	0.76	0.67	35.9

The above analysis indicates a LoS of A to D for most movements to 2031 with no LHS, for the current geometry. Stop rates for all movements are less than 1 and the degree of saturation is 0.395 and 0.573. Queues in excess of 60m are forecast in Templeton Crescent during the pm peak hour indicating this two lane approach should be extended. The analysis indicates that minor upgrade is required to improve the performance.

Wanneroo Road/Marangaroo Dr Intersection 2031
Existing Geometry



Marangaroo Dr / Wanneroo Rd No LHS 2031 AM
Signals - Fixed Time Cycle Time = 150 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	1156	5.0	0.425	8.9	LOS A	16.6	121.2	0.44	0.40	46.6
3	R	254	5.0	0.966	116.8	LOS F	11.9	87.0	1.00	1.14	14.3
Approach		1410	5.0	0.966	28.3	LOS C	16.6	121.2	0.54	0.53	33.1
East: Marangaroo Dr (east)											
4	L	213	5.0	1.000 [3]	42.7	LOS D	11.2	81.8	0.79	0.78	27.8
6	R	615	5.0	0.940	82.6	LOS F	20.1	146.4	1.00	0.40	20.2
Approach		828	5.0	1.000	72.4	LOS E	30.6	223.6	0.95	0.50	22.9
North: Wanneroo Rd (North)											
7	L	182	5.0	0.183	8.9	LOS A	1.6	11.5	0.17	0.64	48.4
8	T	2224	5.0	0.971	67.7	LOS E	105.6	770.8	1.00	1.14	20.3
Approach		2406	5.0	0.971	63.3	LOS E	105.6	770.8	0.94	1.10	21.2
All Vehicles		4644	5.0	1.000	54.3	LOS D	105.6	770.8	0.82	0.82	24.3

Marangaroo Dr / Wanneroo Rd No LHS 2031 PM
Signals - Fixed Time Cycle Time = 127 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	2452	5.0	0.896	19.0	LOS B	63.4	462.5	0.86	0.84	37.4
3	R	463	5.0	0.631	58.4	LOS E	13.3	96.9	0.97	0.83	23.1
Approach		2915	5.0	0.896	25.2	LOS C	63.4	462.5	0.88	0.84	34.0
East: Marangaroo Dr (east)											
4	L	356	5.0	0.845	24.2	LOS C	11.2	81.6	0.49	0.78	36.3
6	R	318	5.0	0.490	59.2	LOS E	9.0	65.6	0.95	0.81	22.9
Approach		674	5.0	0.845	40.7	LOS D	11.2	81.6	0.70	0.79	28.5
North: Wanneroo Rd (North)											
7	L	193	5.0	0.231	9.8	LOS A	2.1	15.6	0.25	0.66	47.4
8	T	1144	5.0	0.641	27.0	LOS C	26.5	193.4	0.82	0.73	33.0
Approach		1337	5.0	0.641	24.5	LOS C	26.5	193.4	0.73	0.72	34.5
All Vehicles		4926	5.0	0.896	27.1	LOS C	63.4	462.5	0.81	0.80	33.3

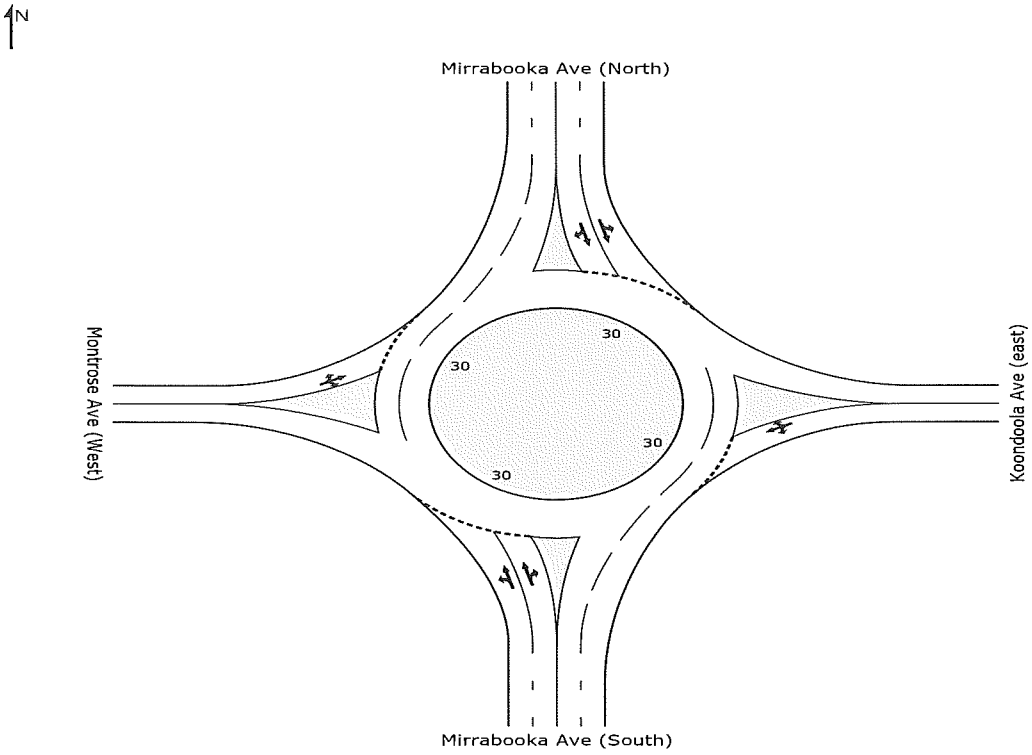
The above analysis indicates a LoS of E and F for some movements to 2031 with no LHS, for the current geometry. Stop rates for all movements during the pm peak hour are less than 1 however some are greater than 1 during the am peak hour. The degree of saturation is 1 and 0.896. Queues in excess of 700m are forecast on Wanneroo Road north during the am peak hour. The analysis indicates upgrade is required to improve the performance.

Appendix F - Summary of Sidra analysis - 2031 with LHS existing and proposed geometry

Sidra Analysis with LHS 2031

This technical note provides the Sidra analysis and output for the Proposed Ultimate Intersection Geometry for full development (2031) WITH LHS and a compromise Geometry where the site is constrained to avoid land acquisition.

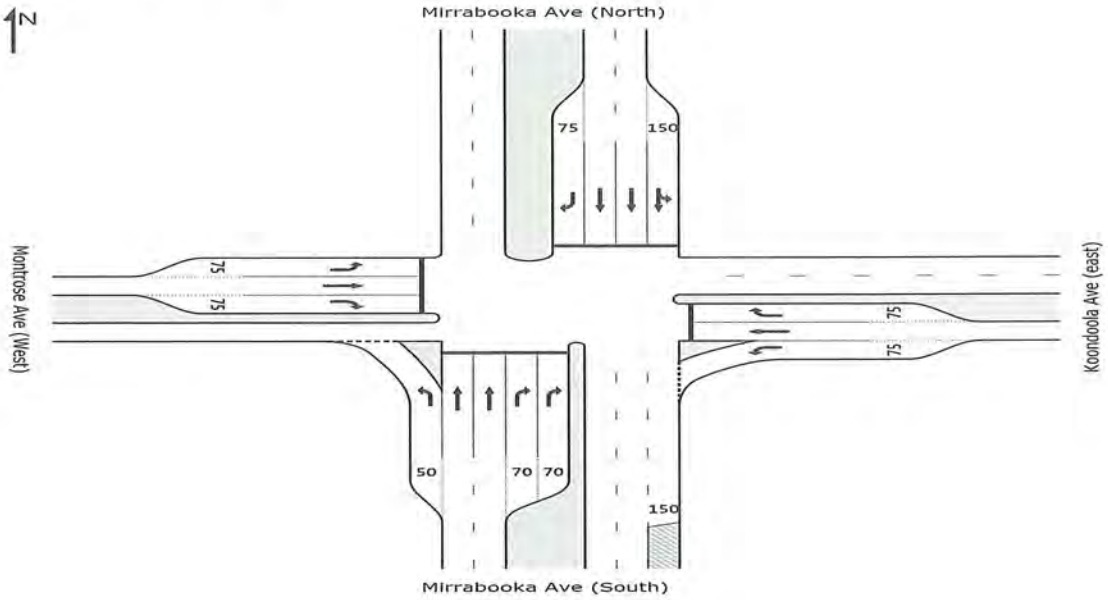
Mirrabooka/Koondoola Intersection 2031



Analysis indicates that the existing roundabout will not accommodate forecast traffic volumes to 2031 with LHS.

The following analysis indicates the requirements to accommodate the forecast traffic volumes to 2031.

Proposed Ultimate Geometry



Mirabooka Koondoola With LHS 2031 am
Signals - Fixed Time Cycle Time = 92 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Mirrabooka Ave (South)											
1	L	153	4.0	0.245	11.3	LOS B	1.9	13.8	0.37	0.68	45.9
2	T	798	4.0	0.601	27.5	LOS C	15.0	108.5	0.89	0.77	32.6
3	R	253	4.0	0.777	57.7	LOS E	6.2	44.7	1.00	0.90	23.4
Approach		1204	4.0	0.777	31.8	LOS C	15.0	108.5	0.84	0.79	31.1
East: Koondoola Ave (east)											
4	L	283	4.0	0.442	15.5	LOS B	5.4	39.4	0.56	0.74	42.3
5	T	301	4.0	0.611	33.4	LOS C	12.2	88.0	0.94	0.80	29.9
6	R	155	4.0	0.734	53.0	LOS D	7.0	50.6	1.00	0.94	24.6
Approach		739	4.0	0.734	30.7	LOS C	12.2	88.0	0.81	0.80	32.0
North: Mirrabooka Ave (North)											
7	L	130	4.0	0.759	39.3	LOS D	20.7	150.1	0.95	0.91	30.0
8	T	1536	4.0	0.880	39.1	LOS D	29.6	214.4	0.99	1.02	27.5
9	R	104	4.0	0.639	55.1	LOS E	4.9	35.2	1.00	0.82	24.0
Approach		1770	4.0	0.880	40.0	LOS D	29.6	214.4	0.99	1.00	27.5
West: Montrose Ave (West)											
10	L	100	4.0	0.254	38.0	LOS D	3.6	26.0	0.83	0.77	29.3
11	T	437	4.0	0.887	47.7	LOS D	22.9	165.4	1.00	1.08	24.9
12	R	156	4.0	0.534	41.5	LOS D	6.3	45.8	0.96	0.80	28.2
Approach		693	4.0	0.887	44.9	LOS D	22.9	165.4	0.97	0.97	26.2
All Vehicles		4406	4.0	0.887	37.0	LOS D	29.6	214.4	0.91	0.90	28.9

Mirabooka Koondoola with LHS 2031 pm
Signals - Fixed Time Cycle Time = 72 seconds (Practical Cycle Time)

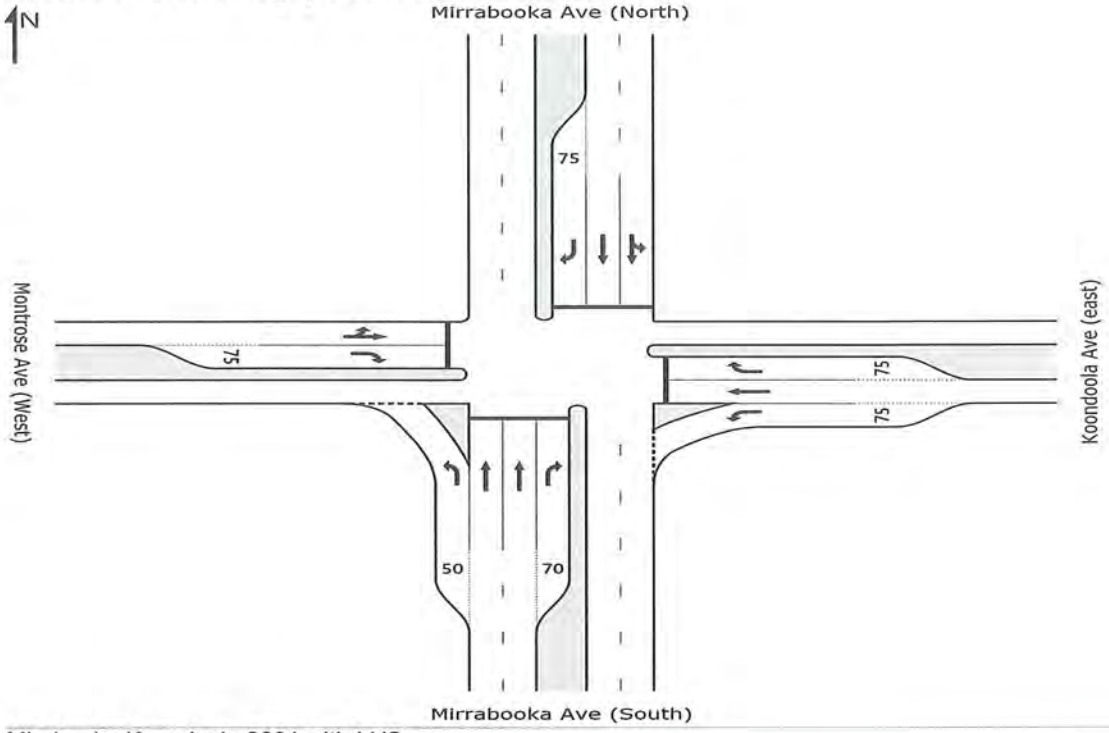
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	272	4.0	0.316	9.5	LOS A	2.1	15.1	0.33	0.68	47.6
2	T	1305	4.0	0.883	33.8	LOS C	27.1	195.9	1.00	1.10	29.6
3	R	249	4.0	0.798	48.7	LOS D	4.9	35.6	1.00	0.93	25.8
Approach		1826	4.0	0.883	32.2	LOS C	27.1	195.9	0.90	1.01	30.7
East: Koondoola Ave (east)											
4	L	227	4.0	0.271	10.4	LOS B	2.1	15.5	0.40	0.70	46.7
5	T	78	4.0	0.317	32.4	LOS C	2.6	19.0	0.95	0.73	30.2
6	R	232	4.0	0.873	48.1	LOS D	8.7	62.9	1.00	1.09	26.1
Approach		537	4.0	0.873	29.9	LOS C	8.7	62.9	0.74	0.87	32.9
North: Mirrabooka Ave (North)											
7	L	141	4.0	0.376	26.1	LOS C	7.0	50.5	0.77	0.84	35.8
8	T	773	4.0	0.436	18.2	LOS B	8.5	61.8	0.79	0.67	37.8
9	R	132	4.0	0.846	50.8	LOS D	5.4	38.9	1.00	0.99	25.2
Approach		1046	4.0	0.846	23.4	LOS C	8.5	61.8	0.81	0.73	35.3
West: Montrose Ave (West)											
10	L	197	4.0	0.842	48.9	LOS D	7.9	57.3	1.00	0.98	25.6
11	T	80	4.0	0.325	32.5	LOS C	2.7	19.5	0.95	0.73	30.2
12	R	224	4.0	0.686	35.9	LOS D	7.4	53.3	0.99	0.87	30.4
Approach		501	4.0	0.842	40.5	LOS D	7.9	57.3	0.99	0.89	28.3
All Vehicles		3910	4.0	0.883	30.6	LOS C	27.1	195.9	0.87	0.90	31.8

The above analysis indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031 with LHS. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required.

A compromise design is indicated as follows. The performance is not as good as the optimal upgrade however the site is constrained.

Possible Geometry (if no land resumption)



Mirabooka Koondoola 2031 with LHS am
Signals - Fixed Time Cycle Time = 150 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Mirrabooka Ave (South)											
1	L	153	4.0	0.276	11.0	LOS B	2.3	16.6	0.28	0.66	46.3
2	T	798	4.0	0.416	26.1	LOS C	18.4	133.3	0.69	0.61	33.6
3	R	253	4.0	0.881	78.0	LOS E	17.6	127.1	1.00	1.05	19.2
Approach		1204	4.0	0.881	35.1	LOS D	18.4	133.3	0.70	0.71	29.9
East: Koondoola Ave (east)											
4	L	283	4.0	0.795	39.0	LOS D	14.5	105.0	0.69	0.83	29.2
5	T	301	4.0	0.882	76.3	LOS E	24.1	174.5	1.00	1.02	18.8
6	R	155	4.0	0.722	79.5	LOS E	11.2	81.0	1.00	0.97	18.9
Approach		739	4.0	0.882	62.7	LOS E	24.1	174.5	0.88	0.94	21.8
North: Mirrabooka Ave (North)											
7	L	130	4.0	0.873	48.7	LOS D	56.3	407.3	0.97	0.95	26.8
8	T	1536	4.0	0.873	40.3	LOS D	56.6	409.8	0.97	0.92	27.1
9	R	104	4.0	0.227	31.3	LOS C	4.5	32.4	0.65	0.77	32.3
Approach		1770	4.0	0.873	40.4	LOS D	56.6	409.8	0.95	0.91	27.4
West: Montrose Ave (West)											
10	L	100	4.0	0.727	73.1	LOS E	17.2	124.6	1.00	0.86	20.4
11	T	143	4.0	0.727	64.7	LOS E	17.2	124.6	1.00	0.86	20.5
12	R	156	4.0	0.858	92.1	LOS F	12.1	88.0	1.00	1.10	17.1
Approach		399	4.0	0.858	77.5	LOS E	17.2	124.6	1.00	0.95	19.0
All Vehicles		4112	4.0	0.882	46.5	LOS D	56.6	409.8	0.87	0.86	25.7

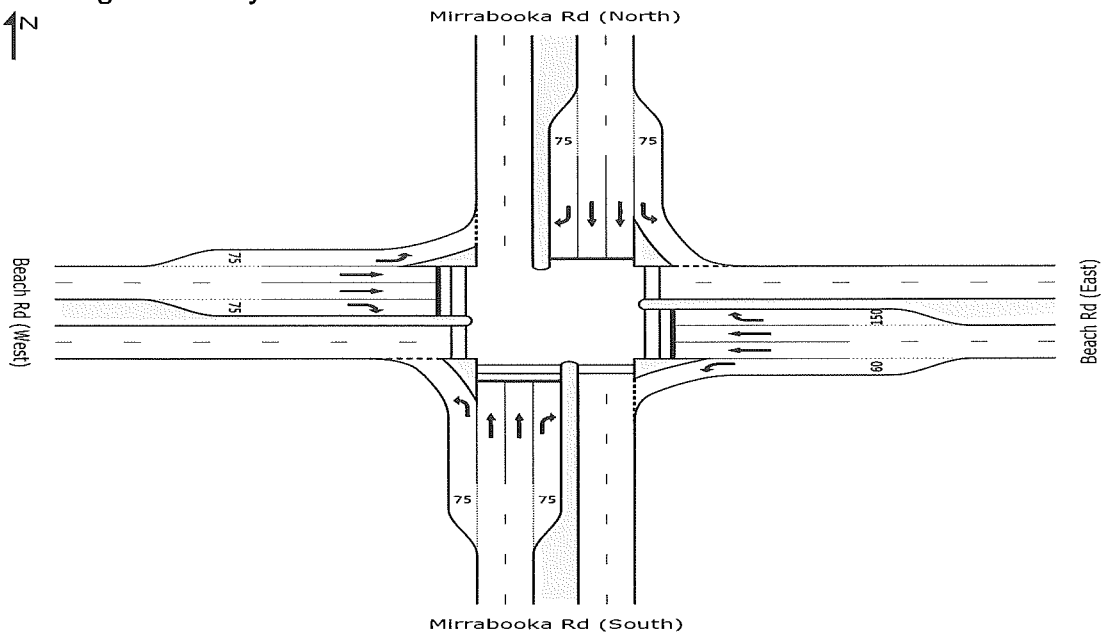
Mirabooka Koondoola 2031 with LHS pm
Signals - Fixed Time Cycle Time = 83 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	272	4.0	0.265	8.6	LOS A	1.4	10.3	0.23	0.66	48.5
2	T	1305	4.0	0.887	37.9	LOS D	30.7	221.9	1.00	1.09	28.1
3	R	249	4.0	0.825	47.5	LOS D	10.9	79.0	1.00	1.05	26.2
Approach		1826	4.0	0.887	34.8	LOS C	30.7	221.9	0.88	1.02	29.7
East: Koondoola Ave (east)											
4	L	227	4.0	0.309	12.1	LOS B	2.9	21.3	0.47	0.71	45.3
5	T	78	4.0	0.235	33.0	LOS C	2.8	20.3	0.90	0.70	30.1
6	R	232	4.0	0.841	52.1	LOS D	9.6	69.8	1.00	1.07	24.8
Approach		537	4.0	0.841	32.4	LOS C	9.6	69.8	0.76	0.87	31.7
North: Mirrabooka Ave (North)											
7	L	141	4.0	0.626	31.4	LOS C	15.1	109.5	0.87	0.88	33.5
8	T	773	4.0	0.626	23.1	LOS C	15.4	111.3	0.87	0.76	34.6
9	R	132	4.0	0.555	42.8	LOS D	5.1	37.1	0.98	0.82	27.7
Approach		1046	4.0	0.626	26.7	LOS C	15.4	111.3	0.89	0.79	33.4
West: Montrose Ave (West)											
10	L	197	4.0	0.865	53.8	LOS D	12.9	93.3	1.00	1.03	24.5
11	T	80	4.0	0.865	45.4	LOS D	12.9	93.3	1.00	1.03	24.6
12	R	224	4.0	0.557	34.4	LOS C	7.8	56.2	0.94	0.81	31.0
Approach		501	4.0	0.865	43.8	LOS D	12.9	93.3	0.97	0.94	27.1
All Vehicles		3910	4.0	0.887	33.5	LOS C	30.7	221.9	0.88	0.92	30.5

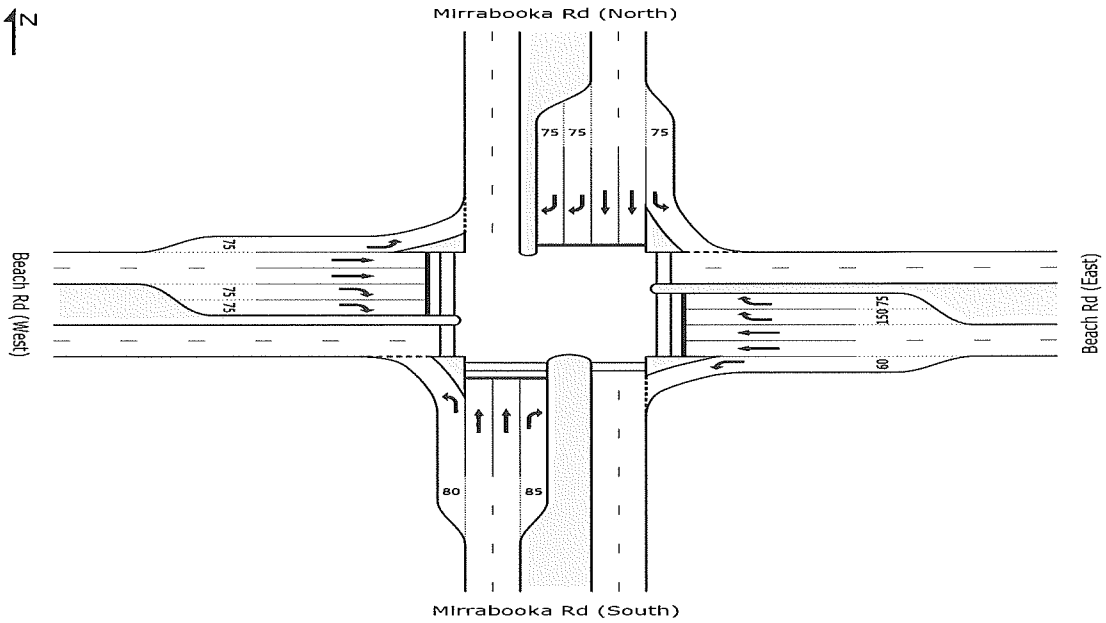
Beach Road/Mirrabooka Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



New Site
Signals - Fixed Time Cycle Time = 100 seconds (Practical Cycle Time) am 2031

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Rd (South)											
1	L	239	4.0	0.312	13.2	LOS B	4.1	29.6	0.43	0.71	44.2
2	T	624	4.0	0.684	38.1	LOS D	14.2	102.5	0.97	0.83	28.0
3	R	128	4.0	0.889	68.7	LOS E	7.3	52.9	1.00	1.00	20.9
Approach		992	4.0	0.889	36.1	LOS D	14.2	102.5	0.84	0.82	29.3
East: Beach Rd (East)											
4	L	120	4.0	0.237	19.7	LOS B	2.9	21.2	0.57	0.72	39.1
5	T	533	4.0	0.667	40.1	LOS D	12.3	88.7	0.97	0.83	27.3
6	R	339	4.0	0.782	59.2	LOS E	8.8	63.9	1.00	0.91	23.0
Approach		992	4.0	0.782	44.2	LOS D	12.3	88.7	0.93	0.84	26.6
North: Mirrabooka Rd (North)											
7	L	488	4.0	0.549	13.5	LOS B	9.4	68.2	0.49	0.73	43.9
8	T	1175	4.0	0.883	43.7	LOS D	31.9	230.6	1.00	1.05	26.1
9	R	432	4.0	0.629	49.0	LOS D	9.9	72.0	0.97	0.82	25.7
Approach		2095	4.0	0.883	37.7	LOS D	31.9	230.6	0.87	0.93	28.8
West: Beach Rd (West)											
10	L	301	4.0	0.387	13.9	LOS B	5.6	40.7	0.47	0.72	43.6
11	T	638	4.0	0.799	45.0	LOS D	16.1	116.3	1.00	0.94	25.7
12	R	356	4.0	0.821	61.1	LOS E	9.5	68.7	1.00	0.94	22.5
Approach		1295	4.0	0.821	42.2	LOS D	16.1	116.3	0.88	0.89	27.3
All Vehicles		5373	4.0	0.889	39.7	LOS D	31.9	230.6	0.88	0.88	28.1

New Site
Signals - Fixed Time Cycle Time = 100 seconds (Practical Cycle Time) pm 2031

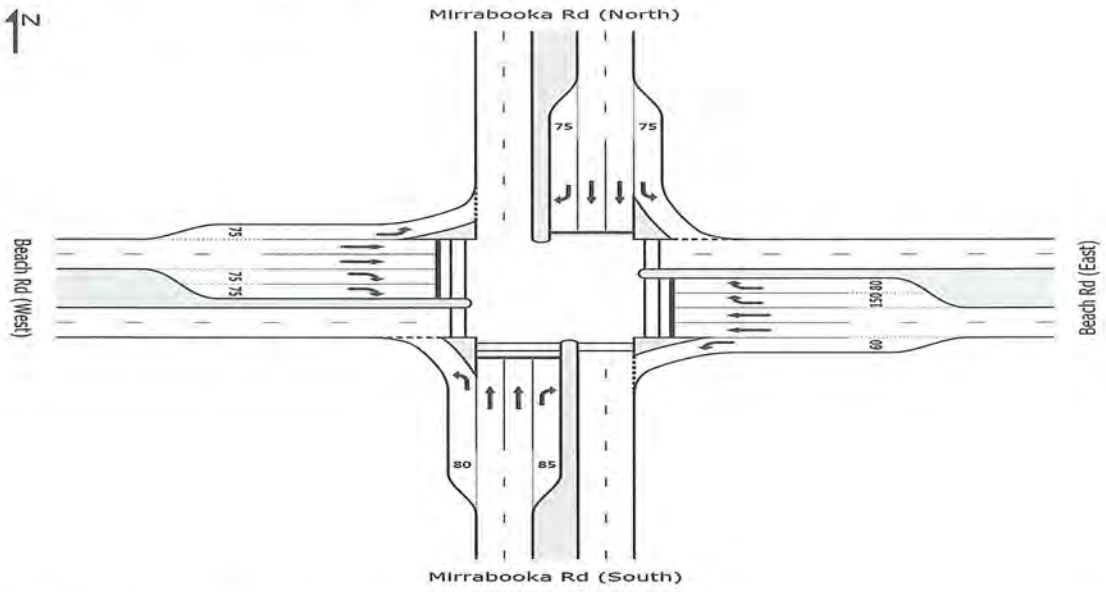
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Rd (South)											
1	L	308	4.0	0.387	16.1	LOS B	6.7	48.6	0.52	0.73	41.8
2	T	1117	4.0	0.864	41.6	LOS D	29.2	211.6	1.00	1.02	26.8
3	R	122	4.0	0.845	65.3	LOS E	6.7	48.6	1.00	0.95	21.6
Approach		1547	4.0	0.864	38.4	LOS D	29.2	211.6	0.91	0.96	28.3
East: Beach Rd (East)											
4	L	124	4.0	0.207	11.1	LOS B	1.6	11.5	0.34	0.67	46.1
5	T	946	4.0	0.889	49.1	LOS D	26.4	191.1	1.00	1.06	24.5
6	R	404	4.0	0.861	63.1	LOS E	11.1	80.5	1.00	0.99	22.1
Approach		1475	4.0	0.889	49.8	LOS D	26.4	191.1	0.94	1.01	24.8
North: Mirrabooka Rd (North)											
7	L	408	4.0	0.449	10.1	LOS B	4.8	34.5	0.33	0.69	47.0
8	T	678	4.0	0.525	28.6	LOS C	13.3	96.5	0.86	0.74	32.1
9	R	256	4.0	0.885	68.3	LOS E	7.3	52.5	1.00	1.00	21.0
Approach		1342	4.0	0.885	30.6	LOS C	13.3	96.5	0.72	0.77	32.0
West: Beach Rd (West)											
10	L	507	4.0	0.803	28.5	LOS C	16.9	122.4	0.78	0.91	33.9
11	T	294	4.0	0.368	37.0	LOS D	6.2	45.1	0.90	0.73	28.5
12	R	162	4.0	0.748	63.9	LOS E	4.3	31.4	1.00	0.86	21.9
Approach		963	4.0	0.803	37.0	LOS D	16.9	122.4	0.85	0.85	29.5
All Vehicles		5327	4.0	0.889	39.3	LOS D	29.2	211.6	0.86	0.90	28.2

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include double turn lanes on the eastern, western and northern approaches. It is noted that the reserve on Mirrabooka Road north would not appear to be wide enough to

accommodate a double right turn and significant land acquisition would likely be required.
A compromise design with a reduced performance is therefore recommended as follows. It should be noted however that the analysis indicates lengthy queues and some movements will not clear the intersection within a single cycle.

Possible Geometry (if no land resumption)



Beach Mirabooka 2031 with LHS am
Signals - Fixed Time Cycle Time = 150 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Rd (South)											
1	L	227	4.0	0.416	15.9	LOS B	5.7	41.2	0.42	0.70	41.9
2	T	593	4.0	0.478	42.9	LOS D	17.1	124.1	0.85	0.73	26.5
3	R	122	4.0	0.413	55.8	LOS E	7.1	51.5	0.84	0.78	23.9
Approach		942	4.0	0.478	38.1	LOS D	17.1	124.1	0.75	0.73	28.7
East: Beach Rd (East)											
4	L	114	4.0	0.343	25.8	LOS C	4.0	29.2	0.56	0.71	35.3
5	T	506	4.0	0.799	69.1	LOS E	18.8	136.1	1.00	0.92	20.0
6	R	322	4.0	0.955	111.2	LOS F	14.8	107.4	1.00	1.12	14.9
Approach		942	4.0	0.955	78.3	LOS E	18.8	136.1	0.95	0.96	18.8
North: Mirrabooka Rd (North)											
7	L	464	4.0	0.784	17.1	LOS B	12.8	92.5	0.43	0.73	41.1
8	T	1262	4.0	1.022	151.9	LOS F	79.4	574.6	1.00	1.48	11.4
9	R	264	4.0	1.000 [3]	63.8	LOS E	16.9	122.4	0.99	0.84	21.9
Approach		1990	4.0	1.022	108.8	LOS F	79.4	574.6	0.87	1.22	14.8
West: Beach Rd (West)											
10	L	286	4.0	0.501	13.9	LOS B	6.4	46.0	0.38	0.70	43.6
11	T	607	4.0	0.958	100.7	LOS F	28.7	207.7	1.00	1.21	15.5
12	R	337	4.0	1.000 [3]	130.2	LOS F	16.9	122.4	1.00	1.15	13.2
Approach		1230	4.0	1.000	88.6	LOS F	28.7	207.7	0.86	1.08	17.3
All Vehicles		5104	4.0	1.022	85.2	LOS F	79.4	574.6	0.86	1.05	17.7

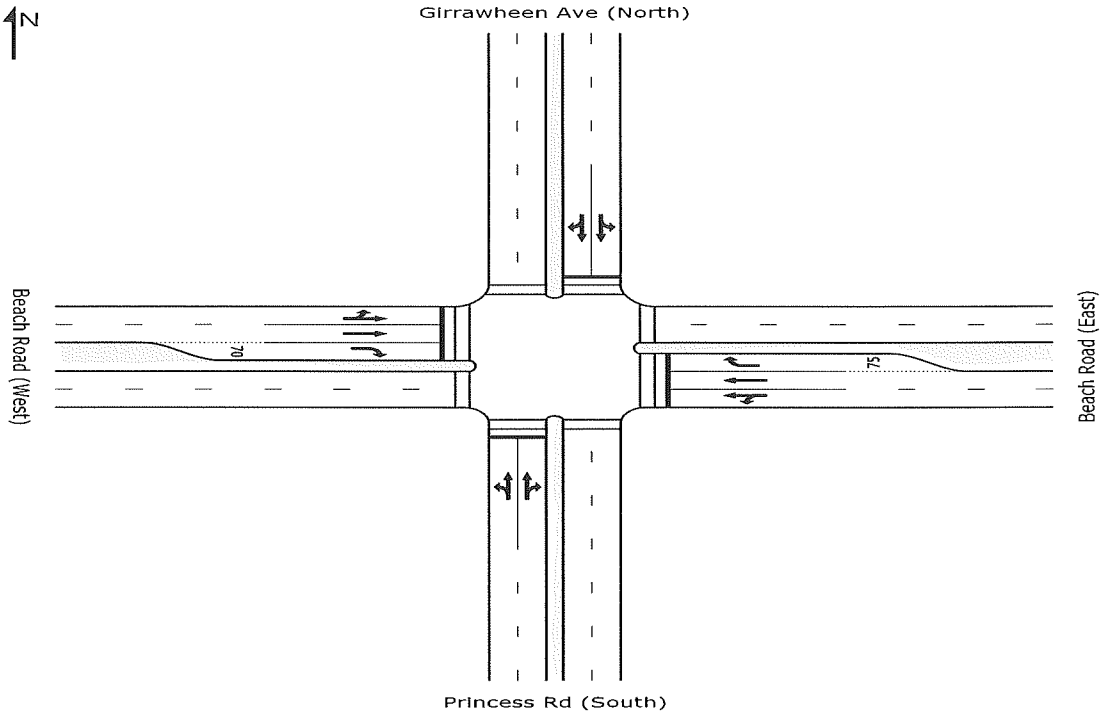
Beach Mirabooka 2031 with LHS pm
Signals - Fixed Time Cycle Time = 150 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Rd (South)											
1	L	293	4.0	0.643	23.0	LOS C	10.2	74.2	0.56	0.74	37.0
2	T	1061	4.0	0.891	64.2	LOS E	41.7	302.1	1.00	1.01	21.0
3	R	116	4.0	0.433	67.2	LOS E	7.6	54.7	0.93	0.79	21.2
Approach		1470	4.0	0.891	56.2	LOS E	41.7	302.1	0.91	0.94	23.0
East: Beach Rd (East)											
4	L	118	4.0	0.220	12.0	LOS B	2.0	14.7	0.30	0.67	45.3
5	T	899	4.0	0.959	95.7	LOS F	43.0	311.5	1.00	1.22	16.1
6	R	384	4.0	0.997	128.5	LOS F	20.5	148.2	1.00	1.14	13.3
Approach		1401	4.0	0.997	97.7	LOS F	43.0	311.5	0.94	1.16	16.1
North: Mirrabooka Rd (North)											
7	L	388	4.0	0.535	10.8	LOS B	6.3	45.6	0.30	0.68	46.4
8	T	648	4.0	0.544	45.5	LOS D	19.5	140.9	0.88	0.76	25.7
9	R	239	4.0	1.000[3]	72.3	LOS E	16.9	122.4	1.00	0.83	20.2
Approach		1275	4.0	1.000	40.0	LOS D	19.5	140.9	0.73	0.75	28.1
West: Beach Rd (West)											
10	L	416	4.0	1.000[3]	26.1	LOS C	16.9	122.7	0.65	0.78	35.1
11	T	345	4.0	0.372	50.2	LOS D	10.5	76.2	0.88	0.73	24.2
12	R	154	4.0	0.400	76.9	LOS E	5.4	39.0	0.98	0.77	19.4
Approach		915	4.0	1.000	43.8	LOS D	16.9	122.7	0.79	0.76	26.9
All Vehicles		5061	4.0	1.000	61.3	LOS E	43.0	311.5	0.85	0.92	22.0

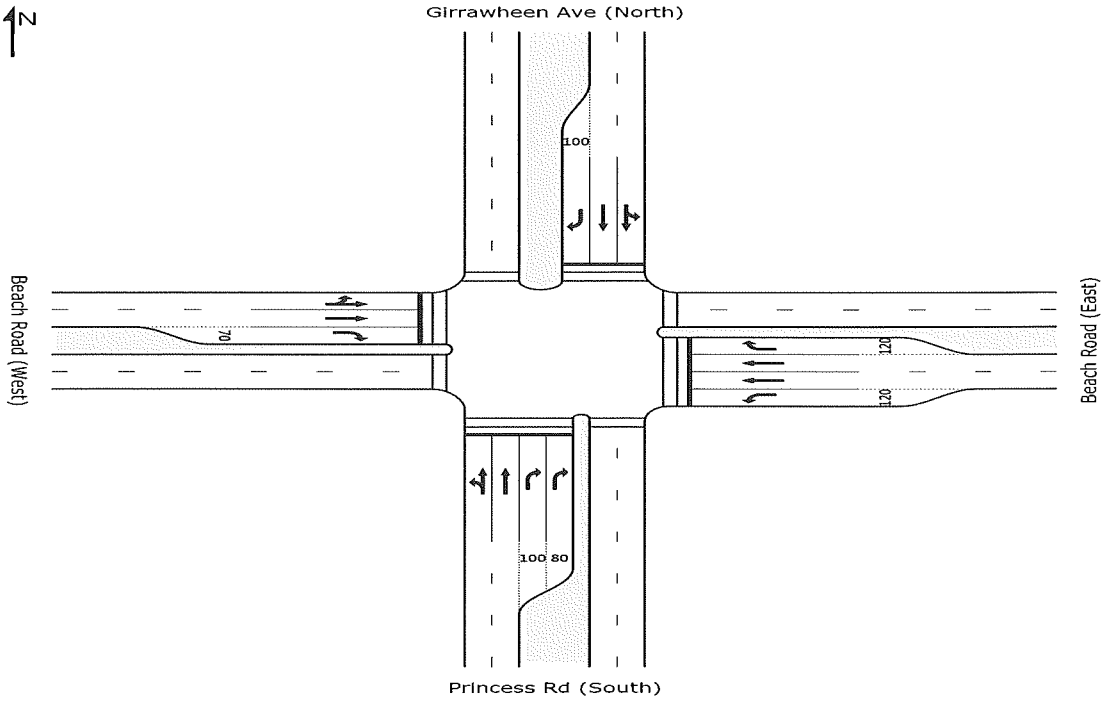
Girrawheen/Beach Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS am
Signals - Fixed Time Cycle Time = 111 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Princess Rd (South)											
1	L	170	2.0	0.535	44.9	LOS D	12.9	91.5	0.90	0.84	27.3
2	T	396	2.0	0.535	36.7	LOS D	13.2	94.3	0.90	0.76	28.4
3	R	188	2.0	0.518	61.3	LOS E	5.1	36.0	0.99	0.78	22.4
Approach		754	2.0	0.535	44.7	LOS D	13.2	94.3	0.92	0.79	26.4
East: Beach Road (East)											
4	L	416	2.0	0.901	66.7	LOS E	26.5	188.8	1.00	1.00	21.1
5	T	474	2.0	0.488	38.4	LOS D	11.0	78.5	0.90	0.76	28.0
6	R	244	2.0	0.870	68.0	LOS E	14.9	106.0	1.00	0.98	21.0
Approach		1134	2.0	0.901	55.1	LOS E	26.5	188.8	0.96	0.89	23.5
North: Girrawheen Ave (North)											
7	L	285	2.0	0.925	71.3	LOS E	32.7	232.8	1.00	1.10	20.6
8	T	695	2.0	0.925	62.6	LOS E	33.5	238.7	1.00	1.14	21.1
9	R	153	2.0	0.843	69.4	LOS E	9.2	65.4	1.00	0.96	20.7
Approach		1133	2.0	0.925	65.7	LOS E	33.5	238.7	1.00	1.11	20.9
West: Beach Road (West)											
10	L	82	2.0	0.781	53.0	LOS D	20.0	142.2	0.99	0.92	25.3
11	T	672	2.0	0.781	44.7	LOS D	20.2	143.6	0.99	0.91	25.7
12	R	189	2.0	0.674	57.7	LOS E	10.1	71.7	1.00	0.84	23.3
Approach		943	2.0	0.781	48.0	LOS D	20.2	143.6	0.99	0.90	25.1
All Vehicles		3964	2.0	0.925	54.5	LOS D	33.5	238.7	0.97	0.94	23.5

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement

Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS pm
Signals - Fixed Time Cycle Time = 127 seconds (Practical Cycle Time)

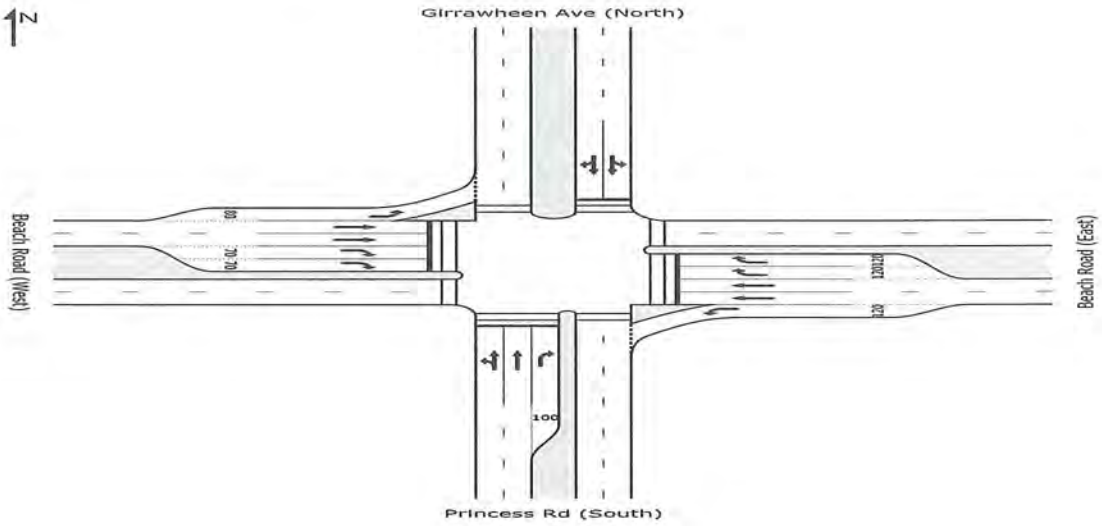
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Princess Rd (South)											
1	L	317	2.0	0.904	69.1	LOS E	36.9	262.6	1.00	1.02	21.0
2	T	736	2.0	0.904	60.5	LOS E	37.8	269.4	1.00	1.06	21.6
3	R	451	2.0	0.869	75.9	LOS E	15.5	110.5	1.00	0.97	19.5
Approach		1504	2.0	0.904	66.9	LOS E	37.8	269.4	1.00	1.03	20.8
East: Beach Road (East)											
4	L	206	2.0	0.493	54.4	LOS D	11.2	79.6	0.92	0.82	24.0
5	T	799	2.0	0.909	67.7	LOS E	28.9	205.9	1.00	1.10	20.3
6	R	220	2.0	0.898	80.7	LOS F	15.7	112.0	1.00	1.01	18.7
Approach		1225	2.0	0.909	67.8	LOS E	28.9	205.9	0.99	1.03	20.5
North: Girrawheen Ave (North)											
7	L	197	2.0	0.631	48.9	LOS D	19.3	137.5	0.92	0.86	26.1
8	T	539	2.0	0.631	40.6	LOS D	19.8	141.2	0.92	0.80	27.0
9	R	107	2.0	0.412	62.6	LOS E	6.2	44.0	0.96	0.79	22.1
Approach		843	2.0	0.631	45.4	LOS D	19.8	141.2	0.92	0.81	26.0
West: Beach Road (West)											
10	L	106	2.0	0.593	55.7	LOS E	14.2	101.2	0.95	0.84	24.3
11	T	410	2.0	0.593	47.4	LOS D	14.5	103.3	0.95	0.80	24.9
12	R	127	2.0	0.518	64.4	LOS E	7.5	53.5	0.98	0.80	21.8
Approach		643	2.0	0.593	52.1	LOS D	14.5	103.3	0.95	0.81	24.1
All Vehicles		4215	2.0	0.909	60.6	LOS E	37.8	269.4	0.97	0.95	22.0

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include double

turn lanes on the southern approach and additional through and turn lanes. It is noted that the reserve on Girrawheen Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required.
A compromise is therefore recommended as follows, the performance is poor in comparison but the site is constrained.

Possible Geometry (if no land resumption)



Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS am
Signals - Fixed Time Cycle Time = 117 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Princess Rd (South)											
1	L	170	2.0	0.794	61.6	LOS E	16.3	116.1	1.00	0.92	22.6
2	T	396	2.0	0.794	53.2	LOS D	16.8	119.4	1.00	0.92	23.2
3	R	188	2.0	0.546	54.8	LOS D	9.9	70.4	0.96	0.81	24.1
Approach		754	2.0	0.794	55.5	LOS E	16.8	119.4	0.99	0.90	23.3
East: Beach Road (East)											
4	L	416	2.0	0.531	15.9	LOS B	9.9	70.7	0.52	0.75	41.8
5	T	474	2.0	0.626	47.0	LOS D	12.6	89.6	0.97	0.81	25.1
6	R	244	2.0	0.866	76.0	LOS E	7.9	56.0	1.00	0.98	19.4
Approach		1134	2.0	0.866	41.9	LOS D	12.6	89.6	0.81	0.82	27.5
North: Girrawheen Ave (North)											
7	L	285	2.0	0.900	62.7	LOS E	36.8	262.4	1.00	1.03	22.5
8	T	695	2.0	0.900	54.3	LOS D	37.2	265.0	1.00	1.05	22.8
9	R	153	2.0	0.900	62.0	LOS E	37.2	265.0	1.00	1.06	22.9
Approach		1133	2.0	0.900	57.5	LOS E	37.2	265.0	1.00	1.04	22.7
West: Beach Road (West)											
10	L	82	2.0	0.107	11.8	LOS B	1.2	8.5	0.33	0.66	45.4
11	T	672	2.0	0.888	61.6	LOS E	21.8	155.3	1.00	1.06	21.5
12	R	189	2.0	0.671	68.8	LOS E	5.6	40.1	1.00	0.82	20.8
Approach		943	2.0	0.888	58.7	LOS E	21.8	155.3	0.94	0.98	22.4
All Vehicles		3964	2.0	0.900	52.9	LOS D	37.2	265.0	0.93	0.94	23.9

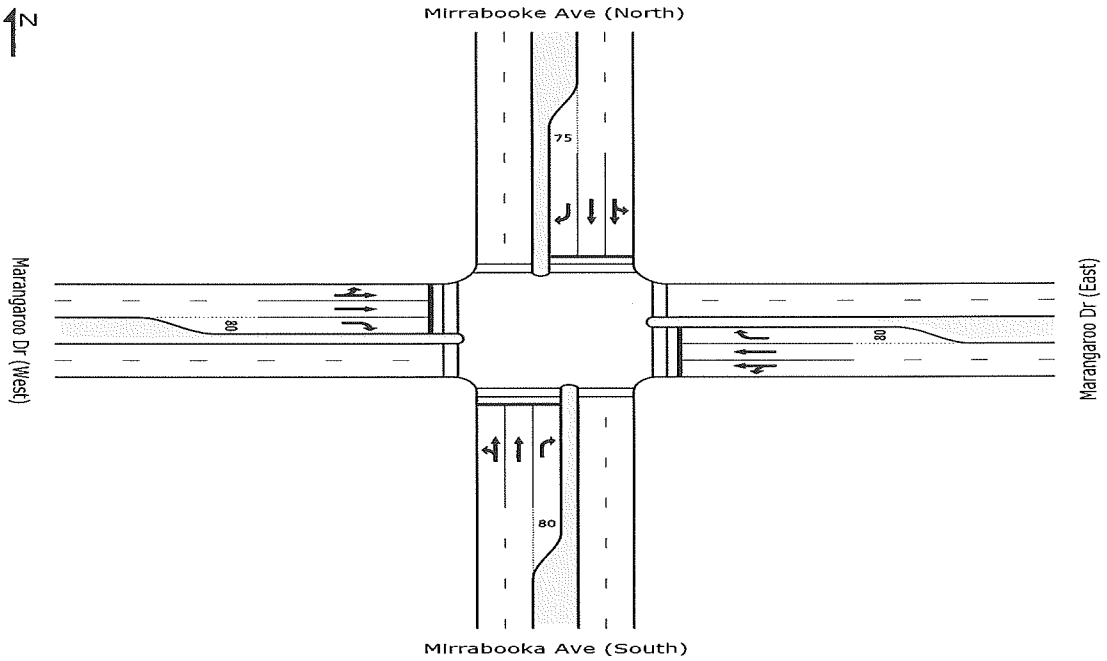
Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS pm
Signals - Fixed Time Cycle Time = 126 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Princess Rd (South)											
1	L	317	2.0	0.956	89.1	LOS F	44.8	319.1	1.00	1.15	17.6
2	T	774	2.0	0.956	80.4	LOS F	45.8	326.1	1.00	1.21	18.0
3	R	413	2.0	1.000 [3]	51.8	LOS D	22.9	163.2	0.99	0.87	24.9
Approach		1504	2.0	1.000	74.4	LOS E	45.8	326.1	1.00	1.10	19.4
East: Beach Road (East)											
4	L	206	2.0	0.228	12.1	LOS B	3.4	24.0	0.34	0.68	45.1
5	T	799	2.0	0.968	93.0	LOS F	34.4	245.0	1.00	1.30	16.4
6	R	220	2.0	0.946	94.7	LOS F	8.4	59.8	1.00	1.12	16.7
Approach		1225	2.0	0.968	79.7	LOS E	34.4	245.0	0.89	1.16	18.5
North: Girrawheen Ave (North)											
7	L	197	2.0	0.969	101.4	LOS F	36.4	259.3	1.00	1.24	16.1
8	T	539	2.0	0.969	93.0	LOS F	36.8	261.8	1.00	1.28	16.2
9	R	107	2.0	0.969	100.7	LOS F	36.8	261.8	1.00	1.30	16.4
Approach		843	2.0	0.969	95.9	LOS F	36.8	261.8	1.00	1.27	16.2
West: Beach Road (West)											
10	L	106	2.0	0.186	17.3	LOS B	2.5	17.7	0.46	0.69	40.8
11	T	410	2.0	0.497	47.2	LOS D	11.2	79.5	0.93	0.77	25.1
12	R	127	2.0	0.546	73.4	LOS E	4.0	28.6	1.00	0.76	19.9
Approach		643	2.0	0.546	47.4	LOS D	11.2	79.5	0.87	0.76	25.5
All Vehicles		4215	2.0	1.000	76.1	LOS E	45.8	326.1	0.95	1.10	19.1

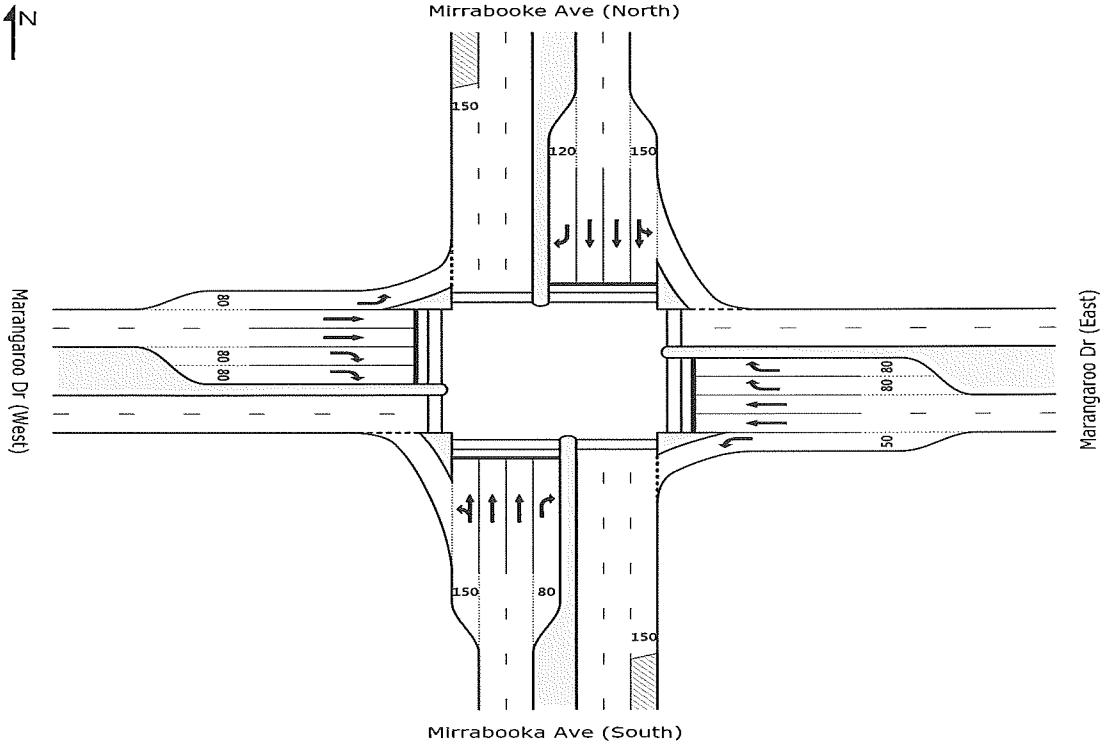
Mirabooka/Marangaroo Ave Intersection 2031

Exiting Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Marangaroo Dr / Mirrabooka Ave
Signals - Fixed Time Cycle Time = 130 seconds (Practical Cycle Time) pm 2031

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	276	4.0	0.495	28.5	LOS C	10.8	78.0	0.75	0.87	34.0
2	T	731	4.0	0.563	38.3	LOS D	17.7	128.5	0.88	0.76	28.0
3	R	81	4.0	0.269	52.9	LOS D	4.2	30.6	0.86	0.76	24.6
Approach		1087	4.0	0.563	36.9	LOS D	17.7	128.5	0.84	0.79	29.0
East: Marangaroo Dr (East)											
4	L	254	4.0	0.653	21.3	LOS C	8.2	59.3	0.56	0.74	38.1
5	T	379	4.0	0.498	50.2	LOS D	10.8	78.0	0.94	0.78	24.3
6	R	141	4.0	0.462	71.6	LOS E	4.4	32.2	0.99	0.77	20.3
Approach		774	4.0	0.653	44.6	LOS D	10.8	78.0	0.83	0.76	26.5
North: Mirrabooke Ave (North)											
7	L	188	4.0	0.792	50.0	LOS D	25.3	183.0	0.94	0.95	26.0
8	T	1353	4.0	0.901	55.6	LOS E	38.1	275.9	0.99	1.02	22.8
9	R	340	4.0	0.874	71.5	LOS E	23.6	171.1	1.00	0.97	20.4
Approach		1881	4.0	0.901	57.9	LOS E	38.1	275.9	0.99	1.00	22.6
West: Marangaroo Dr (West)											
10	L	122	4.0	0.196	11.8	LOS B	2.0	14.3	0.32	0.67	45.4
11	T	368	4.0	0.485	50.0	LOS D	10.4	75.6	0.94	0.77	24.3
12	R	276	4.0	0.903	85.7	LOS F	10.1	72.9	1.00	1.01	18.0
Approach		766	4.0	0.903	56.8	LOS E	10.4	75.6	0.86	0.84	23.1
All Vehicles		4508	4.0	0.903	50.4	LOS D	38.1	275.9	0.90	0.88	24.6

Marangaroo Dr / Mirrabooka Ave
Signals - Fixed Time Cycle Time = 130 seconds (Practical Cycle Time) pm 2031

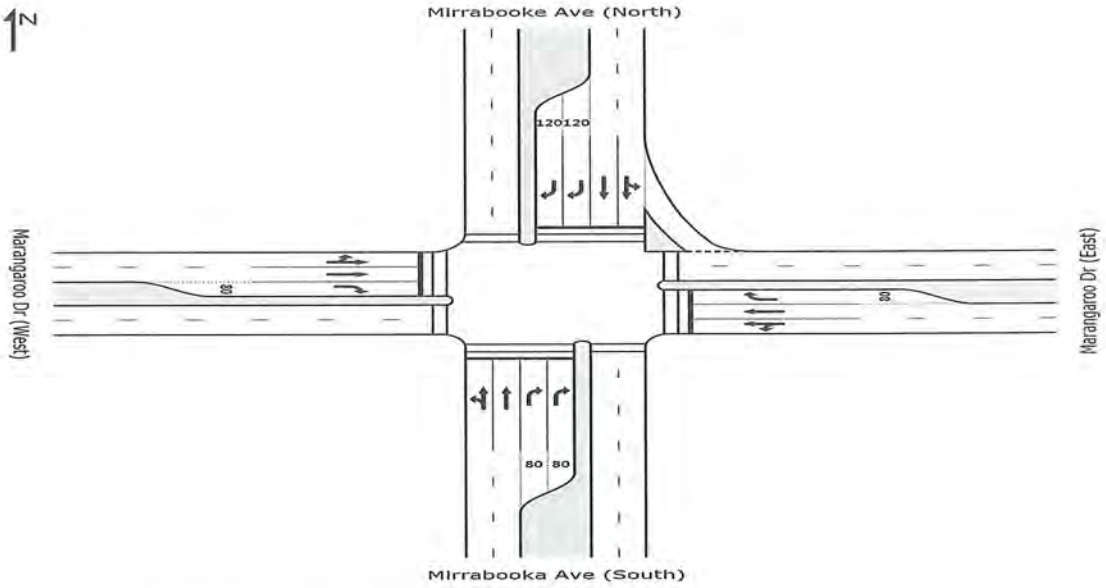
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	283	4.0	0.794	47.6	LOS D	24.6	178.3	0.93	1.00	26.5
2	T	1404	4.0	0.902	53.8	LOS D	42.5	307.9	0.99	1.02	23.2
3	R	183	4.0	0.599	62.5	LOS E	10.9	79.2	0.98	0.82	22.3
Approach		1871	4.0	0.902	53.7	LOS D	42.5	307.9	0.98	1.00	23.6
East: Marangaroo Dr (East)											
4	L	103	4.0	0.266	33.3	LOS C	4.0	28.9	0.65	0.75	31.4
5	T	466	4.0	0.613	51.6	LOS D	13.6	98.7	0.97	0.81	23.9
6	R	182	4.0	0.546	71.2	LOS E	5.7	41.6	1.00	0.78	20.4
Approach		752	4.0	0.613	53.8	LOS D	13.6	98.7	0.93	0.79	23.7
North: Mirrabooke Ave (North)											
7	L	103	4.0	0.410	37.9	LOS D	9.8	71.3	0.76	0.89	30.2
8	T	774	4.0	0.466	33.8	LOS C	15.3	110.4	0.81	0.71	29.8
9	R	261	4.0	0.854	73.1	LOS E	17.9	129.7	1.00	0.95	20.1
Approach		1138	4.0	0.854	43.2	LOS D	17.9	129.7	0.85	0.78	26.8
West: Marangaroo Dr (West)											
10	L	397	4.0	0.698	25.6	LOS C	14.4	104.1	0.67	0.83	35.5
11	T	372	4.0	0.489	50.1	LOS D	10.5	76.3	0.94	0.77	24.3
12	R	281	4.0	0.843	79.2	LOS E	9.8	70.6	1.00	0.94	19.0
Approach		1049	4.0	0.843	48.6	LOS D	14.4	104.1	0.85	0.84	25.5
All Vehicles		4809	4.0	0.902	50.1	LOS D	42.5	307.9	0.91	0.88	24.7

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include double

turn lanes on Marangaroo Drive and additional left turn lanes on each approach. It is noted that the reserve on Marangaroo Drive and Mirabooka Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required.
A compromise is therefore recommended as follows, the performance is poor in comparison but the site is constrained. Significant queuing on Mirrabooka Ave north and south is forecast.

Possible Geometry (if no land resumption)



Marangaroo Dr / Mirrabooka Ave 2031 with LHS am
Signals - Fixed Time Cycle Time = 140 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Mirrabooka Ave (South)											
1	L	262	4.0	0.595	36.5	LOS D	20.6	149.5	0.70	0.86	30.5
2	T	694	4.0	0.595	28.1	LOS C	21.2	153.7	0.70	0.62	32.3
3	R	77	4.0	0.230	73.2	LOS E	2.4	17.7	0.94	0.74	20.0
Approach		1033	4.0	0.595	33.6	LOS C	21.2	153.7	0.72	0.69	30.5
East: Marangaroo Dr (East)											
4	L	241	4.0	0.983	113.6	LOS F	27.5	198.7	1.00	1.14	14.6
5	T	360	4.0	0.983	104.6	LOS F	28.5	206.3	1.00	1.23	15.0
6	R	134	4.0	0.520	68.9	LOS E	8.4	60.7	0.95	0.80	20.8
Approach		735	4.0	0.983	101.1	LOS F	28.5	206.3	0.99	1.12	15.7
North: Mirrabooke Ave (North)											
7	L	179	4.0	0.914	65.7	LOS E	54.8	396.7	1.00	1.06	22.1
8	T	1285	4.0	0.916	56.9	LOS E	56.9	412.3	1.00	1.05	22.4
9	R	323	4.0	0.963	109.7	LOS F	14.3	103.8	1.00	1.14	15.0
Approach		1787	4.0	0.963	67.3	LOS E	56.9	412.3	1.00	1.07	20.6
West: Marangaroo Dr (West)											
10	L	116	4.0	0.763	71.3	LOS E	15.5	112.0	0.99	0.87	20.7
11	T	354	4.0	0.763	62.8	LOS E	15.8	114.6	0.99	0.87	21.1
12	R	258	4.0	1.000 [3]	74.2	LOS E	18.1	130.8	1.00	0.84	19.8
Approach		728	4.0	1.000	68.2	LOS E	18.1	130.8	1.00	0.86	20.6
All Vehicles		4283	4.0	1.000	65.1	LOS E	56.9	412.3	0.93	0.95	21.1

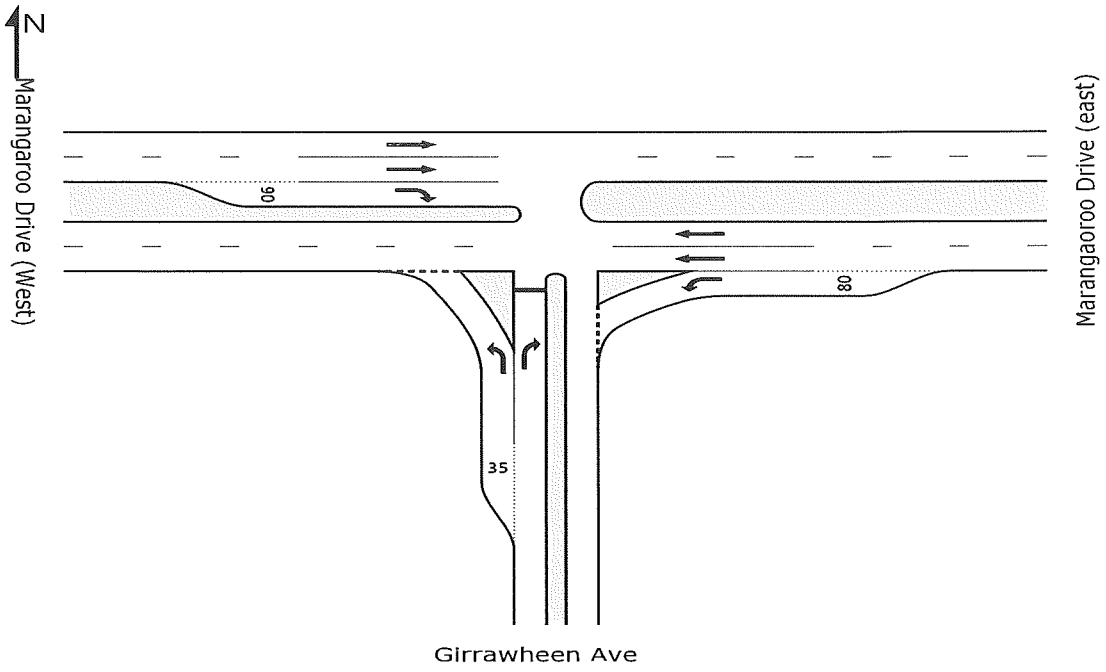
Marangaroo Dr / Mirrabooka Ave 2031 with LHS pm
Signals - Fixed Time Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Mirrabooka Ave (South)											
1	L	269	4.0	1.006	117.1	LOS F	88.5	641.0	1.00	1.26	14.5
2	T	1334	4.0	1.006	108.4	LOS F	89.9	650.5	1.00	1.30	14.7
3	R	174	4.0	0.718	86.3	LOS F	6.6	47.4	1.00	0.82	17.8
Approach		1777	4.0	1.006	107.6	LOS F	89.9	650.5	1.00	1.25	14.9
East: Marangaroo Dr (East)											
4	L	98	4.0	0.714	68.8	LOS E	17.8	129.1	0.96	0.85	21.3
5	T	443	4.0	0.714	60.4	LOS E	18.1	131.4	0.96	0.82	21.6
6	R	173	4.0	0.649	73.5	LOS E	11.8	85.3	0.97	0.82	20.0
Approach		714	4.0	0.714	64.7	LOS E	18.1	131.4	0.96	0.82	21.2
North: Mirrabooke Ave (North)											
7	L	98	4.0	0.523	43.7	LOS D	21.2	153.7	0.79	0.91	28.2
8	T	735	4.0	0.525	34.6	LOS C	22.4	162.0	0.79	0.71	29.4
9	R	248	4.0	1.023	168.2	LOS F	14.4	103.9	1.00	1.31	10.7
Approach		1081	4.0	1.023	66.1	LOS E	22.4	162.0	0.84	0.87	20.9
West: Marangaroo Dr (West)											
10	L	377	4.0	1.037	178.5	LOS F	47.2	342.0	1.00	1.24	10.1
11	T	353	4.0	0.924	78.7	LOS E	29.1	210.4	1.00	1.06	18.4
12	R	267	4.0	1.000 [3]	77.8	LOS E	19.8	143.3	1.00	0.84	19.2
Approach		997	4.0	1.037	116.2	LOS F	47.2	342.0	1.00	1.07	14.2
All Vehicles		4569	4.0	1.037	93.0	LOS F	89.9	650.5	0.96	1.05	16.6

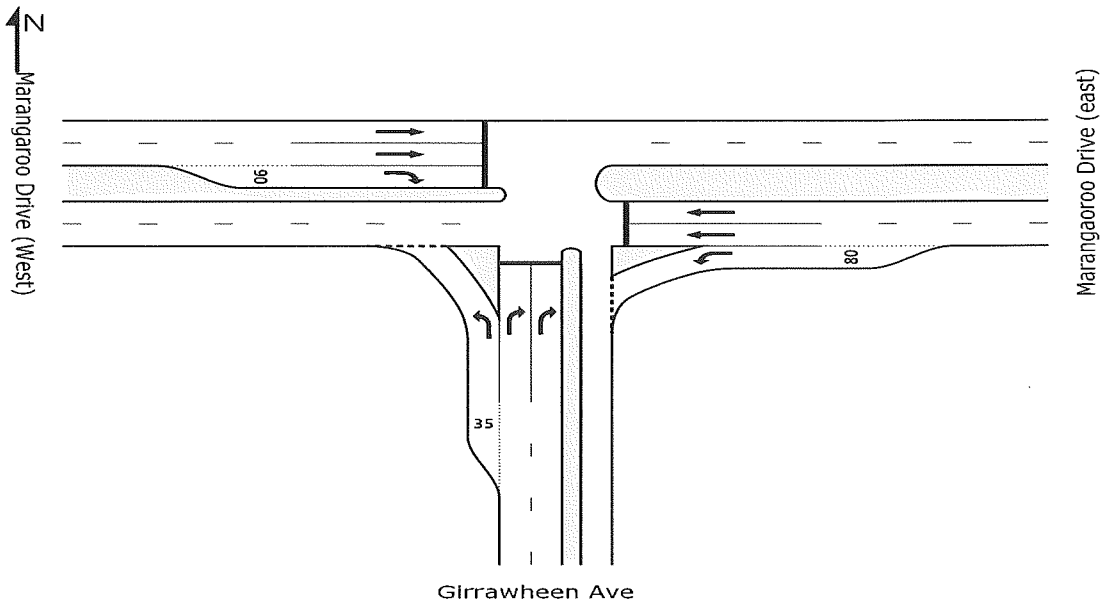
Marangaroo Drive/Girawheen Ave Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Marangaroo Drive / Girrawheen Avenue
Signals - Fixed Time Cycle Time = 100 seconds (User-Given Cycle Time) am 2031

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Girrawheen Ave											
1	L	518	4.0	0.861	16.1	LOS B	8.0	57.6	0.64	0.82	41.9
3	R	147	4.0	0.680	62.9	LOS E	3.9	28.1	1.00	0.82	22.0
Approach		665	4.0	0.861	26.4	LOS C	8.0	57.6	0.72	0.82	35.0
East: Marangaoroo Drive (east)											
4	L	403	4.0	0.608	13.4	LOS B	8.2	59.1	0.55	0.76	44.1
5	T	722	4.0	0.863	49.5	LOS D	19.5	141.3	1.00	1.02	24.4
Approach		1125	4.0	0.863	36.5	LOS D	19.5	141.3	0.84	0.92	29.1
West: Marangaroo Drive (West)											
11	T	595	4.0	0.191	2.0	LOS A	3.0	21.9	0.23	0.20	55.7
12	R	632	4.0	0.870	30.1	LOS C	20.3	146.9	0.68	0.91	32.9
Approach		1226	4.0	0.870	16.5	LOS B	20.3	146.9	0.46	0.57	41.1
All Vehicles		3017	4.0	0.870	26.2	LOS C	20.3	146.9	0.66	0.76	34.5

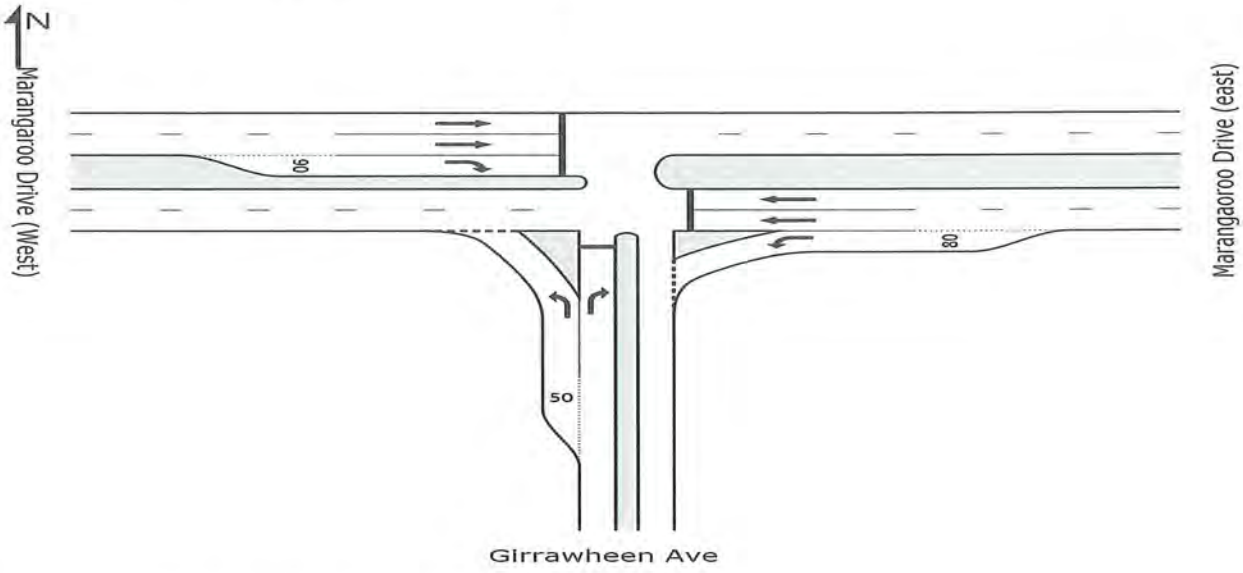
Marangaroo Drive / Girrawheen Avenue
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time) pm 2031

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Girrawheen Ave											
1	L	478	4.0	0.906	18.5	LOS B	8.7	62.8	0.68	0.84	40.0
3	R	287	4.0	0.682	65.9	LOS E	8.5	61.5	1.00	0.83	21.4
Approach		765	4.0	0.906	36.3	LOS D	8.7	62.8	0.80	0.84	30.2
East: Marangaoroo Drive (east)											
4	L	211	4.0	0.303	10.1	LOS B	2.4	17.7	0.30	0.68	47.2
5	T	768	4.0	0.898	62.2	LOS E	25.7	185.9	1.00	1.06	21.4
Approach		979	4.0	0.898	51.0	LOS D	25.7	185.9	0.85	0.97	24.3
West: Marangaroo Drive (West)											
11	T	923	4.0	0.310	3.9	LOS A	7.5	54.6	0.31	0.28	52.8
12	R	453	4.0	0.741	22.7	LOS C	12.1	87.8	0.65	0.83	37.1
Approach		1376	4.0	0.741	10.1	LOS B	12.1	87.8	0.42	0.46	46.3
All Vehicles		3120	4.0	0.906	29.3	LOS C	25.7	185.9	0.65	0.71	32.7

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include signalising the intersection and providing a double right turn lanes on Girrawheen Avenue. It is noted that the reserve on Girawheen Ave would not appear to be wide enough to accommodate the proposed double right turn and significant land acquisition would be likely. The following geometry is therefore recommended.

Possible Geometry (if no land resumption)



Marangaroo Drive / Girrawheen Avenue 2031 with LHS am
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Girrawheen Ave											
1	L	490	4.0	0.738	14.2	LOS B	8.1	58.4	0.45	0.76	43.4
3	R	140	4.0	0.846	74.9	LOS E	9.1	65.6	1.00	0.95	19.6
Approach		630	4.0	0.846	27.7	LOS C	9.1	65.6	0.57	0.80	34.3
East: Marangaoroo Drive (east)											
4	L	383	4.0	0.673	13.0	LOS B	8.1	58.5	0.48	0.74	44.4
5	T	686	4.0	0.902	65.5	LOS E	23.4	169.5	1.00	1.09	20.7
Approach		1069	4.0	0.902	46.7	LOS D	23.4	169.5	0.81	0.96	25.7
West: Marangaroo Drive (West)											
11	T	565	4.0	0.184	2.7	LOS A	3.6	26.2	0.24	0.21	54.6
12	R	600	4.0	0.915	28.8	LOS C	20.3	146.9	0.65	0.88	33.5
Approach		1165	4.0	0.915	16.2	LOS B	20.3	146.9	0.45	0.55	41.3
All Vehicles		2864	4.0	0.915	30.1	LOS C	23.4	169.5	0.61	0.76	32.4

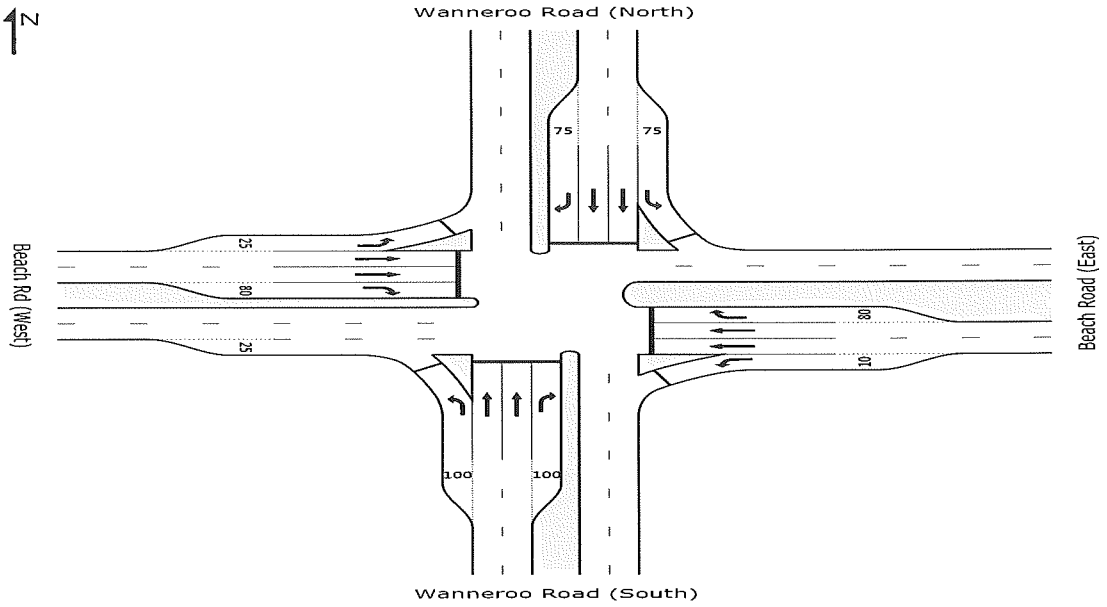
Marangaroo Drive / Girrawheen Avenue 2031 with LHS pm
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Girrawheen Ave											
1	L	454	4.0	0.676	14.1	LOS B	9.0	65.1	0.46	0.75	43.5
3	R	273	4.0	0.756	59.9	LOS E	15.8	114.7	1.00	0.88	22.7
Approach		727	4.0	0.756	31.3	LOS C	15.8	114.7	0.66	0.80	32.4
East: Marangaoroo Drive (east)											
4	L	200	4.0	0.266	10.2	LOS B	2.3	16.6	0.30	0.68	47.1
5	T	730	4.0	0.743	45.3	LOS D	20.1	145.7	0.98	0.87	25.6
Approach		930	4.0	0.743	37.8	LOS D	20.1	145.7	0.83	0.83	28.4
West: Marangaroo Drive (West)											
11	T	877	4.0	0.330	7.4	LOS A	9.8	70.8	0.42	0.37	48.2
12	R	430	4.0	0.766	27.2	LOS C	13.1	95.1	0.77	0.87	34.4
Approach		1307	4.0	0.766	13.9	LOS B	13.1	95.1	0.54	0.54	42.6
All Vehicles		2964	4.0	0.766	25.7	LOS C	20.1	145.7	0.66	0.69	34.5

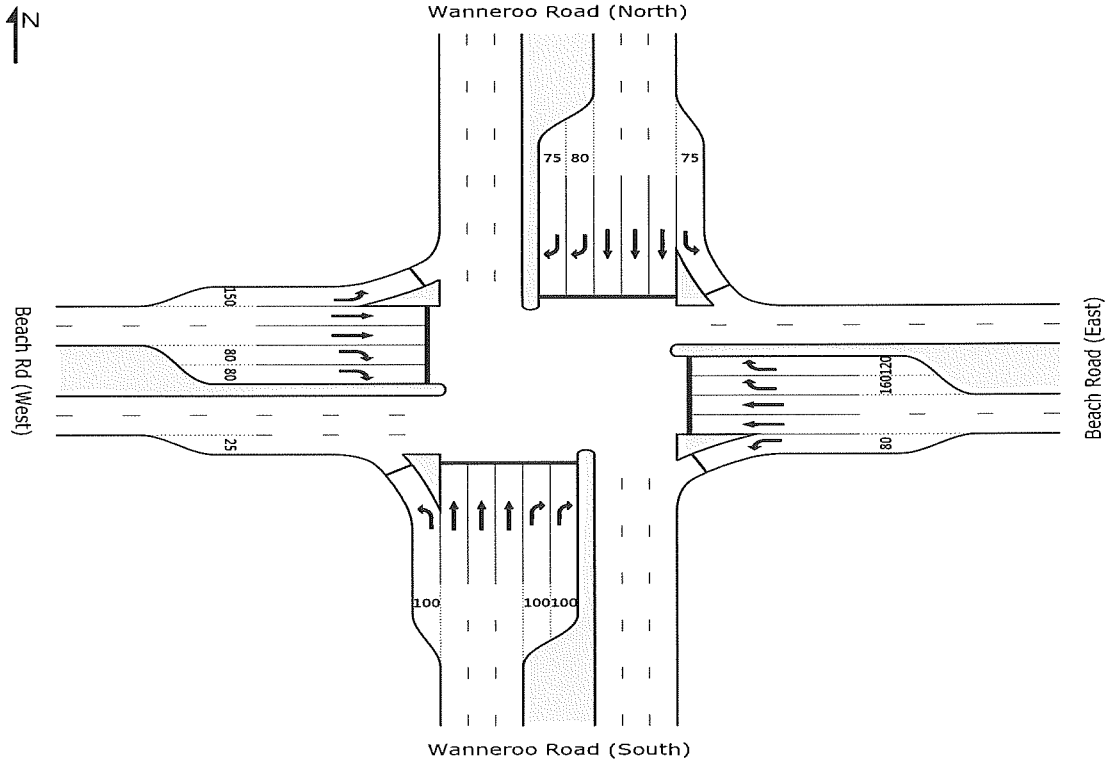
Beach Road/Wanneroo Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry - Recommended



Wanneroo Beach with LHS 2031 am
Signals - Fixed Time Cycle Time = 130 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road (South)											
1	L	108	4.0	0.169	17.6	LOS B	2.6	18.9	0.42	0.69	40.7
2	T	874	4.0	0.311	20.9	LOS C	10.9	78.8	0.64	0.55	36.6
3	R	71	4.0	0.320	74.0	LOS E	2.3	16.5	0.99	0.73	20.0
Approach		1053	4.0	0.320	24.2	LOS C	10.9	78.8	0.64	0.58	35.0
East: Beach Road (East)											
4	L	216	4.0	0.669	49.6	LOS D	11.3	82.0	0.87	0.81	25.6
5	T	408	4.0	0.634	55.0	LOS D	12.2	88.6	0.98	0.81	23.0
6	R	291	4.0	0.873	81.7	LOS F	10.4	75.0	1.00	1.00	18.7
Approach		915	4.0	0.873	62.2	LOS E	12.2	88.6	0.96	0.87	21.9
North: Wanneroo Road (North)											
7	L	283	4.0	0.540	18.7	LOS B	7.7	55.6	0.47	0.72	39.9
8	T	2490	4.0	0.887	40.2	LOS D	52.9	383.1	0.98	0.97	27.3
9	R	197	4.0	0.886	85.7	LOS F	7.1	51.7	1.00	1.00	18.0
Approach		2970	4.0	0.887	41.2	LOS D	52.9	383.1	0.93	0.95	27.2
West: Beach Rd (West)											
10	L	210	4.0	0.420	49.1	LOS D	10.9	78.9	0.87	0.81	25.8
11	T	574	4.0	0.892	70.2	LOS E	20.7	149.7	1.00	1.05	19.8
12	R	283	4.0	0.849	79.5	LOS E	9.9	71.5	1.00	0.97	19.1
Approach		1067	4.0	0.892	68.5	LOS E	20.7	149.7	0.97	0.98	20.5
All Vehicles		6005	4.0	0.892	46.3	LOS D	52.9	383.1	0.89	0.88	25.8

Wanneroo Beach 2031 with LHS pm
Signals - Fixed Time Cycle Time = 110 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

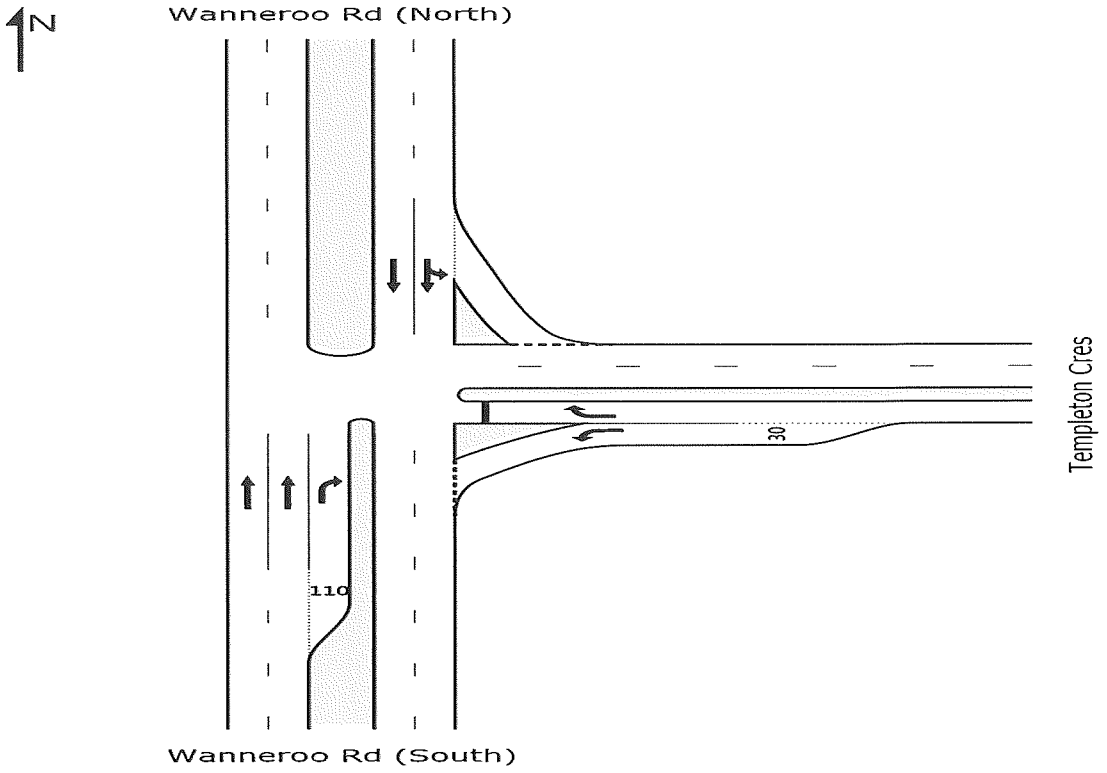
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road (South)											
1	L	166	4.0	0.265	20.4	LOS C	4.3	31.1	0.52	0.72	38.7
2	T	2244	4.0	0.902	44.8	LOS D	45.3	328.1	1.00	1.06	25.8
3	R	111	4.0	0.376	62.0	LOS E	3.0	21.5	0.99	0.75	22.4
Approach		2521	4.0	0.902	43.9	LOS D	45.3	328.1	0.97	1.02	26.2
East: Beach Road (East)											
4	L	98	4.0	0.275	43.5	LOS D	4.2	30.5	0.84	0.76	27.6
5	T	572	4.0	0.752	47.4	LOS D	15.2	110.2	1.00	0.90	25.0
6	R	508	4.0	0.910	73.6	LOS E	16.4	118.8	1.00	1.08	20.0
Approach		1178	4.0	0.910	58.4	LOS E	16.4	118.8	0.99	0.96	22.7
North: Wanneroo Road (North)											
7	L	244	4.0	0.404	16.1	LOS B	5.3	38.1	0.44	0.71	41.8
8	T	1066	4.0	0.428	22.9	LOS C	13.1	94.9	0.74	0.64	35.2
9	R	271	4.0	0.917	78.2	LOS E	8.8	63.4	1.00	1.09	19.2
Approach		1581	4.0	0.917	31.4	LOS C	13.1	94.9	0.74	0.73	31.5
West: Beach Rd (West)											
10	L	362	4.0	0.817	55.3	LOS E	20.1	145.2	1.00	0.93	24.0
11	T	374	4.0	0.902	66.1	LOS E	11.8	85.3	1.00	1.07	20.6
12	R	175	4.0	0.762	68.5	LOS E	5.1	37.0	1.00	0.87	21.0
Approach		911	4.0	0.902	62.3	LOS E	20.1	145.2	1.00	0.98	21.9
All Vehicles		6191	4.0	0.917	46.2	LOS D	45.3	328.1	0.92	0.93	25.8

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS to a reasonable LoS. Most traffic

will clear the intersection in a single cycle. Upgrade will include additional through lanes on Wanneroo Road and the provision of double right turns on the north, south, east and west approaches. No land acquisition would appear to be required. (To be confirmed as part of a concept design)

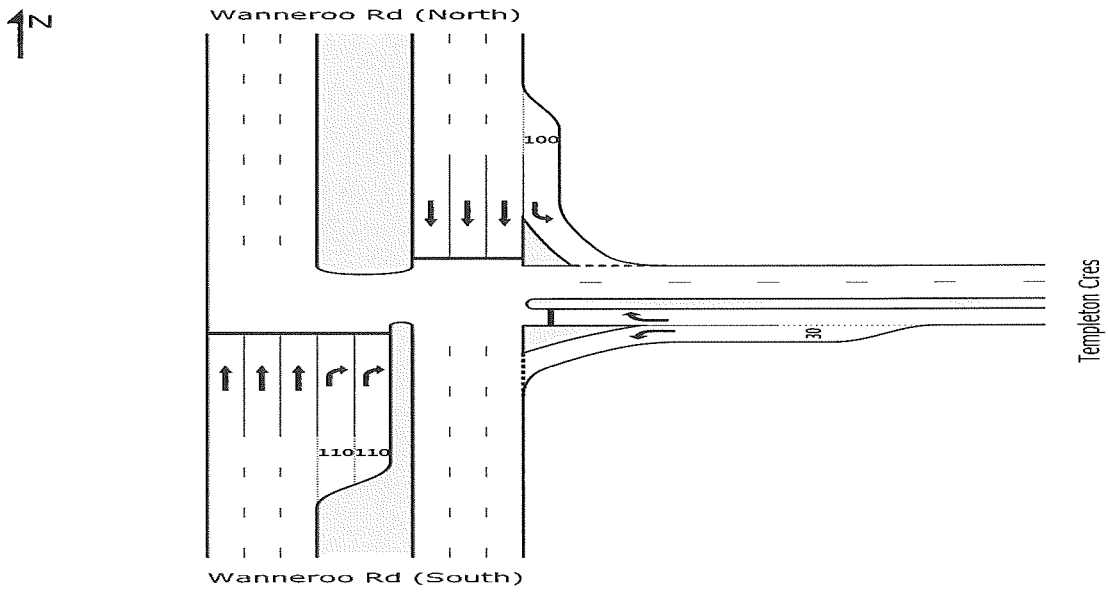
Wanneroo Road/Templeton Road Intersection 2031

Existing Geometry



Analysis for 2031 indicates this intersection will not accommodate the forecast traffic volumes to 2031.

Proposed Ultimate Geometry – Recommended



Wanneroo Rd/ Templeton Cres AM 2031 with LHS Signals
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	1223	4.0	0.292	5.7	LOS A	7.9	57.2	0.37	0.32	50.3
3	R	153	4.0	0.726	73.9	LOS E	4.8	34.9	1.00	0.84	19.9
Approach		1376	4.0	0.726	13.3	LOS B	7.9	57.2	0.44	0.38	43.0
East: Templeton Cres											
4	L	214	4.0	1.000 [3]	20.4	LOS C	6.8	49.1	0.62	0.76	38.6
6	R	210	4.0	0.697	60.8	LOS E	12.0	87.1	1.00	0.85	22.6
Approach		424	4.0	1.000	40.4	LOS D	12.0	87.1	0.81	0.81	28.7
North: Wanneroo Rd (North)											
7	L	107	4.0	0.082	8.3	LOS A	0.6	4.0	0.15	0.63	48.9
8	T	2607	4.0	0.732	16.5	LOS B	34.6	250.4	0.75	0.69	39.3
Approach		2714	4.0	0.732	16.1	LOS B	34.6	250.4	0.73	0.69	39.6
All Vehicles		4514	4.0	1.000	17.5	LOS B	34.6	250.4	0.65	0.61	39.1

Wanneroo Rd/ Templeton Cres PM 2031 with LHS Signals
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

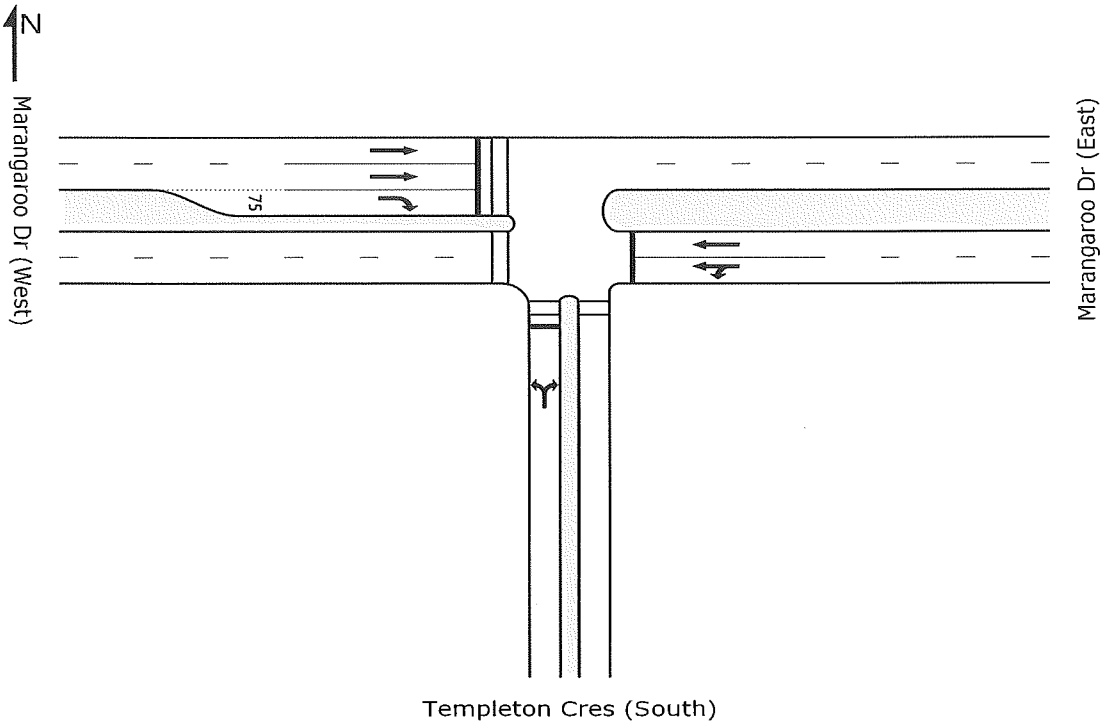
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	2520	4.0	0.541	3.8	LOS A	15.8	114.3	0.36	0.33	52.7
3	R	622	4.0	0.629	38.4	LOS D	13.7	99.0	0.81	0.81	29.3
Approach		3142	4.0	0.629	10.6	LOS B	15.8	114.3	0.45	0.43	45.5
East: Templeton Cres											
4	L	190	4.0	0.529	12.2	LOS B	3.1	22.2	0.36	0.68	45.1
6	R	88	4.0	0.585	68.1	LOS E	5.2	37.9	1.00	0.79	21.0
Approach		278	4.0	0.585	29.9	LOS C	5.2	37.9	0.56	0.72	33.1
North: Wanneroo Rd (North)											
7	L	129	4.0	0.162	10.1	LOS B	1.5	10.7	0.26	0.66	47.1
8	T	1395	4.0	0.625	31.4	LOS C	21.8	157.8	0.86	0.76	30.8
Approach		1524	4.0	0.625	29.6	LOS C	21.8	157.8	0.81	0.75	31.7
All Vehicles		4944	4.0	0.629	17.6	LOS B	21.8	157.8	0.57	0.54	39.4

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include additional through lanes on Wanneroo Road and the provision of a double right turns on the south approach and a left turn lane in Wanneroo Road north. No land acquisition would appear to be required.

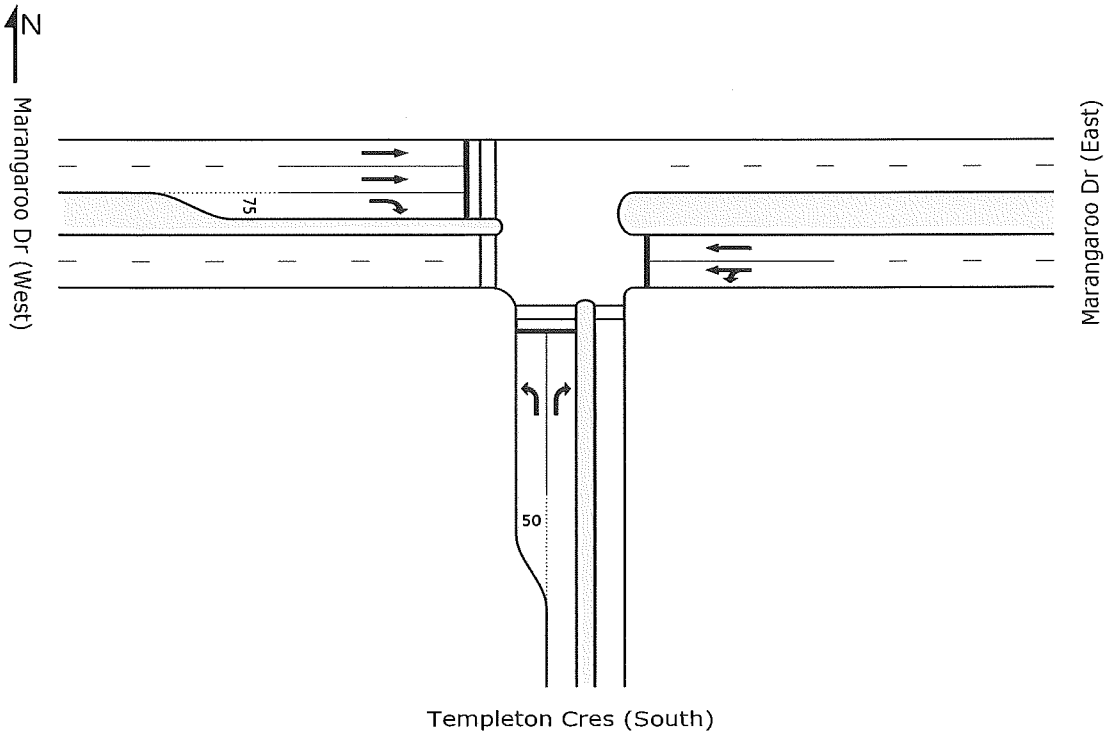
Marangaroo Dr/Templeton Crescent Intersection 2031

Existing Geometry



The existing geometry will operate to a reasonable performance however pm queue lengths in Templeton Crescent are forecast to exceed 200m. Further analysis has therefore been undertaken of a modified geometry.

Proposed Ultimate Geometry - Recommended



Marangaroo Drive / Templeton Crescent with LHS Signals am 2031
Signals - Fixed Time Cycle Time = 80 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Templeton Cres (South)											
1	L	78	4.0	0.245	33.1	LOS C	2.4	17.2	0.81	0.75	31.4
3	R	221	4.0	0.466	35.6	LOS D	7.4	53.6	0.89	0.81	30.4
Approach		299	4.0	0.466	34.9	LOS C	7.4	53.6	0.87	0.80	30.6
East: Marangaroo Dr (East)											
4	L	189	4.0	0.575	19.4	LOS B	15.3	110.9	0.67	0.90	40.7
5	T	1085	4.0	0.575	11.0	LOS B	15.5	112.6	0.67	0.60	43.5
Approach		1274	4.0	0.575	12.3	LOS B	15.5	112.6	0.67	0.65	43.1
West: Marangaroo Dr (West)											
11	T	618	4.0	0.277	8.7	LOS A	5.9	42.6	0.53	0.45	46.5
12	R	60	4.0	0.312	27.9	LOS C	1.8	12.7	0.73	0.77	34.0
Approach		678	4.0	0.312	10.4	LOS B	5.9	42.6	0.54	0.48	45.1
All Vehicles		2251	4.0	0.575	14.7	LOS B	15.5	112.6	0.66	0.62	41.4

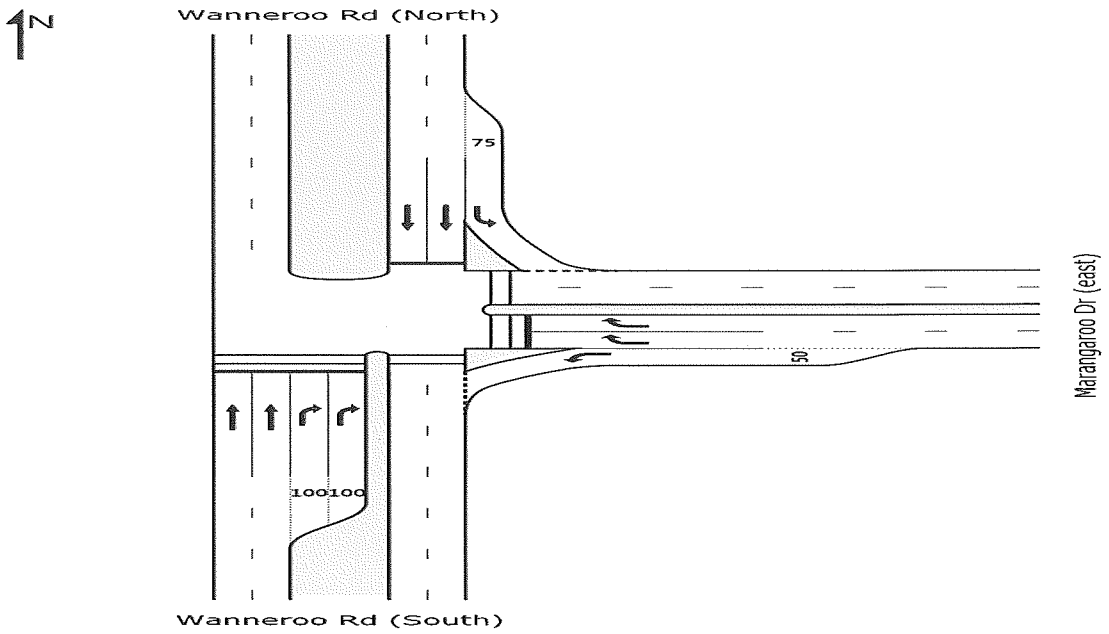
Marangaroo Drive / Templeton Crescent with LHS Signals pm 2031
Signals - Fixed Time Cycle Time = 80 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Templeton Cres (South)											
1	L	181	4.0	0.428	21.5	LOS C	4.1	29.7	0.62	0.76	37.8
3	R	670	4.0	0.781	29.4	LOS C	23.3	168.3	0.90	0.90	33.2
Approach		851	4.0	0.781	27.7	LOS C	23.3	168.3	0.84	0.87	34.1
East: Marangaroo Dr (East)											
4	L	156	4.0	0.770	34.4	LOS C	19.8	143.4	0.94	0.93	32.1
5	T	934	4.0	0.770	26.0	LOS C	20.1	145.3	0.94	0.88	32.9
Approach		1090	4.0	0.770	27.2	LOS C	20.1	145.3	0.94	0.89	32.8
West: Marangaroo Dr (West)											
11	T	664	4.0	0.466	20.5	LOS C	9.9	71.6	0.81	0.69	36.5
12	R	89	4.0	0.684	49.6	LOS D	3.8	27.3	1.00	0.87	25.4
Approach		753	4.0	0.684	24.0	LOS C	9.9	71.6	0.83	0.71	34.7
All Vehicles		2694	4.0	0.781	26.5	LOS C	23.3	168.3	0.88	0.83	33.7

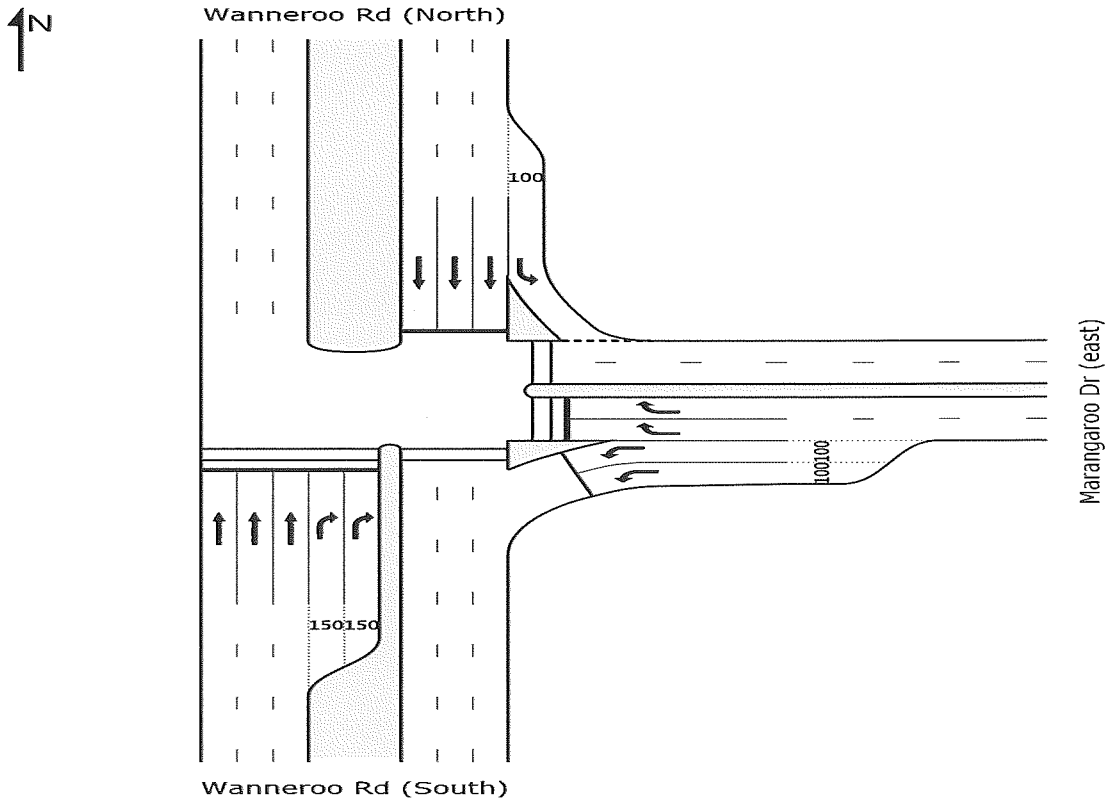
The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include a 50m widening along the Templeton Crescent approach to accommodate two lanes of traffic. No land acquisition would appear to be required.

Wanneroo Road/Marangaroo Road Intersection 2031
Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry – Recommended



Marangaroo Dr / Wanneroo Rd with LHS 2031 AM Upgraded Geometrey
Signals - Fixed Time Cycle Time = 114 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Rd (South)											
2	T	1158	5.0	0.319	9.8	LOS A	9.5	69.5	0.49	0.43	45.6
3	R	407	5.0	0.863	70.1	LOS E	12.7	92.4	1.00	0.99	20.6
Approach		1565	5.0	0.863	25.5	LOS C	12.7	92.4	0.62	0.57	34.6
East: Marangaroo Dr (east)											
4	L	722	5.0	0.879	63.2	LOS E	22.2	162.4	1.00	1.00	22.2
6	R	380	5.0	0.417	46.4	LOS D	8.9	64.8	0.88	0.81	26.5
Approach		1102	5.0	0.879	57.4	LOS E	22.2	162.4	0.96	0.93	23.5
North: Wanneroo Rd (North)											
7	L	351	5.0	0.332	9.8	LOS A	3.8	28.0	0.28	0.67	47.4
8	T	2337	5.0	0.904	44.8	LOS D	48.6	354.5	1.00	1.06	25.8
Approach		2688	5.0	0.904	40.3	LOS D	48.6	354.5	0.91	1.01	27.4
All Vehicles		5355	5.0	0.904	39.5	LOS D	48.6	354.5	0.83	0.86	28.1

Marangaroo Dr / Wanneroo Rd with LHS 2031 PM Upgraded Geometry
Signals - Fixed Time Cycle Time = 87 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Rd (South)											
2	T	2460	5.0	0.821	21.7	LOS C	31.4	229.2	0.90	0.87	35.6
3	R	694	5.0	0.886	55.9	LOS E	17.5	127.8	1.00	1.04	23.8
Approach		3154	5.0	0.886	29.2	LOS C	31.4	229.2	0.92	0.91	32.1
East: Marangaroo Dr (east)											
4	L	531	5.0	0.487	32.4	LOS C	8.9	65.0	0.83	0.80	32.0
6	R	443	5.0	0.371	31.9	LOS C	7.2	52.6	0.81	0.80	32.1
Approach		974	5.0	0.487	32.2	LOS C	8.9	65.0	0.82	0.80	32.1
North: Wanneroo Rd (North)											
7	L	316	5.0	0.327	11.6	LOS B	4.1	30.1	0.42	0.71	45.6
8	T	1206	5.0	0.882	45.7	LOS D	19.9	145.6	1.00	1.08	25.5
Approach		1522	5.0	0.882	38.6	LOS D	19.9	145.6	0.88	1.00	28.1
All Vehicles		5650	5.0	0.886	32.3	LOS C	31.4	229.2	0.89	0.92	30.9

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include an additional lane in Wanneroo Road and a signalised double left turn lane in Marrangaroo Drive. Intersection C/D is achieved and Stop rates generally below 1. The degree of saturation is 0.904 for the am peak hour. No land acquisition would appear to be required.

Appendix G - Council and Main Roads Response to Draft Measures and GHD Commentary

From: HOLMES Rob (RPO) [rob.holmes@mainroads.wa.gov.au]

Sent: Monday, 26 November 2012 6:40 AM

To: Koroveshi, Jordan

Cc: Zamir, Marzia; BROADHURST Lindsay (MRP); MCKIRDY Justin (URPM)

Subject: TRIM: Local Housing Strategies -Girrawheen-Koondoola Housing Precinct & Wanneroo Housing Precinct

Hi Jordan

I refer to your email dated 5 November 2012 providing copies the following documents:

Draft Report for Wanneroo Housing Precinct Traffic Impact Assessment – September 2012; and .

Draft Report for Girrawheen-Koondoola Housing Precinct Traffic Impact Assessment – September 2012.

Please note that we were not provided a copy of Appendix A, C and D for either draft report so we are unable to provide feedback on the data / information contained within these sections.

I also make reference to our meeting on 5 November 2012 where discussion focused on the changes in R- Coding around the Wanneroo Centre and Girrawheen-Koondoola precincts, resulting from the implementation of Local Planning Policy 3.1, and the effect this will have on road networks.

It is our understanding that the City of Wanneroo is keen to understand future implications of the R-Coding changes with the intention of being able to progressively move toward an appropriate outcome. Main Roads is very supportive of this approach and is keen to remain involved in the process. The following comments are provided in response to your request for comments and are intended to be constructive without being a detailed critique:

General Comments

1. The draft reports appear to be a good start and provide some good information. We consider some of the recommendations debatable and worthy of further consideration and discussion.

2.Network analysis seems to have jumped to 'single solutions' too fast. What network options were considered and tested?

GHD Response

The planned road network as provided was analysed additional road networks are beyond the scope of this project.

The City and Main Roads should be aiming to make the most appropriate use of the road hierarchy. For example:

Within the Girrawheen-Koondoola Housing precinct, instead of assuming Templeton Cr (a local distributor road) should be automatically signalised to deal with its capacity constraints at Wanneroo Rd, how else might the broader network be able to cater for this demand.

GHD Response

Based on the forecast traffic volumes the intersection of Templeton Cr/Wanneroo Rd will ultimately need to be upgraded. A review of the 5 year crash history at this intersection indicates there have been 25 crashes in 5 years , 7 crashes involve right angle and right through indicating there may already be a safety issue involving turning movements. As traffic volumes increase this will be exacerbated.

Analysis for the signalised intersections at Wanneroo Road/Beach Road and Wanneroo Road/Marrangaroo Drive intersections indicate that these upgraded intersections will operate satisfactorily as traffic volumes increase, therefore a strategy that includes upgrade to the major intersections first is recommended and further upgrade to the Templeton Crescent intersection is reviewed as development occurs.

State Frequency Rank No. 919 State Cost Rank No. 994 Intersection No. 14048

Summary of Intersection Crashes			
Street 1	WANNEROO RD	Authority Name	WANNEROO (C)
Street 2	TEMPLETON CR	Region	METROPOLITAN
Street 3		Cost	$1,119,772
Intersection Classification	State and Local Roads	Total Crashes	25

Crash Details										
Rear End	Side Swipe	Right Angle	Right Thru	Wet	Night	Ped	Cycle	Truck	Motorcycle	Casualty
12	1	2	5	4	4	0	0	0	1	6

Within the Wanneroo Housing Precinct, a similar question can be put to the proposed signalising of the Wanneroo Rd and Ariti Ave and similarly for some of the other locations.

GHD Response

See note for Templeton Crescent above. Strategy to improve major intersections first.

3. If demand in particular areas is considered to exceed the capacity of the network, then there are three options available to manage this issue; those being:.

- **Expand the capacity of the road network – if possible (difficulty in adopting this option has been highlighted in the draft Wanneroo Housing Precinct Report);**
- **Provide opportunities for other modes of transport to cater for an increased proportion of the demand; and**
- **Limit to scale of development.**

GHD Response

Whilst improve public transport will go some way to reducing demand, it should be recognised that the scale of development should be limited and network impacts regularly monitored and updated. GHD's/Main Roads modelling assume the full build out by 2031. Even without the increased housing density the analysis indicates that the network is forecast to be under pressure. The network could be further tested using a reduced housing density, GHD would be pleased to provide an estimate for this work.

A recommended strategy would be to limit the scale of development.

Agree that increased shift to PT, and assumed reduction in private vehicle trips, could reduce or at least postpone some of the suggested network upgrades. However, our analysis (and scope) has offered a like-for-like comparison between with/without the proposed local housing strategies, so as to provide an indication to council of the direct impact of the proposed density increases. Any heightened push towards PT usage would assist either scenario.

4. With regards to the second option reflected in Point 3, there appears to be no consideration of how other modes may be used to cater for some of the future demands. For example: .

a) **If light rail is introduced to Mirrabooka Ave in relation to the Girrawheen-Koondoola Housing Precinct.**

b) **If new or upgraded public transport services are implemented within the Wanneroo Housing Precinct.**

c) **Promotion of walking and cycling for localised trips (especially those which may require a short trip crossing a regional road).**

GHD Response

The modelling ROM/GHD takes no account of mode split changes due to the above and was not included or intended as part of the scope for this study.

Mode share options would require further modelling with the ROM modelling and Paramics modelling as this will impact on the study areas and the broader area.

5. Further to Point 4, it is understood that a number of reports (one example being ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009) have identified the importance of achieving a significant increase in public transport use and employment self sufficiencies (ESS) in assisting the existing and planned regional transport network to adequately service the proposed development within the North West Corridor. The role of ESS in relation to this proposed development is not reflected in the draft reports.

GHD Response

Noted, this is not built in to any modelling.

6. The SIDRA analysis completed to date may well be correct, given the assumptions that have been made. However, we have not verified the cycle times utilised and how these relate to current settings.

It is also possible that future road operations will see greater priority given to the movement of traffic on higher order roads within the road hierarchy, resulting in the traffic on lower order connecting roads being required to accept a lower level of service and longer delays.

GHD Response

Noted.

The Paramics modelling incorporated current cycle time data as supplied by Main Roads and the Sidra modelling duplicated the results with recommended layouts. As previously mentioned priority should be given to the major intersections accepting some delays on the minor roads and a strategy to upgrade should reflect this. The priority for upgrade will be addressed in the report.

7. Main Roads' Transport Modelling Branch are currently reviewing the 'Paramics Base Model Validation Report' associated with each draft report. It is anticipated that this review will be completed by the 30 November 2012. It is planned that any review comments will be provided to the City shortly after its completion.

Comments now received. These have been copied to the end of this document and responses provided.

8. It is acknowledged that future predicted volumes, especially on Wanneroo Rd, suggest the need to consider upgrading this road to six lanes, however current ultimate planning is for four lanes. Current thinking would suggest, if any additional lanes are introduced then they would be for public transport purposes, such as bus lanes. Additionally, the extra demand predicted may actually result in peak spreading with the demand being forced to utilise the infrastructure available. Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 has not been made in the draft Girrawheen-Koondoola Housing Precinct report as it was in the draft Wanneroo Housing Precinct, however, this review concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods.

GHD Response

Noted

9. Agree that the Wanneroo Rd and Beach Rd intersection should be considered for double right turns on each approach in the future. As previously advised, the Public Transport Authority are currently progressing a study to provide bus priority measures at this intersection which may constrain future plans to provide these double right turns for general traffic.

GHD Response

Noted.

The recommendation will be for upgrade to include double right turns on each approach noting the PTA study.

10. The following network considerations are presented for investigation and discussion:

a) Make Warwick Rd / Marangaroo Dr a four way intersection, however noting the following:

- May need to research why the staggered arrangement was initially created. There appears to be available road reserve to allow this to occur.

This will create a long straight approach from the east and west to Wanneroo Rd which may have some safety concerns.

GHD Response

Not included in scope of work. GHD happy to provide a price to consider this option.

b) Main Roads does not support the signalising of the Wanneroo Rd and Templeton Cr intersection. Suggest converting Templeton Cr intersection into a left in / left out junction and promote the use of Blackmore Ave and Templeton Cr connection to the existing east west regional roads to access Girrawheen instead of direct access via Templeton Cr to Wanneroo Rd -that is use the road hierarchy approach to determine access

arrangements which will assist in retaining the integrity of Wanneroo Rd as a primary regional road.

GHD Response

As previously mentioned give priority to the major intersection upgrades and consider the Main Roads option as a future strategy.

c) Convert Montrose Ave and Koondoola Ave to left in / left out at their junction with Mirrabooka Ave and promote distribution of traffic to the existing east west regional roads, which have existing controlled connections to Wanneroo Rd.

GHD Response

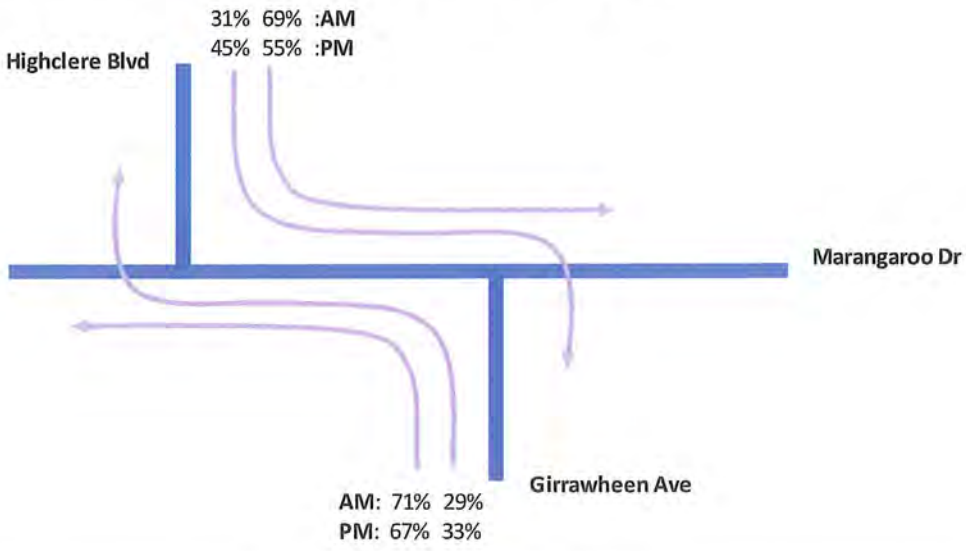
If Main Roads are not supportive of signals a preferred option is to convert the Koondoola Ave and Montrose Ave approaches to left in/out when the intersection is at capacity.

11. If Girrawheen Ave is signalised at Marangaroo Dr, how does this proposal impact Highclere Bvd (currently signalised)? What is the relationship between these intersections in terms of movement patterns? The separation between these intersections is only approximately 280m.

GHD Response

The movement pattern between these two roads is indicated on the figure below. Observed of the modelled 2031 upgraded configurations shows queuing is not expected to extend from one junction to the upstream junction. Nor were any weaving issues identified.

2031 Movement pattern between Highclere Blvd and Girrawheen Ave



Thank you for informing Main Roads of these proposals and for the opportunity to comment. It is hoped that the City finds this feedback beneficial. The opportunity to discuss our feedback would also be welcomed should the City desire. If you require any further information please contact Justin McKirdy, Urban Road Planning Manager North, on 9323 4991.

Regards

Lindsay Broadhurst

Manager Road Planning

City of Wanneroo Comments

1. **Local roads – Comment re local road impacts.**

   Will add comments re local roads as per GHD email.

   The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.

   The WAPC document 'Liveable Neighbourhoods' indicates the anticipated traffic volumes for residential streets:

   Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd

   Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd

   The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.

   The following intersection thresholds are indicated by Austroads below which capacity analysis is unnecessary.

Major Road Flow	*Minor Road Flow*
400vph	*250vph*
500vph	*200vph*
650vph	*100vph*

   Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.

2. **Traffic apportioning and clarity**

   Will add to report as suggested by City.

3. **Upgrade trigger/threshold**

   GHD have undertaken a staging analysis (looking at 25% and 50% development horizons). This analysis has been included into the body of the report.

4. **Cost apportioning should be b-a/b**

   Noted will add to report.

5. **Involvement of Main Roads. Confirm consultation.**

   Will add to report.

6. **Consistency, Wanneroo Rd/Celestine not recommended for signals in Appendix. Remove mention of traffic signals.**

   Noted re Wanneroo Rd/Celestine will amend report.

7. **Cost estimates**

   Will prepare conceptual design for each location following CoW confirmation of agreed measure.

   Six designs allowed for in tender.

Main Roads Transport Modelling team comments:

- **The greatest strength of Paramics is its dynamic assignment. This works to reroute traffic in response to congestion. However, the two models developed by GHD have little to none sensible route choices available, (acknowledged in sections 3.7). Furthermore SCATS is showing little congestion is occurring around this area (low saturation flow rates). This means traffic assignment becomes redundant. In my opinion, if you are building a model without route choice and with standard (4 leg & 3 leg) signalised intersections, Paramics isn't necessary, you might as well stick with SIDRA.**

  GHD Response
  It is agreed that the networks being assessed have little logical alternate route choices (and no route choice at all in the case of the Wanneroo study network). However, one of the biggest drawbacks of using SIDRA analyses only is that the interaction and impact of upstream and downstream intersections cannot be efficiently considered. The microsimulation model enables the network to be considered as an integrated system and the interaction between junctions can be evaluated. In the case of the corridor network of the Wanneroo study area, the impact of queuing, vehicle platooning and signal co-ordination was easily considered within microsimulation framework. Additionally, the ability to visual see the simulation model in operation enables a greater understanding (particularly to non-technical persons) of the anticipated network performance.

- **GHD have used fixed time signals rather than vehicle actuated signals. If traffic demand increases dramatically in the 2031 scenarios, the signal phasings may need to be modified.**

  GHD Response
  During the 2031 scenario testing phase times were modified from the existing times to account for change in volumes, if required. Sidra models were initially run to obtain the starting point for signal operations, and then modified further through inspections of the models in operation.

- **Heavy vehicles have been considered which is good.**

- **The reports are not clear whether or not public transport (bus routes) have been considered.**

  GHD Response
  Bus routes were not coded into the models, as public transport operations were not critical to the traffic model component of the study.

- **The calibration results are excellent. However this isn't surprising given the models have limited route choice.**
  GHD Response
  Agree, given the study area neworks a high level of calibration could be reasonably expected.

- **The travel time validation criteria is stated as "*Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).*" I am not sure where this criteria has come from. Is a reference available?**

  GHD Response
  This travel time validation criteria is from the Design Manual for Roads and Bridges (DMRB) (prublished by Highways Agency, UK) and is also stated within the latest RMS (previously RTA) Traffic Modelling Guidelines (to be officially released shortly).

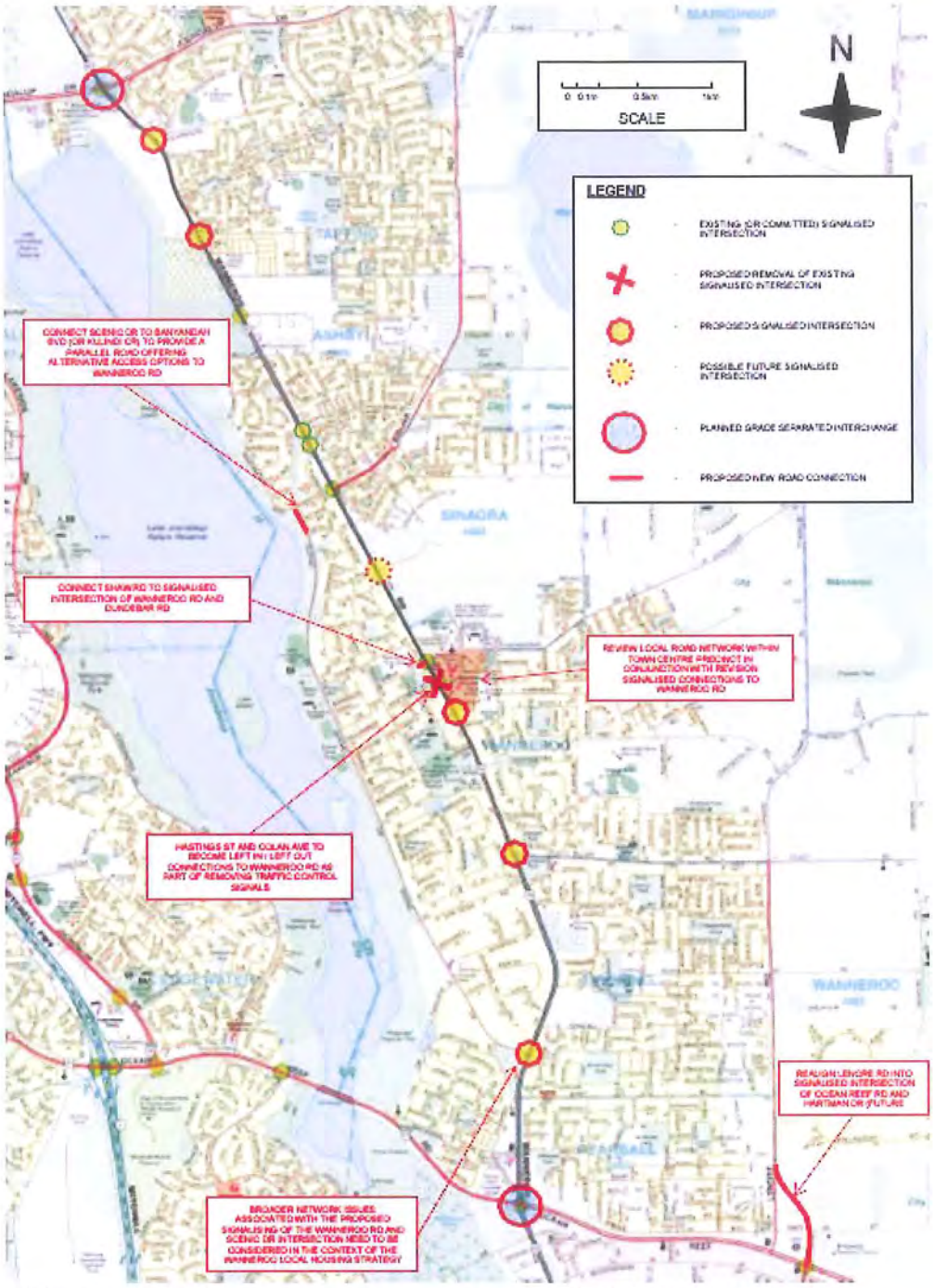
- **The report is not clear whether the observed journey times where measured once each, or are averaged over multiple runs. Best practice is to measure multiple journey times on site, and then calculate both an average and a confidence interval for each journey (as per the RTA guidelines).**

  GHD Response
  Observed travel times were the result (average) of multiple runs of a floating car travel time survey. The Wanneroo study area consisted 5 recordings for each direction and the Girrawheen study area 2 recordings for each network section (Note, there were 14 sections in total).

- **GHD have used an Azalient Ceejazz plugin which isn't owned by Main Roads. This means the model runs cannot be run by Main Roads (unless we purchase a plugin of our own)**
  GHD Response
  These plugins enhance the functionality of the core simulation software (and are available from Azalient at a modest cost).

- **Sections 5.3 demonstrates that the model is stable (no gridlocking) which is good.**

A copy of Main Roads preferred signal strategy for Wanneroo Road and road network option is shown overleaf.



WANNEROO HOUSING PRECINCT - POSSIBLE ALTERNATIVE ROAD NETWORK OPTION 1

MAIN ROADS Western Australia
Wanneroo Local Housing Strategy – Possible Alternative Road Network Option 1

GHD

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\\ghdnet\ghd\AU\Perth\Projects\61\28180\WP\128871.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S McDermott S Bennet	P Fisher	*Paul Fisher*	P Fisher	*Paul Fisher*	*21-1-2013*

www.ghd.com

City of Wanneroo

Wanneroo Housing Precinct
Traffic Impact Assessment

January 2013

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Appendices

1. Introduction

The City of Wanneroo is proposing increases to R Coding in the Wanneroo Housing Precinct. This will result in a significant increase in the number of dwellings and population in this area, which will impact on the number of trips generated.

A plan showing the location of the Wanneroo Housing Precinct is shown in Figure 1-1 and Figure 1-2.

As a result, a traffic impact assessment (TIA) is required for the road network to satisfy MRWA and Department of Planning and for the local road network which is the City's responsibility. The broad requirements of the TIA are identified as follows:

- Assess impacts of this additional traffic on the immediate regional road network as well as the local road network.
- Recommend improvements which may be required to those road networks to address the impacts.
- Estimate for each of these improvements, the proportion of that improvement which can be considered attributable to the density increases in the Wanneroo Precinct, as distinct from population and traffic increases occurring in the wider region.
- Estimate costs for the undertaking of each of the recommended road network improvements and then applying the proportions estimated to each cost estimate.

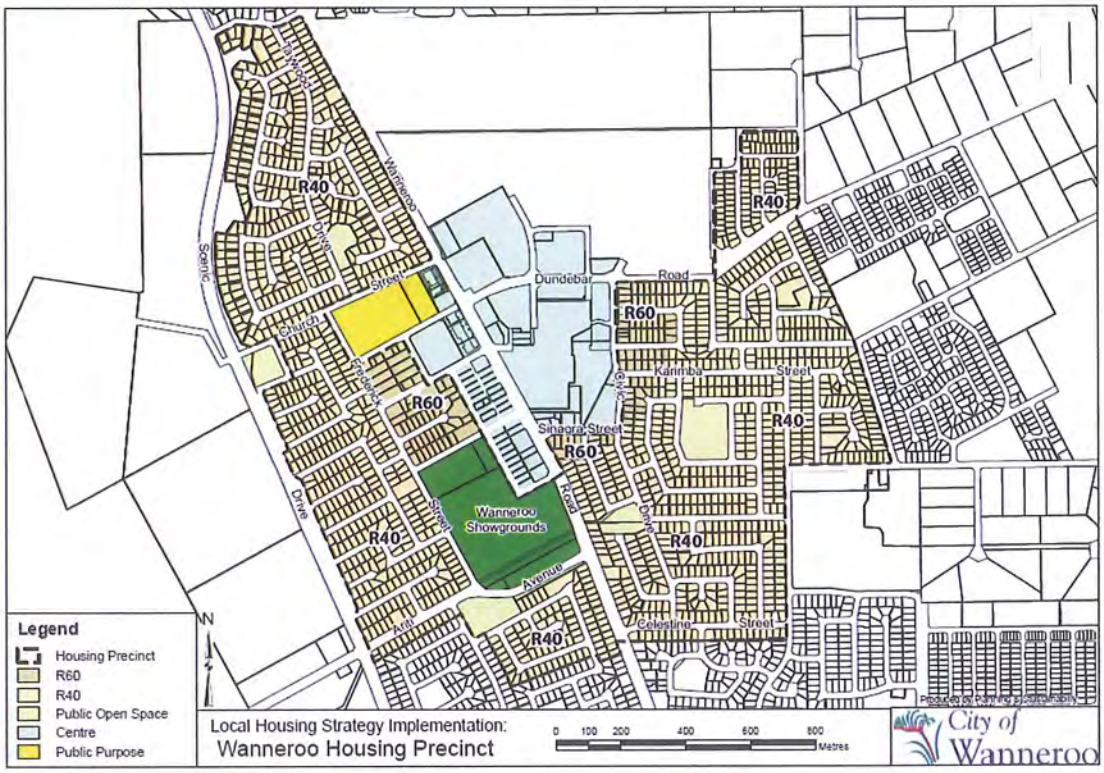
1.1 Scope of work

The following scope of work has been undertaken:

- Land Use Input to Main Roads Regional Operations Model (ROM) to allow Main Roads to model the increased densities.
- Undertake localised modelling.
- Undertake Sidra intersection analysis for the following scenarios:
  - Existing layout to 2031, no local housing strategy (LHS) forecast traffic volumes
  - Proposed layout using future traffic volumes 2031 with LHS
- Make recommendations for road network improvements.
- Prepare concept designs for improvements.
- Prepare cost estimates.
- Apportion costs based on ROM modelling.
- Review Wanneroo Town Centre area local traffic study.
- Prepare final report.

Figure 1-1 General location of study area

Figure 1-2 Housing strategy area



2. Stakeholder liaison

2.1 City of Wanneroo

The following summarises the consultation with the City of Wanneroo.

- An inception meeting was held with Planning Officers at the City of Wanneroo. The following was discussed.
  - Base aerial photo, high res. - Council will arrange.
  - Traffic data - Planners were liaising with Council's engineers and will provide any available information.
  - Intersection Counts – Main Roads have been asked for SCATS info at all relevant signals. GHD will need to arrange others up to the provisional sum value.
  - Council were asked for their construction rates for our subsequent costing of measures.
  - Council can provide suitable base for any conceptual design.
  - Shawmac report for Wanneroo Town Centre has been provided.
  - GHD's Planning Officer to follow up with Council regarding Structure Plans.
  - Council were advised GHD can provide estimate of costs for land acquisition (based on Council advice regarding land costs), design costs and survey costs. However we cannot provide costs for services implications only flag issues. Council were advised that costing for relocation, protection etc is impossible at this stage. GHD will flag issues based on One Call Info and allow a contingency based on experience elsewhere (subject to exclusions and qualifications).
  - Council advised that the contact for liaison with DoT is Mohsin Mutaqui.
  - Council advised that the contacts at Main Roads are John Van Luen, David van Den Dries, Wes Soet (Modelling)

Council advised recent road upgrades include:

  - Pinjar Rd/Wanneroo Rd signals
  - Dundebar Rd/Wanneroo Rd, double right turn from Dundebar Road is underway.
  - There are plans for Wanneroo Rd north of Dundebar Rd.
  - Wanneroo Rd (Ashby to Tapping recently upgraded)
  - Grade separation of Ocean Reef Rd/Wanneroo Rd long term plan (discuss timing with Main Roads)
  - Ocean Reef Road now connects with Gnangara Road.

Council confirmed:

  - Important to look specifically at traffic volume increase within the precincts of Wanneroo and Girrawheen - Koondoola and their impacts.
  - East Wanneroo to be included as per brief.
  - Keep client advised of progress and any issues.
  - Council were advised of likely delays in ROM modelling turnaround in view of Main Roads commitments in this area.
- The City was consulted regarding the content of the land use input to the ROM model and asked for acceptance of the results prior to asking Main Roads to run the ROM model

2.2 Main Roads Western Australia (MRWA)

Contact was made with Main Roads as follows:

- Main Roads was contacted for base traffic data including:
  - SCATS information
  - ROM model traffic zones for land use input
  - Traffic signal information
- Main Roads was also consulted regarding confirmation of the extent of Paramics modelling and ROM areas to be modelled.
- Main Roads was asked to advise of any road upgrades planned in the future and GHD were advised that no works were planned that would impact on this study.

2.3 Department of Transport (DoT)

Contact was made with DoT regarding the East Wanneroo North-South Road (EWNSR) and the following provides a summary of the current status:

- Department of Planning has completed a route alignment study for the East Wanneroo N-S Road between East Wanneroo and Tonkin Highway. There is more work to be done.
- The route will be a freight route and Primary Regional Road.
- The route is justified within the study.
- This has now been handed over to Main Roads. (Lindsay Broadhurst/Justin McKirdy)
- The N-S route will connect with Tonkin Highway along the new section of Hepburn Avenue.
- There will be no connection to Marshall Road; this will be a fly over.
- EWNSR joins Perth Darwin National Highway north of Reid Highway. There will be an interchange at Hepburn Ave.
- There will be an interchange at N-S Road/Reid Highway/Tonkin Highway
- The treatment and intersections of Beechboro Road is uncertain at this stage.
- The N-S road is likely within 20 years and may or may not include grade separation in the first stage.
- The will be no connection to Hepburn Avenue (new N-S Route) permitted.
- Main Roads will probably commence their Planning Study in 2012 and anticipate this will take 12-18 months to complete.

3. Literature review

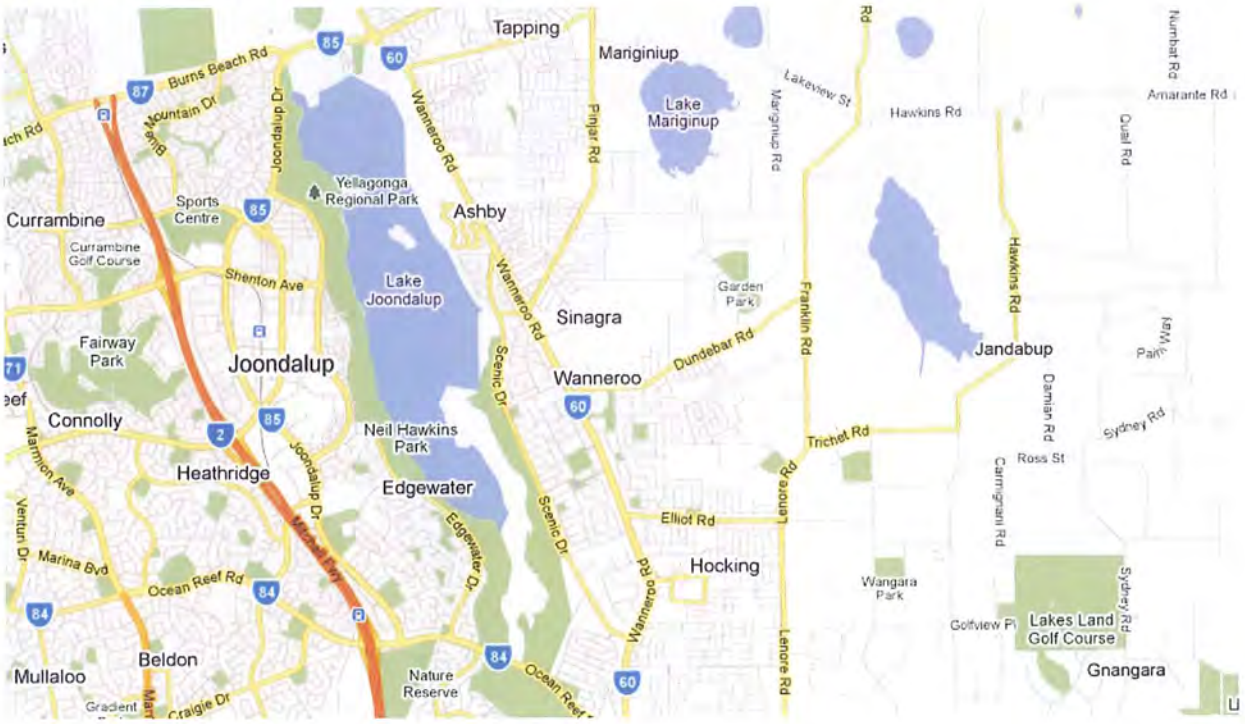
3.1 Transport assessment – Wanneroo town centre, (22 September 2011)

The City of Wanneroo has previously engaged Shawmac to undertake a local traffic study for a section of the Wanneroo town centre area.

3.1.1 Study area

The study area for the Wanneroo Town Centre Transport Assessment is shown in Figure 3-1.

Figure 3-1 General location of study area



3.1.2 Road hierarchy

Figure 3-2 identifies the existing road hierarchy

- Light Blue – Primary Distributor
- Green – District Distributor A
- Dark Blue - District Distributor B
- Brown - Local Distributor

Figure 3-2 Road hierarchy

3.1.3 Future road network

The road network will be expanded as shown in Figure 3-3 to accommodate planned development i.e Roads 1 to Road 7.

Figure 3-3 Future road network in Wanneroo town centre

3.1.4 Regional considerations

The Department of Planning, Urban Transport Systems Directorate commissioned a planning study entitled North West Corridor Structure Plan Review - Strategic Assessment of Regional Transport Requirements (2009) which was conducted in the context of the proposals for residential, industrial and commercial developments in the Region such as St. Andrews, Alkimos-Eglinton, Neerabup Industrial Area and East Wanneroo. These developments are

expected to generate substantial traffic and will therefore have a significant impact on transport infrastructure and service requirements in the North West Corridor.

This study recommends Wanneroo Road to remain as four lanes, with provision for bicycle and public transport as required. This study also recommends additional north south traffic capacity along Lenore-Franklin Roads and a new high standard road east of East Wanneroo.

3.1.5 Proposed road hierarchy

The report recommends the road hierarchy shown in Figure 3-4.

Figure 3-4 Proposed road hierarchy

3.1.6 Conclusions and recommendations

The report provides the following conclusions and recommendations:

- Based on an expected trip generation rate, it is estimated that the WTC will generate approximately 11,000 trips per day and attract approximately 27,800 trips per day. Assuming a distribution based on predicted desire lines based on the MRWA OD Matrix it is expected that flows on Dundebar Road could increase to approximately 21,800 vehicles per day (vpd) near the intersection with Wanneroo Road.
- It is anticipated that the intersection of Wanneroo Road and Dundebar Road will be at a level of service F in peak hours if two lanes per carriageway on Wanneroo Road is maintained. The upgrading of this intersection and the section of Wanneroo Road adjacent to the intersection is currently being investigated by State Government agencies.
- The future development scenario of East Wanneroo envisages that the road alignment of Franklin - Lenore Road will be upgraded to a dual carriageway 4-lane cross section with medians and turn pockets. Existing roads and intersections except the intersection of Wanneroo Road and Dundebar Road are predicted to perform satisfactorily under the increased traffic load and no upgrading of existing infrastructure is required.

- The future widening of Wanneroo Road between Dundebar Road and Wallawa Street currently under investigation may require additional land area east of Wanneroo Road as road reserve; and if this proposal proceeds the development land area will be reduced.
- The proposed mixed use development fronting Wanneroo Road will be accessed from lane ways servicing the lots and connect to local side roads. No new crossovers will be created for these developments.
- Roundabout on Neighbourhood Connectors can be supported on the grounds of moderating operating speed and improve safety. Intersections within the Residential Precinct can be configured as unchannelised intersections without loss of serviceability.
- Footpaths network are recommend for all local roads within the Residential Precinct given the density of the development and to encourage residents to walk to WTC and access public transport services.
- A shared footway is to be provided on Friars Drive linking the Residential Precinct with the adjacent development area in Sinagra.

3.2 Planning documents

GHD has reviewed planning documents as follows:

- Mirrabooka Local Area Plan
- City of Wanneroo Local Housing Strategy, Estimated Rates of Development of New Dwellings in Wanneroo and Girrawheen-Koondoola Precincts.
- Wanneroo Local Area Strategy Plan, Planning and Sustainability, Local Planning Policy Framework, Local Planning Policy 3.1: Local Housing Strategy Implementation.

4. Land use update

4.1 Planning investigation

Main Roads Western Australia has provided GHD with details of the traffic zones within the ROM model for the study area including a 1km buffer around the Wanneroo Housing Precinct.

GHD's Planners have updated the landuse for each of the traffic zones following a review of local structure plans, relevant planning documents, liaison with the City of Wanneroo and Main Roads Western Australia. The City of Wanneroo have reviewed and agreed the planned landuse inputs and assumptions.

A spreadsheet showing the content of the ROM traffic zones for 2031 with and without the R Code Increases is shown in Appendix A.

Main Roads WA has subsequently run the ROM model incorporating the increased R Code for use in the transport assessment for the Wanneroo Housing Precinct.

The land use inputs include:

- Population.
- Occupied dwellings.
- Households.
- Manufacturing, commercial and retail employment numbers.
- School attendee numbers.

The Paramics model also includes the increased R codes and ROM output and is discussed further in Section 5.

5. Network modelling

A localised network model of the central Wanneroo area was required in order to assess the impacts of forecast traffic volumes. The development of models simulating both 'with density increase' (with LHS) and 'without density increase' (without LHS) scenarios was undertaken to allow a clear comparison to be drawn that isolates the traffic impacts attributable to the proposed changes in R-coding.

Paramics microsimulation traffic modelling software has been used in conjunction with Azalient Ceejazz plugins.

5.1 Localised network modelling study area

GHD has developed models that include the key Wanneroo Road corridor, and its intersections with the following:

- Pinjar Road.
- Church Street.
- Dundebar Road.
- Celestine Street.
- Ariti Avenue; and
- Elliot Road.

The modelled network is displayed in Figure 5-1.

Figure 5-1 Simulation model network

5.2 Base models

Base models were initially developed to represent the current on-site conditions through the study area. These AM and PM peak models were calibrated to traffic volume data and validated against recorded on-site sectional travel times to ensure they provided a comprehensive representation of the existing conditions.

A detailed model validation report has been prepared which documents the inputs, methodology, and results of the base model development and calibration. This validation report is attached as Appendix B The key elements of the validation process are summarised below.

5.2.1 Data inputs

The key data sources and inputs into the base model included the following:

- Traffic volume data: Data included manual turning movement surveys, SCATS detector loop counts and historical tube counts.
- Traffic signal information: SCATS data was sourced from Main Roads (including IDM files, Traffic Control Signal (TCS) graphics and intersection timing charts).
- Travel time data: Sectional travel times were recorded for the key sections along Wanneroo Road; and
- ROM outputs: Main Roads provided strategic model sub-area trip matrices from the ROM.

Public transport data i.e. bus routes, were not coded into the model network as operationally they were not considered critical to the traffic modelling component.

5.2.2 Base trip matrices

Trip matrices for both the AM and PM periods were developed by combining the known turning movement volumes (from recent surveys) with the routing patterns and trip distributions obtained from the ROM sub-area cordon outputs. These trip matrices were refined and entered into the simulation model as demand inputs. (Further information regarding the trip matrix developed is in Appendix B).

5.2.3 Calibration/validation results

Each recorded turning movement count was compared against the equivalent model output to assess whether the model was representing on-site conditions. The statistical GEH measure was used as the primary acceptance criteria (the GEH statistic is explained in detail in Appendix B), whereby comparisons should produce a GEH value less than 5 to be considered a reasonable fit. Table 5-1 summarises the AM and PM Base model calibration results. Modelled results are the average of five seed runs.

Table 5-1 Base model turning volume calibration results summary

Time Period	Number of Observations	Observations with GEH < 5	Average GEH	R2 and Slope	Exceeds Criteria?
AM Peak	40	40 (100%)	1.53	0.99, 1.039	Yes
PM Peak	40	40 (100%)	1.19	0.99, 0.969	Yes

Travel time recordings were also compared against the modelled equivalent as a validation check following the traffic volume calibration process. Modelled travel times within 15% or 1 minute of the recorded time were considered to represent a reasonable fit. This validation criteria is adopted from the Design Manual for Roads and Bridges (DMRB) (and is also stated

within the latest RMS NSW Traffic Modelling Guidelines, to be release shortly). Table 5-2 summarises the AM and PM Base model travel time validation results. It should be noted that observed journey times were the result (average) of multiple runs of a floating car travel time survey (5 recordings for each direction for each time period).

Table 5-2 Base model travel time validation results summary

Time Period	Number of recorded travel time sections	Observations within 15% or 1-minute	Exceeds Criteria?
AM Peak	6	6 (100%)	Yes
PM Peak	6	6 (100%)	Yes

Both the AM and PM Base models were found to represent observed on-site conditions closely, and were hence considered a robust platform against which to assess the future year scenarios.

Shared model space: Wanneroo and Girrawheen

It should be noted that this Wanneroo model network has been developed at the same time as a Girrawheen study area model has been developed also for City of Wanneroo. Given the close proximity of these two areas, the two models have been developed within the same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

5.3 Forecast traffic volumes

5.3.1 Trip matrix

The calibrated base model trip matrices were taken as the starting point for determining the forecast 2031 demand matrices. AM and PM peak hour periods were analysed separately. The methodology implemented was as follows:

- The base model demand matrices were factored based upon the updated ROM outputs.
- Trip attractions and productions for individual zones based upon the existing, and proposed, land uses were assessed and applied to the corresponding zones within the simulation model network.
- The movements to/from zones within the Paramics model (which represent roads connecting into the study area) were consequently scaled based upon the revised land uses of the areas feeding these road connections.
- The escalation of trip attractions and trip productions were applied separately and the resulting demand matrix balanced to ensure any changes to distributions were incorporated into the 2031 matrices.

The above process was applied for the AM and PM peak hour matrices for the 'with LHS' and 'without LHS' scenarios.

ROM outputs

Main Roads' Regional Operations Model (ROM) data was provided as a sub-area cordon trip matrix for the alternate scenarios. The coarseness of the zone structure as well as the 24-hour time period which ROM operates meant that the outputs were not used as a direct input into the simulation model. Instead the ROM outputs were used to evaluate the magnitude of forecast trip volume escalations as well as providing an initial distribution of trips across the study area.

Main Roads incorporated the revised and updated lane use figures (discussed in Section 4) for the alternate scenarios into ROM, and subsequently provided the corresponding 2031 trip

matrices for the with and without LHS options. These outputs were then used in the simulation model trip matrix development as described above.

Development north of Dundebar Road

The proposed development north of Dundebar Road and east of Wanneroo Road (including Wanneroo Town Centre) is expected to generate a substantial volume of traffic once developed. This development has been included into the updated land use forecasts and consequently into ROM. Accordingly, the forecast 2031 traffic volumes used for the simulation modelling (for both with and without LHS scenarios) include the trips associated with this development area. It is noted that a previous study has focussed specifically on the proposed Wanneroo Town Centre residential development (*Transport Assessment – Wanneroo Town Centre, Wanneroo, Shawmac, September 2011*). For the purposes for the simulation modelling to assess the network impacts expected to occur due to the broader increase in housing densities, the Wanneroo Town Centre trips needed to be included into the forecast trip matrix development.

Connections from the proposed development area onto Wanneroo Road do not currently exist, as such the movements to and from this area could not be calibrated or recorded as part of the Base modelling. Also, the ROM zone for the development area in question connects onto the wider network through a single connector onto Dundebar Road. A review of the aforementioned traffic report (Shawmac, September 2011) revealed that the proposed development traffic would access the broader area via not only Dundebar Road, but also Wanneroo Road (through a new direct connection and intersection) and Pinjar Road. For the purposes of the trip matrix development it was assumed that half of the new development traffic would connect onto Dundebar Road, with the remaining movements shared equally between Wanneroo Road (through a new intersection) and Pinjar Road.

5.3.2 Turning movement volumes

Following the determination of trip matrices, the corresponding forecast turning movement volumes were then analysed. The 2031 turning movement volumes were determined by applying the demand files (trip matrices) to the simulation network and recording the turning movements. The resulting 2031 forecast turning movement volumes for key intersections within the study network are presented in Appendix C. These display the forecast AM and PM volumes for both the 'with LHS' and 'without LHS' scenarios.

5.4 Scenario testing

A sequential and staged approach was implemented for the various scenario tests to assess the impact to the road network with, and without, the increased R-coding ratings i.e. with/without the local housing strategy (LHS) in place. Consequently the following scenarios were assessed within the simulation model (note, the following scenarios all consisted of a 2031 horizon year):

- Existing network (plus currently planned modifications) 'without LHS' volumes;
- Existing network (plus currently planned modifications) 'with LHS' volumes;
- Suggested network upgrades to facilitate 'without LHS' volumes;
- Suggested network upgrades for 'without LHS' with 'with LHS' volumes; and
- Suggested network upgrades to facilitate 'with LHS' volumes.

Known and committed network upgrades

It is understood that there are currently plans to upgrade the intersection of Wanneroo Road and Dundebar Road to include a double right turn from Dundebar Road to Wanneroo Road. As this modification is believed to be committed, it has been included in the future 'existing network'

scenario tests. Accordingly these scenarios have been referred to as 'Do-Minimum' (DM), which represents the existing on-site network configuration plus the double right turn from Dundebar Road to Wanneroo Road.

5.4.1 Methodology for capacity enhancements

The process adopted to determine the network upgrades necessary to provide an acceptable level of service under the various scenarios, was as follows:

- Forecast traffic volumes were initially applied to the existing network configuration without any upgrades or capacity enhancements.
- The models were visually observed in operation to assess performance.
- Key areas of deficiencies within the network were identified, i.e. areas exhibiting substantial congestion or oversaturated conditions.
- Signal operation adjustments or refinements were implemented to improve the efficiency of the network. That is, congested conditions within the network were initially attempted to be resolved through the refinement of signal operations in the first instance. The dynamic nature of the SCATS signalling functionality on-site would attempt to optimise signal operations in a similar manner. Furthermore, adjustments to signal operations were preferable over capacity increases requiring infrastructure works.
- The performance of the network was evaluated through quantitative model outputs and qualitative model observations to determine where network capacity increases were required.
- Network upgrades were implemented into model network and then the assessment process repeated. That is, visual observations of the simulation model combined with quantitative outputs were used to evaluate the proposed intersection and mid-block modifications. Throughout the iterative process of determining required intersection upgrades, a level of service (LOS) D was targeted as the junction performance measure.

During this process, selected Sidra models were developed to assist with determining necessary upgrades. These Sidra models were used to determine broad capacity requirements and suggested signal operations, which were then taken into the Paramics microsimulation model and assessed as part of an integrated and connected road network.

The process described above was undertaken in an iterative manner to account for the fact that deficiencies within the network were not always initially identifiable. Due to the integrated network of intersections within the simulation model, congestion at neighbouring intersections can obscure or mask the actual performance of a given site. As such, the process above was conducted iteratively do address the most critical areas of concern first.

Following the simulation model scenario testing, and identification of broad network upgrade requirements, comprehensive Sidra models were run and analysed for the key sites throughout the network. These are discussed and presented in detail in Section 6.

- The modelling process outlined above was undertaken to determine the following;
- The upgrades likely to be required by 2031 assuming no change to current R-code ratings or density levels i.e. without implementation of the local housing strategy; and
- The further upgrades likely to be required if the local housing strategy is implemented and R-coding designations are increased to allow higher density developments.

The resulting suggested upgrade requirements from the modelling assessment were as follows for the scenario ***without LHS***:

- Wanneroo Road; Additional lane in each direction i.e. three lanes northbound and southbound, between Pinjar Road and Sinagra Street.
- Wanneroo Road/Pinjar Road; Double right turn from Wanneroo Road into Pinjar Road (i.e. south to east), double left turn from Pinjar Road to Wanneroo Road (i.e. east to south) and extended right turn lane (east to north). Southbound approach flaring to three through lanes.
- Signalisation of the following junctions with Wanneroo Road: Church Street, Ariti Avenue.

It is noted Main Roads do not support these measures and prefer a reconfiguration of access arrangements within the Town Precinct. Warrants for traffic signals at Ariti Avenue are not met as alternative access is available. .

Signalisation of Wanneroo Road/Elliot Road. (Main Roads feedback is discussed further in Section 6).

New signalised intersection connecting into the area to be developed on the eastern side of Wanneroo Road, north of Dundebar Road.

It is noted Main Roads do not support this measure and comment as follows:

"Future development of the land north of the Wanneroo town site in Sinagra will likely necessitate a new connection to Wanneroo Road. The report suggests Road 2, connecting Wanneroo Road opposite Hart Court, should be signalised. Main Roads does not support this suggestion due to its proximity to Church Street and Dundebar Road intersections. Planning work associated with the Wanneroo Road MRS amendment suggests a more appropriate location for a new connection may be within the vicinity of the existing Inghams Enterprises entrance. This location would be preferable to the Road 2 location because it will result in a more efficient arrangement of access along Wanneroo Road. Nevertheless, at a spacing of approximately 500m from up and downstream signalised intersections, such an outcome would be detrimental to the operation of Wanneroo Road. Consideration of implementing a parallel road connecting Pinjar Road and Dundebar Road may reduce the demand for this new connection and allow the proposed land development to access Wanneroo Road via existing signalised connections"

Main Roads Western Australia

Section 6 of this report considers the operation of Pinjar Road/Wanneroo Road and Dundebar Road/Wanneroo Road intersections, the analysis indicates these intersections will be under pressure even without higher densities. It will be important to maintain at least left in/out to Wanneroo Road from any new access to Wanneroo Road. Analysis assumes a signalised intersection at Road 2 but the concerns of Main Roads regarding the proximity to other signalised intersections are acknowledged.

Main Roads also wish to promote the use of the Lenore Road/Franklin Road and the proposed East Wanneroo North-South Route. It is considered that traffic is likely to divert to this route as congestion increases on Wanneroo Road.

- Wanneroo Road/Dundebar Road; Double right turn lanes into and from Dundebar Road, extended left turn lane into and out of Dundebar Road.

Main Roads feedback is discussed further in Section 6.

Signal adjustments as required, i.e. phase times and some cycle times, to cater for changed traffic volumes/movements. Removal of 'all-pedestrian' phase at Wanneroo Road/Hastings Street/Conlan Avenue. The intention is not to remove all pedestrian movements; rather remove them from one crossing leg only, and to remove the scatter-phase (i.e all-ped phase).

Additional upgrades required to facilitate the 2031 ***with LHS***:

- The analysis has shown Wanneroo Road/Celestine Avenue would benefit from upgrading. (However, an alternative approach would be to encourage use of alternate routes as per Main Roads comment discussed further in Section 6)
- Signal adjustments as required.

It should be noted that the suggested upgrades above did not consider the available land on-site at these locations. The proposed configurations represent the ultimate junction layouts which would provide an acceptable level of service based upon the forecast traffic volumes. Consideration has been given to site constraints during the detailed intersection assessments discussed in Section 6.

The modelled intersection configurations of the three scenarios (i.e. Base, upgrades without LHS and upgrades with LHS) are presented in Appendix D.

5.5 Model results

Each scenario model was run five times with different seed values and the results extracted from each model. Statistical outputs were then averaged across the five seed value runs.

Results are presented in the sections below and show comparisons across the different scenarios for the following statistical outputs and performance measures:

- Intersection levels of service (LOS);
- Blocked (unreleased) vehicle summary for each zone; and
- Modelled travel time recordings for key routes through the network.

In addition to the quantitative results listed above, video files of the simulation models in operation have also been produced.

The result summary tables in the sections below display the following abbreviated scenario names:

- **BASE**: Existing conditions as per the calibrated Base model (current 2012 volumes).
- **DM w/o LHS**: Existing network i.e. Do-Minimum (DM), 'without LHS' volumes.
- **DM w/ LHS**: Existing network i.e. Do-Minimum (DM), 'with LHS' volumes.
- **NU w/o LHS**: Suggested network upgrades (NU) necessary to facilitate 'without LHS' volumes.
- **NU w/o LHS, w/ LHS vols**: Suggested network upgrades (NU) for 'without LHS', but modelled with 'with LHS' volumes.
- **NU w/ LHS**: Suggested network upgrades (NU) to facilitate 'with LHS' volumes.

Level of Service

The key statistical performance measure which has been used to evaluate the network and individual junctions is delay, which has subsequently been converted into a level of service (LOS). The intersections which have been analysed using the simulation model include a mixture of signalised and priority controlled sites. The average approach delay thresholds and corresponding LOS categories which have been utilised are as shown in Table 5-3.

Table 5-3 Level of service/delay categories

Level of Service	Signals	Priority Control
A	0s – 10s	0s – 10s
B	10s – 20s	10s – 15s
C	20s – 35s	15s – 25s
D	35s – 55s	25s – 35s
E	55s – 80s	35s – 50s
F	80s+	50s+

Table 5-4 outlines the recorded LOS for the AM peak scenario tests.

Table 5-4 Intersection level of service results: AM peak

	BASE	DM w/o LHS	DM w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Wanneroo Road / Dundebar Road	C	D	F	C	C	C
Wanneroo Road / Pinjar Road	B	F	F	C	C	D
Wanneroo Road / Hastings Street / Conlan Avenue	C	E	D	B	B	B
Wanneroo Road / Church Street	B	E	F	C	C	C
Wanneroo Road / Ariti Avenue	B	C	D	A	B	B
Wanneroo Road / Celestine Street	A	B	C	C	F	C
Wanneroo Road / Elliot Road	A	D	F	B	B	A

Table 5-5 outlines the recorded LOS for the PM peak scenario tests.

Table 5-5 Intersection level of service results: PM peak

	BASE	DM w/o LHS	DM w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Wanneroo Road / Dundebar Road	B	D	D	C	C	C
Wanneroo Road / Pinjar Road	B	F	F	D	D	D
Wanneroo Road / Hastings Street / Conlan Avenue	C	F	D	C	E	D
Wanneroo Road / Church Street	B	F	D	B	B	B
Wanneroo Road / Ariti Avenue	F	F	E	A	B	B
Wanneroo Road / Celestine Street	A	A	A	A	B	A
Wanneroo Road / Elliot Road	A	F	F	B	B	B

It can be seen from Table 5-4 and Table 5-5 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with numerous sites exhibiting LOS E and F. This is due to the forecast increase in traffic volumes, irrespective of an increase in density of the residential zones within the study area. Applying the recommended network upgrades results in acceptable levels of service for both the with/without LHS scenarios. Again, it is noted that the majority of upgrades are required regardless of the proposed housing density increases.

5.5.1 Blocked vehicle summary

Blocked (or 'unreleased') vehicles occur within the simulation when the full extent of the traffic demand cannot be loaded onto the model network. These blocked vehicles occur due to

downstream network congestion or insufficient capacity on the link which connects the zone onto the model network. Blocked vehicles essentially represent the length of queue (in terms of number of vehicles) extending off the study area network.

Table 5-6 displays the modelled blocked vehicle summary for each zone across the various scenarios for the AM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-6.

Table 5-6 Blocked vehicle summary: AM peak

Model Entry Zone	BASE	DM w/o LHS	DM w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Wanneroo Road north	0	317	481	0	0	0
Pinjar Road	0	330	519	0	0	0
Church Street	0	0	76	0	0	0
Dundebar Road	0	310	418	0	0	0
Hastings Street	0	4	61	0	0	0
Celestine Street	0	0	0	0	29	0
Total	0	960	1555	0	29	0

Table 5-6 displays the blocked vehicle summaries for the various scenarios for the PM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-6.

Table 5-7 Blocked vehicle summary: PM peak

Model Entry Zone	BASE	DM w/o LHS	DM w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Wanneroo Rd north	0	161	256	0	0	0
Pinjar Road	0	178	245	0	0	0
Dundebar Road	0	1286	1395	0	76	0
Hastings Street	0	38	21	0	7	0
Conlan Avenue	0	364	624	0	55	0
Elliot Road	0	212	214	0	0	0
Wanneroo Road south	0	162	392	0	98	0
Total	0	2400	3147	0	236	0

It can be seen from Table 5-6 and Table 5-7 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with substantial numbers of trips unable to be access the network due to congestion. In particular Dundebar Road (as well as other connections onto Wanneroo Road) is expected to experience substantial congestion unless the network is upgraded.

5.5.2 Travel times

Modelled travel times for key Wanneroo Road sections have been extracted from each of the scenarios. The recorded sections are consistent with the sections recorded (and validated against) during the Base model development.

Table 5-8 shows the modelled travel time comparisons between each scenario for the AM period.

Table 5-8 Modelled travel time result (seconds): AM peak

Location	BASE	DM w/o LHS	DM w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Southbound						
Pinjar Road to Dundebar Road	100	137	264	181	192	131
Dundebar Road to Conlan Road	16	21	23	22	23	20
Conlan Road to Elliot Road	73	74	74	99	100	115
Northbound						
Elliot Road to Hastings Street	84	126	98	101	102	102
Hastings Street to Dundebar Road	28	49	39	32	32	32
Dundebar Road to Pinjar Road	79	124	120	111	129	113

Table 5-9 shows the modelled travel time comparisons between each scenario for the PM period.

Table 5-9 Modelled travel time results (seconds): PM peak

Location	BASE	DM w/o LHS	DM w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Southbound						
Pinjar Road to Dundebar Road	98	138	139	131	124	125
Dundebar Road to Conlan Road	17	14	15	24	32	33
Conlan Road to Elliot Road	72	73	73	95	95	108
Northbound						
Elliot Road to Hastings Street	96	188	116	141	192	147
Hastings Street to Dundebar Road	20	55	44	39	41	41
Dundebar Road to Pinjar Road	85	225	195	172	180	149

Observations of the travel time results presented in Table 5-8 and Table 5-9 reveal the following trends:

- All sections are expected to experience increased vehicle journey times along the Wanneroo Road corridor if no network modifications are applied; and
- Adopting the suggested network upgrades would provide the least increase in travel times through the study area. However increased journey times compared to current conditions would still be expected.

5.6 Trigger Points

A number of horizon year sensitivity tests were undertaken to determine the required staging of the suggested upgrades. Five and ten year horizons were adopted to determine the intersections requiring treatment within the short/medium term. The trigger/threshold assessments were undertaken separately for the scenarios with and without the proposed LHS. The following methodology was employed for this assessment:

- The escalation of traffic between the current (2012 Base) scenario and 2031 forecast year (i.e. 20 year horizon) was determined for without and with LHS scenarios;
- A linear escalation of the forecast traffic volume increases was assumed, such that 25% of the increase would occur over the next 5 years, and similarly 50% of the forecast increase would occur over ten years;
- The traffic demands corresponding to 5 and 10 year horizons were calculated separately for AM and PM peak periods.
- The calculated interim year traffic volumes were applied to the simulation model with the current road configuration to assess the anticipated network performance.

Table 5-10 and Table 5-11 present the modelled intersection performance results of the scenario testing without LHS and with LHS respectively.

The recommended staging of intersection treatments is discussed in Section 7.

Table 5-10 Intersection Performance – Without LHS

	5 year		10 year	
	AM peak	PM peak	AM peak	PM peak
Wanneroo Rd / Dundebar Rd	C	C	D	D
Wanneroo Rd / Pinjar Rd	B	B	C	D
Wanneroo Rd / Church St	D	D	F	F
Wanneroo Rd / Ariti Ave	B	F	E	F
Wanneroo Rd / Celestine St	B	A	B	A
Wanneroo Rd / Elliot Rd	B	A	C	C

Table 5-11 Intersection Performance – With LHS

	5 year		10 year	
	AM peak	PM peak	AM peak	PM peak
Wanneroo Rd / Dundebar Rd	C	C	E	D
Wanneroo Rd / Pinjar Rd	B	B	D	C
Wanneroo Rd / Church St	C	C	C	F
Wanneroo Rd / Ariti Ave	F	D	F	F
Wanneroo Rd / Celestine St	C	F	D	F
Wanneroo Rd / Elliot Rd	B	A	C	A

6. Intersection analysis and road network improvements

The following section considers the intersection requirements based on the forecast traffic volumes from both the Paramics modelling and ROM modelling and subsequent Sidra modelling.

The following Sidra analysis has been undertaken

- Undertake Sidra intersection analysis for two scenarios:
  - Existing layout to 2031, no LHS forecast traffic volumes
  - Proposed layout using future traffic volumes 2031 with increased R Code

A summary of all Sidra analysis for scenarios with and without LHS to 2031 is shown in Appendix E and F.

The following intersections have been analysed:

- Wanneroo Road/Dundebar Road Intersection 2031.
- Wanneroo Road/Hastings Road Intersection 2031.
- Wanneroo Road/Elliot Road Intersection 2031.
- Wanneroo Road/Celestine Road Intersection 2031.
- Wanneroo Road/Ariti Ave Intersection 2031.
- Wanneroo Road/Pinjar Road Intersection 2031.

6.1 Wanneroo Road cross section

Main Roads have provided the following comment regarding the cross section of Wanneroo Road.

"Wanneroo Road Metropolitan Region Scheme (MRS) amendment from Wallawa Street to Dundebar Road involves widening the road reservation to be consistent with the existing reserve width north and south of the Wanneroo town site. This widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area.

Further, ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded / recommended that:

Wanneroo Road consist of four lanes through Wanneroo town site, with widening for turn lanes, but accepting it will be about 10% overloaded in 2031; and

Additional north south capacity through the area is required and can be achieved by improvements to Lenore Road/Franklin Road and the proposed East Wanneroo North South Route "

Main Roads Western Australia

6.2 Intersection analysis 2031 (existing layout with no LHS)

This section summarises the analysis of the current geometry at key intersections to 2031 with No LHS. It indicates whether the existing geometry needs to be upgraded. Full analysis and intersection layouts are shown in Appendix F. Intersection layouts are not repeated here.

It should be noted that most intersections considered are forecast to require upgrade based on the surrounding traffic growth without the increased traffic generation due to the planned increased housing density.

6.2.1 Wanneroo Road/Dundebar Road intersection 2031

The analysis with no LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for some movements are greater than 3 and the degree of saturation is 1.285 to 1.517. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

6.2.2 Wanneroo Road/Hastings Road intersection 2031

The analysis with no LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for some movements are greater than 2 for some movements and the degree of saturation is 1.024 to 1.206. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

6.2.3 Wanneroo Road/Elliot Road intersection 2031

The analysis with no LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for the right turn out of Elliot Road are around 7 and the degree of saturation is up to 8. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

6.2.4 Wanneroo Road/Celestine Road intersection 2031

The analysis with no LHS indicates an intersection LoS of E/ F to 2031, for the current geometry. Stop rates for the left turn out of Celestine Street Road are around 5 and the degree of saturation is up to 2.223. Queuing is significant and unacceptable in Celestine Street. The analysis indicates that upgrade is required to improve the performance.

6.2.5 Wanneroo Road/Ariti Ave intersection 2031

AM analysis has been undertaken only. The analysis with no LHS indicates an intersection LoS of E/ F to 2031, for the current geometry. Stop rates for the left/right turn out of Ariti Avenue are around 3 and the degree of saturation is up to 1.211. Queuing is significant and unacceptable in Ariti Ave. The analysis indicates that upgrade is required to improve the performance.

6.2.6 Wanneroo Road/Pinjar Road intersection 2031

The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for some movements are in excess of 1 for a number of movements. The degree of saturation is up to 1.291. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

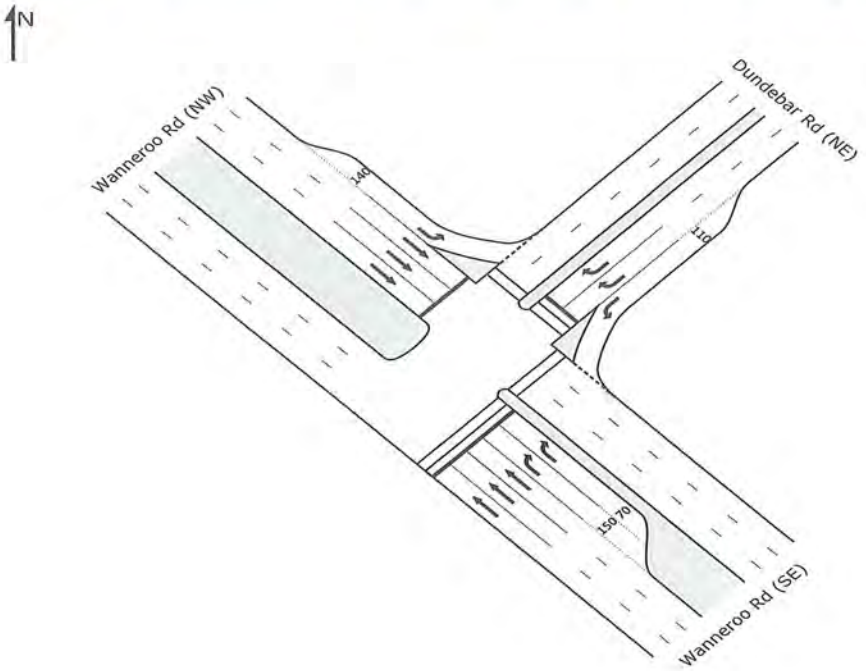
6.3 Intersection analysis 2031 (proposed layout with LHS)

Analysis has been undertaken of a modified intersection to determine the ultimate requirement to achieve a good level of service, however in view of the fact that some sites are constrained a compromise layout is provided to avoid land acquisition. All layouts are shown in Appendix F and are not repeated here, only the recommended layouts.

6.3.1 Wanneroo Road/Dundebar Road intersection 2031

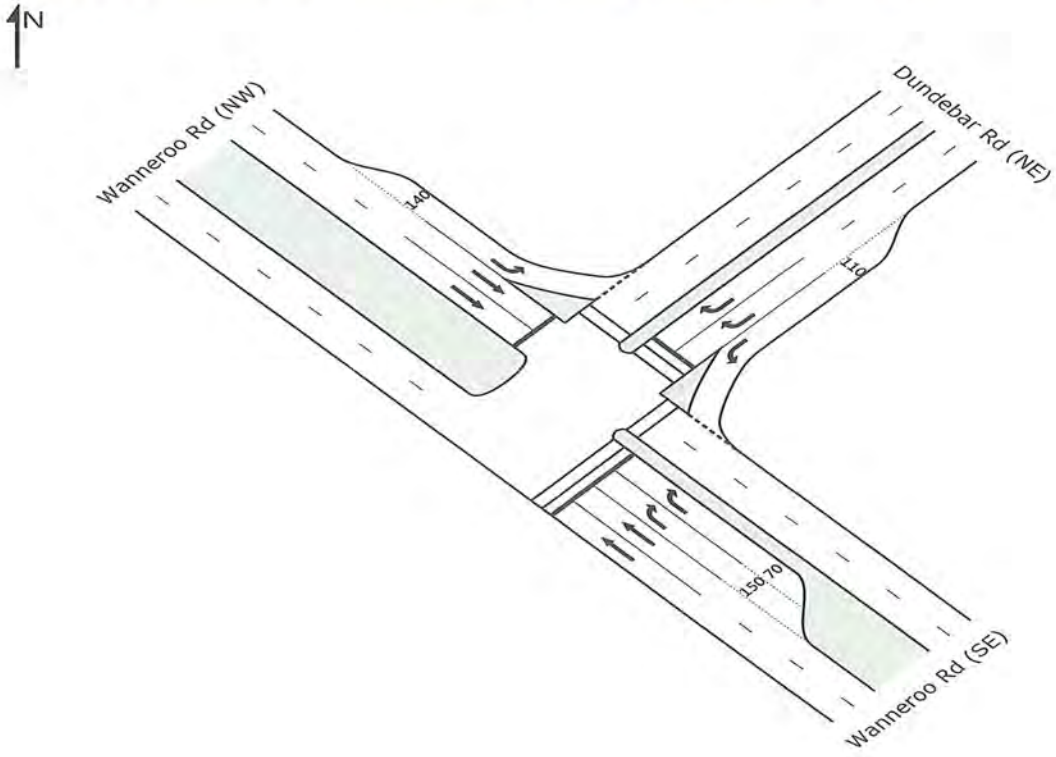
The analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031. Degree of Saturation is 0.887 to 0.898, LoS is C/D, the queue length on Wanneroo Road south is 357m and stop rate is 0.86 to 0.92. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. Figure 6-1 refers.

Figure 6-1 Wanneroo Road/Dundebar Road - ultimate design



A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. Degree of Saturation is 0.952 to 1.092, LoS is D/F, the queue length on Wanneroo Road south is 1.29km and stop rate is 0.89 to 1.38. It should be noted that a good operational; performance cannot be achieved with the compromise. Figure 6-2 refers.

Figure 6-2 Wanneroo Road/Dundebar Road - compromise design



Main Roads comment that a double right turn into Dundebar Road, whilst desirable for efficiency is unlikely to be possible due to land constraints. A concept plan would need to be prepared to confirm this layout can be accommodated.

Recommendation (if no land resumption)

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded, (preferably to include additional through lanes on Wanneroo Road.)

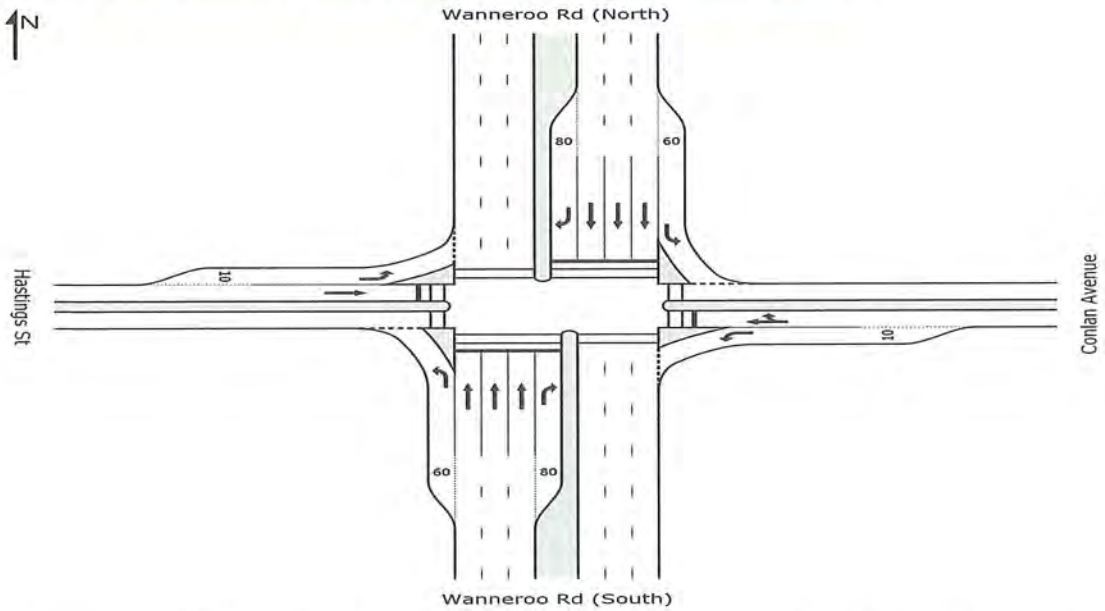
Main Roads comment is acknowledged that

> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Rd within this area".**
>
> Main Roads Western Australia

6.3.2 Wanneroo Road/Hastings Road intersection 2031

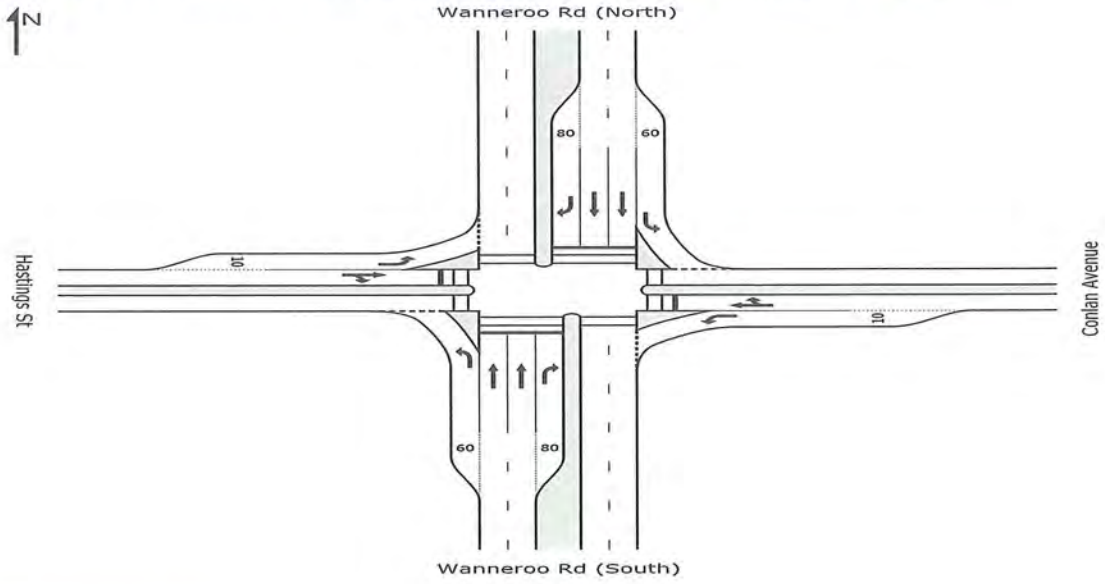
The analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031 in the am peak hour however pm operation is poor. Degree of Saturation is 0.793 to 1.117, LoS is C/F, the queue length on Wanneroo Road south is 1.025km and stop rate is 0.77 to 1.48. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. Figure 6-3 refers.

Figure 6-3 Wanneroo Road/Hastings Street – ultimate design



A compromise is to retain two lanes in each direction on Wanneroo Road to avoid land resumption however operation will be poor as indicated in the analysis, this option therefore is not recommended but is likely to be the only option in view of site constraints. Figure 6-4 refers. Degree of saturation is 1.352, LoS is F, the queue length on Wanneroo Road south is 2.62km and stop rate is 2.24.

Figure 6-4 Wanneroo Road/Hastings Street – compromise design



Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded to include additional through lanes in Wanneroo Road however if this cannot be achieved the layout as shown above could be considered. However a very poor performance is anticipated.

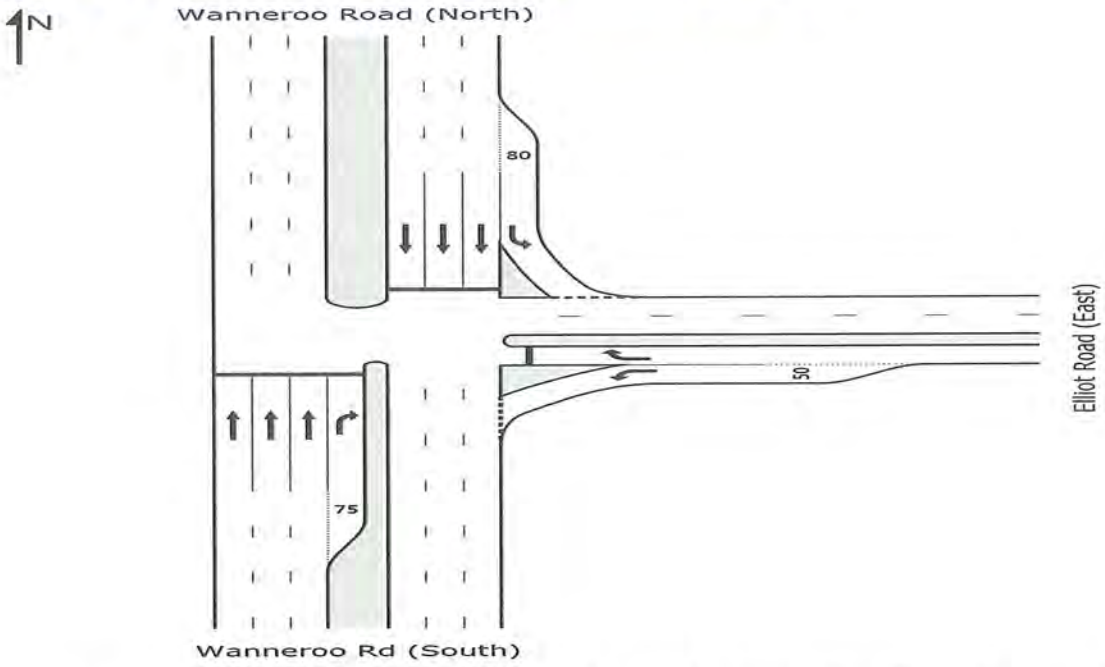
Main Roads comment is acknowledged that

> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Rd within this area"**
>
> Main Roads Western Australia

6.3.3 Wanneroo Road/Elliot Road intersection 2031

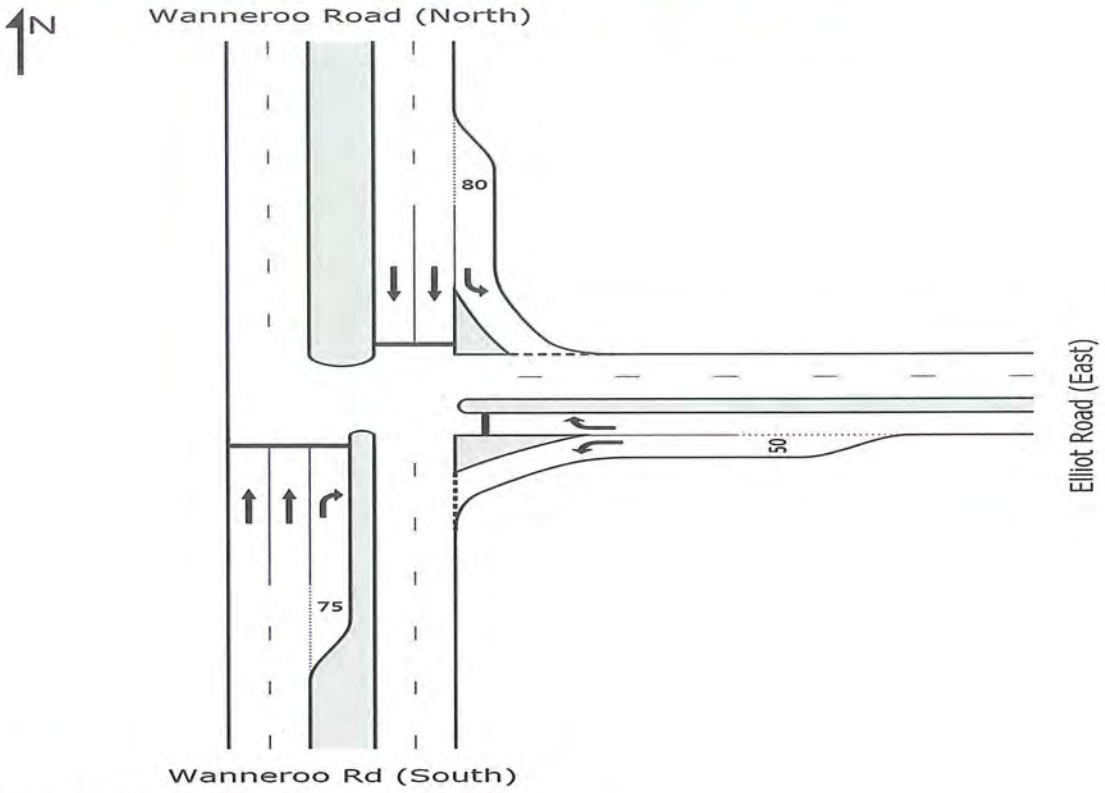
The analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. A LoS of B and stop rates of less than one are forecast. Figure 6-5 refers.

Figure 6-5 Wanneroo Road/Elliot Road – ultimate design



A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design particularly in the am peak hour. Degree of Saturation is 0.901 to 1, LoS is C, the queue length on Wanneroo Road south is 416m and stop rate is 0.87 to 0.88. Figure 6-6 refers.

Figure 6-6 Wanneroo Road/Elliot Road – compromise design



Main Roads have advised the following:

> **"Wanneroo Road and Elliot Road intersection analysis demonstrates that a reasonable level of service could be achieved for this intersection in 2031. However, it is important to recognise that modelling undertaken by Main Roads for the East Wanneroo North South Route and the East Wanneroo Structure Plan has indicated that ultimate volumes at this intersection could be three times, or more, than that analysed in the study undertaken for Wanneroo Housing Strategy. Accordingly, whilst the suggested intersection configuration may prove to be satisfactory at this time, it is highly probable that significant adjustments will be required in the future. This is likely to take the form of longer turning lanes and expansion of Elliot Road to four lanes."**
>
> Main Roads Western Australia

Recommendation (if no land resumption)

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing unsignalised intersection is upgraded to include traffic signals as indicated above.

Main Roads comment is acknowledged that

"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area"

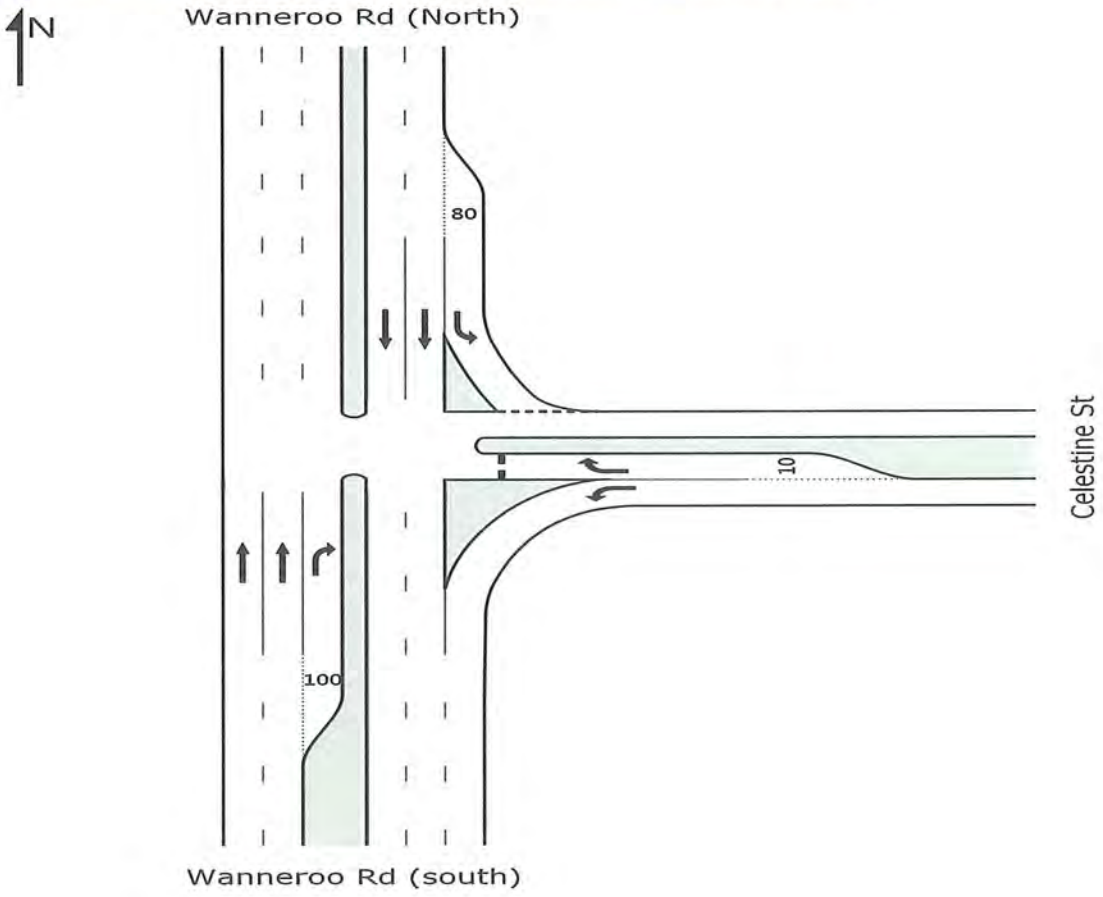
Main Roads Western Australia

Main Roads comments regarding their modelling for the East Wanneroo North-South Route are also noted and it is clear that the treatment at this intersection and of Elliot Road will need to be further considered in the future.

6.3.4 Wanneroo Road/Celestine Road intersection 2031

A number of options have been tested however a good operational performance has not been achieved. The best operation for an unsignalised intersection is indicated below and includes acceleration lanes for the right and left turns from Celestine Street. Improved performance would be gained by traffic signals however it would not be practical to signalise all side road intersections. Degree of saturation is 1.079 to 1.398, LoS is E/F, the queue length on Wanneroo Road south right turn lane is 248m and stop rate is 0.14 to 0.25. Figure 6-7 refers.

Figure 6-7 Wanneroo Road/Celestine Street – ultimate design



Main Roads has commented as follows regarding the treatment of this intersection.

"Wanneroo Road/Celestine Road intersection 2031 is an excellent example to consider when dealing with side road connections. We agree with the statement in this section that all side road intersections cannot be signalised. Similarly, there needs to be consideration of how to deal with traffic at the Wanneroo Road and Celestine Road intersection (or any other specific location). We would promote the idea of a network review to determine how the network could be structured to make best use of locations which are chosen for the higher level of service afforded by signalisation. The suggestion of acceleration lanes is considered inappropriate in the context of adjacent intersections and vehicle crossovers to properties. The separation between intersections is insufficient, as is available land."

Main Roads Western Australia

Recommendation

In view of Main Roads comments regarding this intersection it is recommended that the intersection is retained as existing and promote the use of the planned upgrade of Elliot Road and its planned signalised intersection with Wanneroo Road.

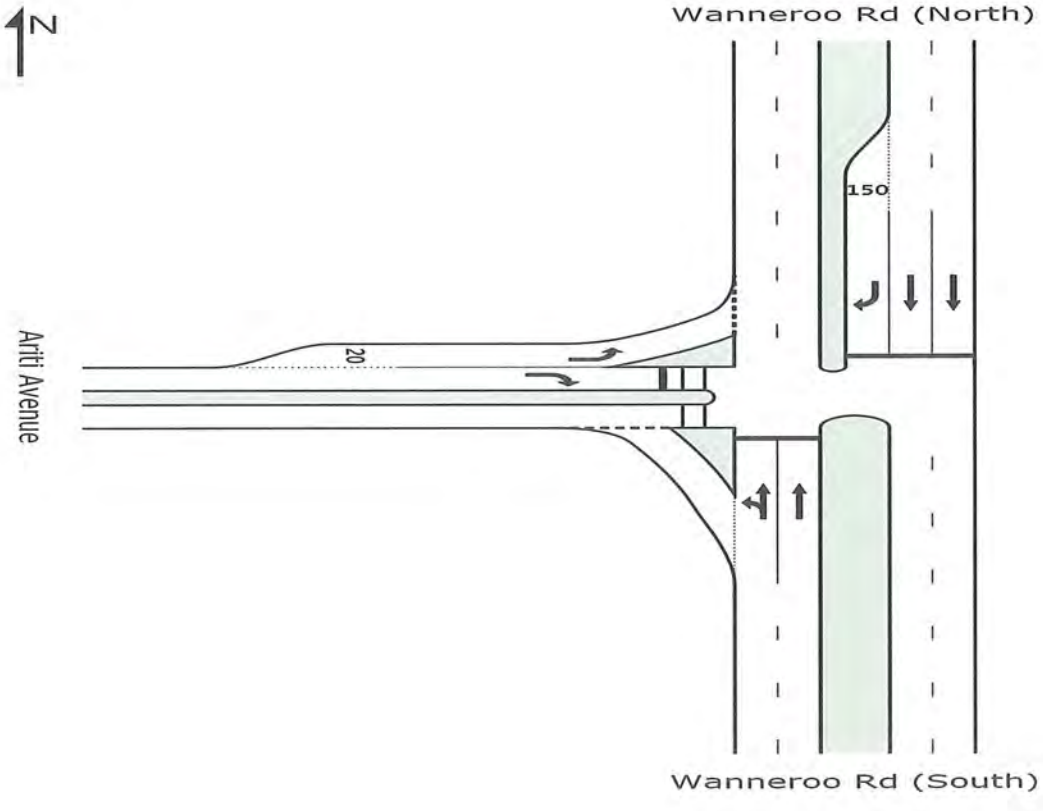
6.3.5 Wanneroo Road/Ariti Ave intersection 2031

The analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of A/B is forecast and stop rates of less than 1. Queues of up to 437m are forecast on Wanneroo Road south in the pm period. A signalised intersection is therefore recommended.

Land resumption is not required.

Figure 6-8 refers.

Figure 6-8 Wanneroo Road/Ariti Avenue – ultimate Design



Mains Road has commented as follows regarding the treatment at this intersection:

> **"Main Roads does not support signalising of the Wanneroo Road and Ariti Avenue intersection. Whilst queuing may be undesirable, the volume of traffic trying to access Wanneroo Rd at this location is insufficient to warrant traffic signals. This traffic can utilise other connections to Wanneroo Road which have traffic signals to assist right turning traffic"**
>
> Main Roads Western Australia

As part of the overall network improvement the signalisation of Scenic Drive/Wanneroo Road has been suggested by Main Roads and is supported by this study. The installation of traffic signals at the Scenic Drive/Wanneroo Road intersection will provide alternative access for the precinct to the west of Wanneroo Road some distance from the Town Centre.

Main Roads also comment that

> **"the current signalisation works at Wanneroo Road and Wallawa Street are an anomaly that could become an opportunity. Serious consideration should be given to how Scenic Drive could be connected to Wanneroo Road at the northern end. Wallawa Street provides an opportunity if the link between Scenic Drive and Banyandah Boulevard or Kilindi Crescent can be created".**
>
> Main Roads Western Australia

It is agreed that the opportunity of connecting Scenic Drive to Wanneroo Road via Wallawa Street should be examined, in view of the likely benefits to accessibility and the operation of Wanneroo Road and its intersections.

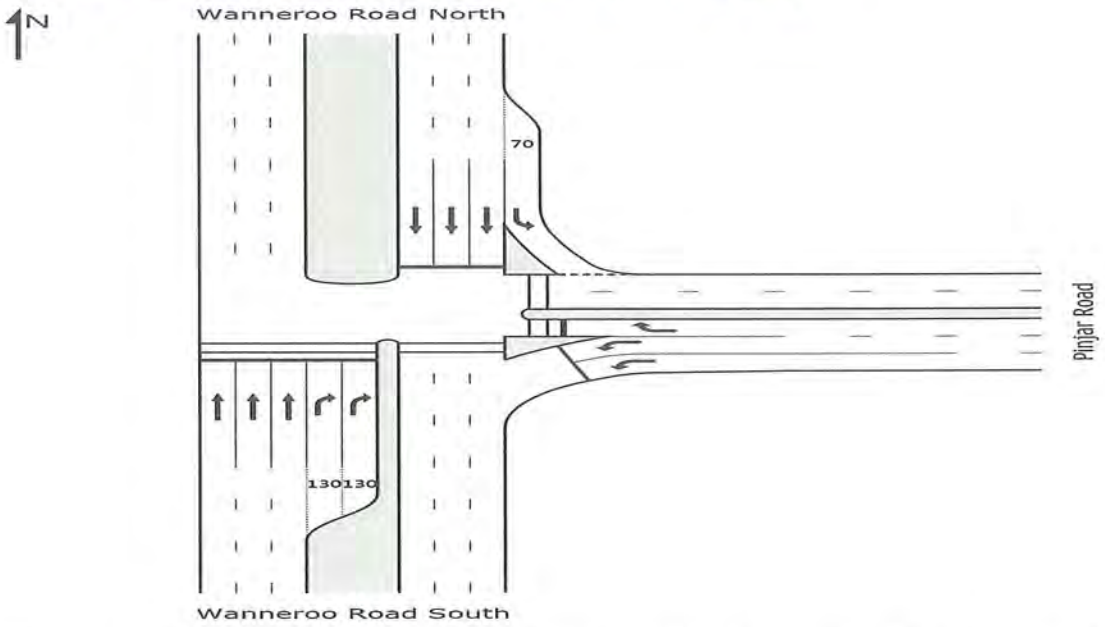
Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the extension of Scenic Drive north to Wanneroo Road and the signalisation of Scenic Drive/Wanneroo Road intersection are further examined.

6.3.6 Wanneroo Road/Pinjar Road intersection 2031

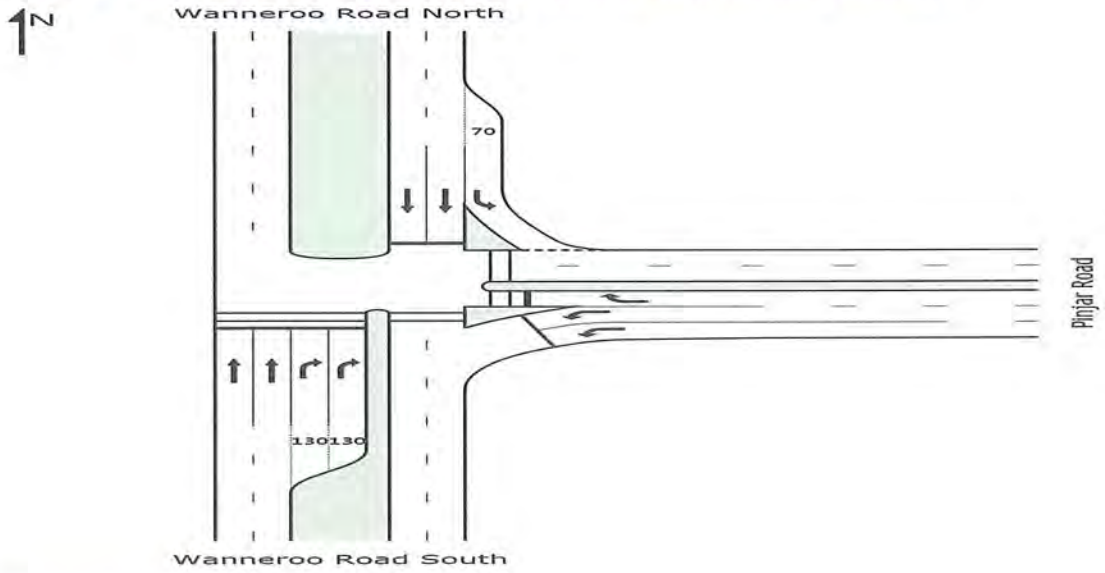
The analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of C/D is forecast and stop rates of less than 1 during the am peak hour but the southbound through movement is 1.36 during the pm peak hour. Queues of 240m-250m are forecast on Wanneroo Road. Significant land resumption is required. Figure 6-9 refers.

Figure 6-9 Wanneroo Road/Pinjar Road – ultimate design



A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design with unacceptable queues and delays and is not therefore recommended. Degree of saturation 0.975 to 1.064, LoS E/F. queue lengths 1.2km on Wanneroo Road south and a stop rate of 0.88 to 1.46. Figure 6-10 refers.

Figure 6-10 Wanneroo Road/Pinjar Road – compromise design



Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded to include additional through lanes in Wanneroo Road, however if this cannot be achieved the layout as shown above could be considered.

Main Roads comment is acknowledged that

> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area".**
>
> Main Roads Western Australia

6.3.7 Wanneroo Road

It is clear from the analysis that Wanneroo Road should be upgraded to include an additional through lane in each direction adjacent to the precinct. The ROM plot (unadjusted) indicates 56,000vpd adjacent to the precinct, just south of Dundebar Road, without LHS and 59,400vpd with LHS. The capacity for a dual carriageway at a level of service C is 38,000vpd so it can be seen that by 2031 volumes will exceed this level with or without LHS.

Main Roads comment is acknowledged that

> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area".**
>
> Main Roads Western Australia

6.3.8 Internal roads

The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.

The WAPC document 'Liveable Neighbourhoods' indicates the anticipated traffic volumes for residential streets:

- Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd
- Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd

The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.

Current volumes on key local roads are indicated in the following table compared with the anticipated volumes based on Liveable Neighbourhoods. It should be noted that the physical capacity of the road is higher than these volumes i.e 8-12,000vpd indicating significant road capacity for higher housing density.

Location	Existing vpd	Liveable Neighbourhoods Anticipated Volumes
Civic Drive	3,180vpd	3,000vpd
Kanimba Street	3,060vpd	3,000vpd
Celestine Street	2,700vpd	3,000vpd
Quarkam Street	3,000vpd	3,000vpd
Ariti Ave	1,500vpd	3,000vpd

Location	Existing vpd	Liveable Neighbourhoods Anticipated Volumes
San Rosa Rd	1,700vpd	3,000vpd
Scenic Dr	2,500vpd	3,000vpd

The following intersection thresholds are indicated by Austroads, below which capacity analysis is unnecessary.

Major Road Flow	Minor Road Flow
400vph	250vph
500vph	200vph
650vph	100vph

Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.

6.4 Stakeholder liaison

Following completion of the technical analysis the outcomes were forwarded to the City of Wanneroo who has also consulted with Main Roads. Their coordinated response is shown in Appendix F together with GHD response. Amendments have been incorporated into this report.

7. Cost estimates

Apportionment of cost estimates

The following calculation has been used to estimate the proportion of each of the cost estimates which are directly attributable to the increase in traffic in the Wanneroo Housing Precinct. This takes into account the likely additional work required due to the increase in housing density.

a. Forecast traffic generation from the Wanneroo Housing Precinct to 2031 based on current planning: 78,917vpd.

b. Forecast traffic generation from the Wanneroo Housing Precinct to 2031 based on increased R Codes: 99,559vpd.

c. Forecast traffic generation from the Wanneroo Housing Precinct and Area of Influence to 2031 based on increased R Codes: 245,616vpd.

Therefore the apportionment of cost is calculated by (b-a)/b and represents 20.7**%** of road upgrade cost. Area of influence: 1km surrounding precinct.

7.1 Cost estimates for road network improvements

Based on the traffic assessment **internal** road upgrades are not anticipated to be required therefore no internal measures are recommended for costing for work by the City of Wanneroo.

7.2 Staging of Works

Based on observations of the models in operation as well as the performance results presented in Section 5 the following table outlines the anticipated staging requirements of intersection treatments.

Table 7-1 Intersection Treatment Staging

	Without LHS			With LHS		
	0-5 years	5-10 years	10-20 years	0-5 years	5-10 years	10-20 years
Wanneroo Road/Dundebar Road		x			x	
Wanneroo Road/Pinjar Road			x			x
Wanneroo Road/Church Street (Signals not supported by Main Roads)		x		x		
Wanneroo Road/Ariti Avenue (Signals not supported by Main Roads)	x			x		
Wanneroo Road/Celestine Street (Upgrade not supported by Main Roads)						x
Wanneroo Road/Elliot Road (Main Roads indicate likely higher volumes due to broader development)			x		x	

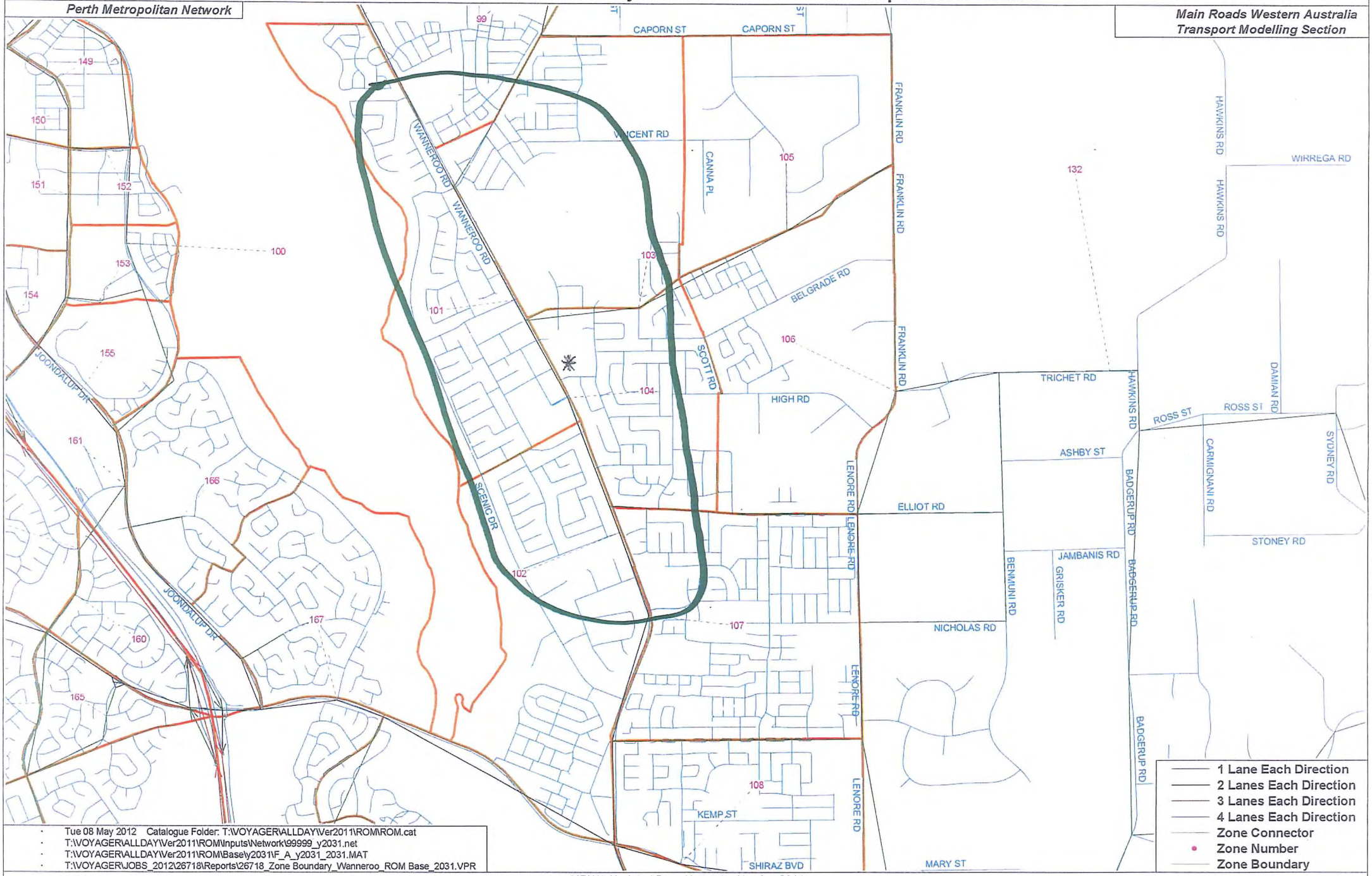
Appendices

Appendix A - Landuse input

2031 Base Model - Zone Boundary Plot for Wanneroo Traffic Impact Assessment

Perth Metropolitan Network

Main Roads Western Australia
Transport Modelling Section



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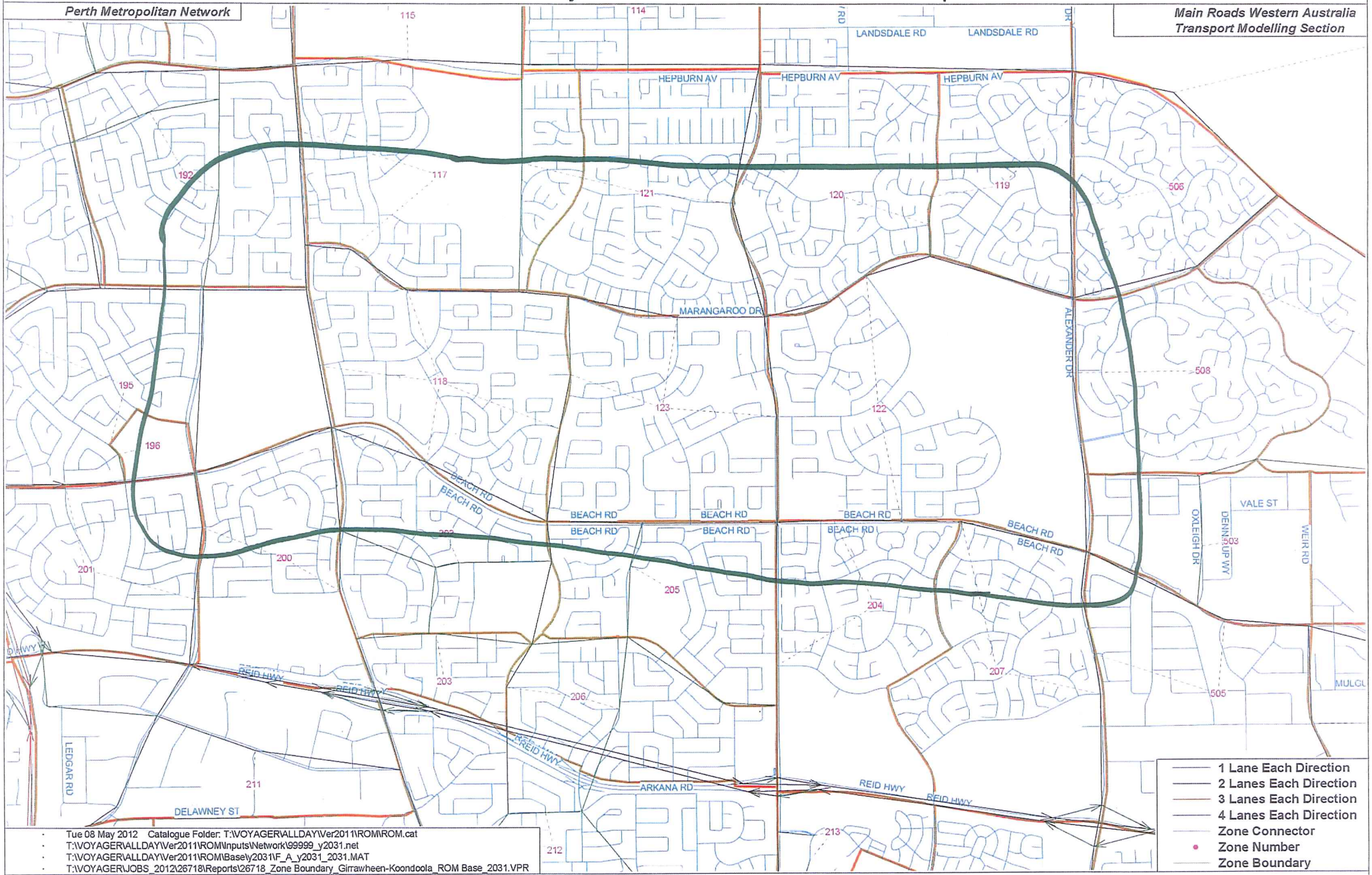
MRWA Updated Base Network - Version 2011

cube

2031 Base Model - Zone Boundary Plot for Girrawheen-Koondoola Traffic Impact Assessment

Perth Metropolitan Network

Main Roads Western Australia
Transport Modelling Section



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MRWA Updated Base Network - Version 2011

Appendix B - Paramics base model validation report

City of Wanneroo

Wanneroo Microsimulation Traffic Model
Base Model Validation Report

29 January 2013

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Appendices

This report: has been prepared by GHD for City of Wanneroo and *may only be used and relied on by City of Wanneroo for the purpose agreed between GHD and the City of Wanneroo as set out in Section 1 of this report.*

GHD otherwise disclaims responsibility to any person other than City of Wanneroo arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by City of Wanneroo, Main Roads, Excel Traffic Data and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1. Introduction

City of Wanneroo has engaged GHD to undertake a Traffic Impact Assessment (TIA) to evaluate the potential effect of the proposed increases to R Coding within the Wanneroo Housing Precinct. As part of this study, GHD is undertaking local area microsimulation traffic modelling to assist in the traffic assessment. This report discusses the development of the initial 'Base' models which provide a representation of the current on-site conditions on the Wanneroo road network, and outlines the calibration and validation methodologies that have been employed.

The purpose of this report is to demonstrate and provide confidence that the Wanneroo Base models are a robust representation of the on-street conditions and as such provide a suitable foundation for the subsequent testing of future year scenario. The report therefore provides information relating to the following topics:

- Data sources used for the modelling;
- Model network development;
- Trip matrix development;
- Model calibration; and
- Model validation.

Figure 1 outlines the adopted study area for the traffic modelling assessment.

Figure 1 Extents of Model Study Area

2. Data Collection

2.1 Introduction

Microsimulation models typically require large volumes of data in order to accurately represent traffic networks at a microscopic level and to ensure the model is a good representation of current on-site conditions. This section of the report details each dataset that has been collected for the study. It provides information relating to the type of data, the source of the data and the date and time periods that the data was collected for.

2.2 Traffic Volume Data

Traffic volume count data was obtained from a number of sources including the following:

- SCATS loop counts;
- Manual turning movement surveys; and
- Historical tube count data.

2.2.1 SCATS Loop Counts

Signalised intersection detector counts were requested from Main Roads for the sites within the Wanneroo study area. These signalised intersections consisted of the following:

- Wanneroo Road / Pinjar Road (TCS 985);
- Wanneroo Road / Dundebar Road (TCS 736); and
- Wanneroo Road / Hastings Street / Conlan Avenue (TCS 487).

Detector counts were provided in hourly intervals for each intersection loop for the week beginning 19 March 2012.

These types of traffic counts have a number of limitations which need to be considered when assessing the suitability of such data to use an input traffic models. These constraints include:

- Some intersection movements are not captured due to some lanes not being covered by an in-pavement detector, e.g. often left turn slip lanes are not detected:
- Some lanes have multiple designations e.g. a shared left turn and through movement lane. In these instances it is unclear from the detector count what proportion of vehicles conduct each movement;
- Detectors are not always reliable e.g. detectors can be faulty and hence not record all vehicles accurately; and
- Detector counts do not differentiate between vehicle classifications.

2.2.2 Manual Turning Movement Count Surveys

To supplement the SCATS detector count data (and to overcome some of the shortcomings of that data set) a number of manual turning movement surveys were collected. These were undertaken by Excel Traffic Data during the week beginning 28 May 2012 at the following sites:

- Wanneroo Road / Ariti Drive;
- Wanneroo Road / Celestine Drive;
- Wanneroo Road / Hastings Street / Conlan Street; and
- Wanneroo Road / Elliot Road.

Surveys were undertaken for the following time periods:

- AM Peak: 7.30 – 9.30; and
- PM Peak: 15.30 – 17.30.

Traffic count data was provided in the form of turning counts in 15 minute intervals and was disaggregated into car and truck vehicle types. These traffic surveys provided a high level of data resolution for input into the model.

2.2.3 Historical Tube Count Data

City of Wanneroo provided a number of tube count surveys which had previously been undertaken throughout the study area. These surveys were used by GHD to inform the project of indicative volumes on lower order roads and to assess the validity of recently collected data. These data sets typically provided only mid-block two-way traffic volumes, and as such they were not used to determine directional or turning movement data inputs. The provided tube counts ranged in currency from 2009 and 2012.

2.3 Signal Data

In additional to the SCATS detector counts (discussed in Section 2.2.1), traffic signal operation data was sourced from Main Roads for each signalised intersection in the study area to ensure signal operations could be represented accurately. The signalised sites included:

- Wanneroo Road / Pinjar Road (TCS 985);
- Wanneroo Road / Dundebar Road (TCS 736); and
- Wanneroo Road / Hastings Street / Conlan Avenue (TCS 487).

The specific signal data which was requested and subsequently provided by Main Roads consisted of the following:

- SCATS TCS graphics;
- IDM (intersection diagnostic monitor) data files (for two consecutive days, June 2012); and
- Intersection timing charts.

2.4 Travel Time Data

Vehicular journey times through the study area were recorded on-site for the key movements. This information would provide the key source of model validation data (discussed in detail in Section 5). GHD collected travel time survey data, as well as in-car video footage for the AM and PM peak periods on Tuesday 5 June 2012. GHD staff undertook these travel time surveys which allowed observations of queuing and congestion levels on-site to be considered during the calibration and validation stages of the modelling process.

The primary route through the Wanneroo road network was identified as Wanneroo Road between Pinjar Road and the southern extent of the model study area i.e. Ocean Reef Road. This route was surveyed in both directions and journey times disaggregated into the following intervals:

- Pinjar Road to Dundebar Road;
- Dundebar Road to Conlan Road ; and
- Conlan Road to Elliot Road.

2.5 ROM Strategic Model Outputs

Main Roads provided outputs from the Regional Operations Model (ROM) to assist with the study. The outputs requested by GHD and provided by Main Roads consisted of the following:

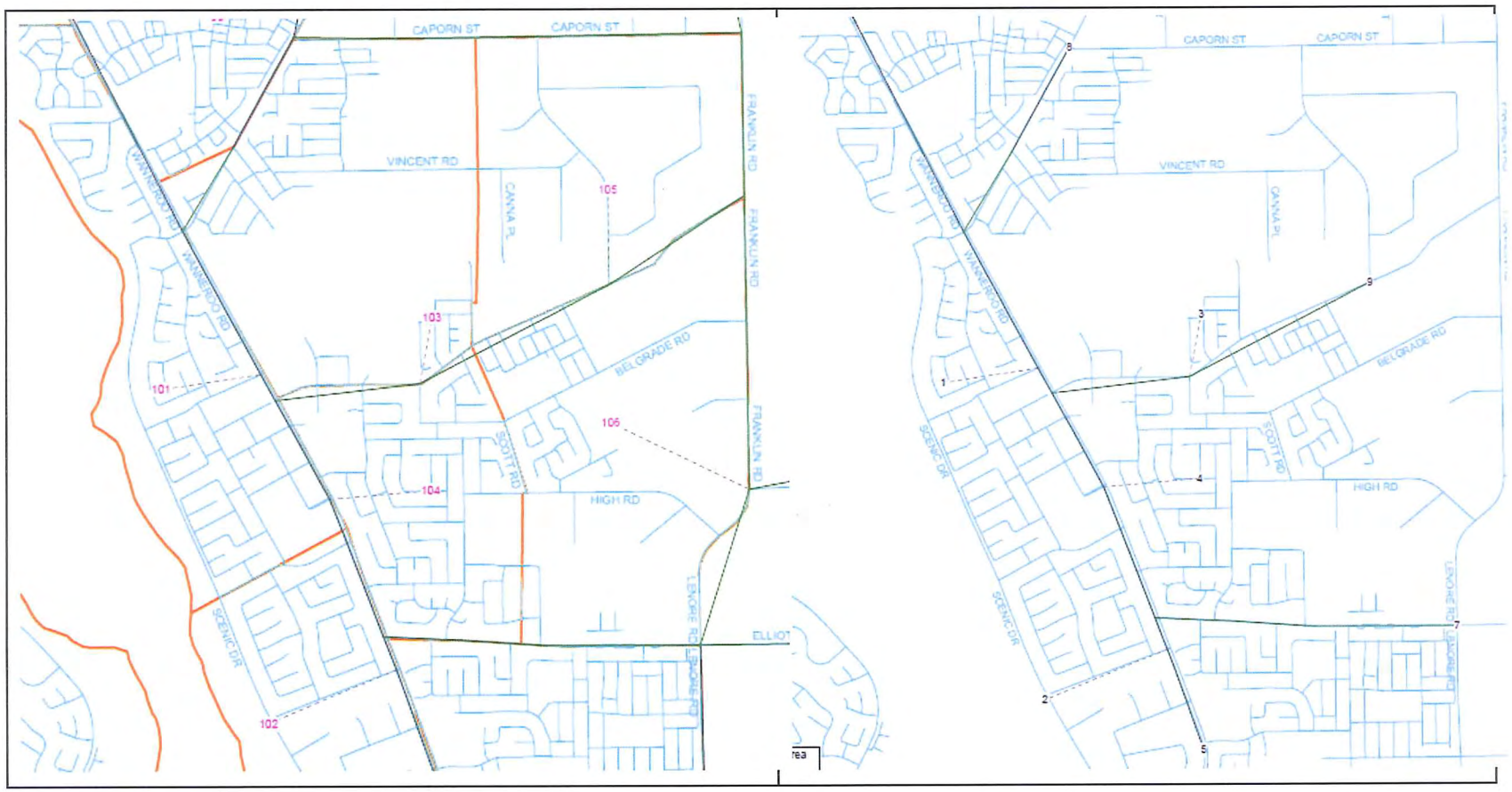
- ROM network layout and zoning structure around the Wanneroo study area; and
- Sub-area cordon trip matrices from ROM for the 2011 Base scenario (as well as the 2031 scenario matrices) for the Wanneroo microsimulation model study area.

The ROM network and the requested sub-area network is shown in Figure 2.

Figure 2 ROM Network and Sub-area

ROM Network

Wanneroo sub-area



3. Model Development

3.1 Introduction

The microsimulation modelling for this study has been developed using Quadstone Paramics software (version 6). Paramics is a traffic simulation software package that can be used to analyse a connected network of road links and signal controlled intersections, roundabouts, priority junctions in a single model network and to a high level of detail. The simulated driver behaviour is based on lane changing and vehicle following models and can provide an accurate reflection of on-site driver and vehicle behaviour.

3.2 Model Definition

The model runs for two discreet one-hour time periods as per the following:

- AM Peak Model: 8.00-9.00 with preceding warm-up period between 7.00 and 8.00; and
- PM Peak Model: 16.00-17.00 with preceding warm-up period between 15.00 and 16.00.

The time periods above were found to be the critical peak periods with regards to the highest traffic volumes following a review of the available traffic data for the study area. The warm-up periods are in place to ensure vehicles are upon the network at the commencement of the evaluation period.

The Base model is simulated using five variable 'seed values' with the resultant outputs analysed for discrepancies and ultimately averaged for output purposes. The seed value affects the generation of the random numbers that influence the model operation and variability. Therefore each time the model is run with a different seed value a slightly different set of outputs is generated. It would generally be expected that these outputs would be very similar (but not identical), and can loosely be thought of as day-to-day on-site fluctuations. The use of multiple seed values therefore provides confidence that the model results are not based upon a single outlying model run, but the result of a larger sample of model runs.

3.3 Model Network

The core model network was coded through the assistance of aerial photography and on-site observations to ensure the following attributes were included into the network:

- Intersection configurations;
- Number of lanes and lane allocations;
- Roadway widths, kerb locations and stopline positions;
- Road speed limits;
- Unsignalised intersection priority controls; and
- Turning lane storage lengths.

The model network is shown in Figure 3.

Figure 3 Wanneroo Model Network

Shared Model Space: Wanneroo and Girrawheen

It should be noted that this Wanneroo model network has been developed at the same time as a Girrawheen study area model has been developed also for City of Wanneroo. Given the close proximity of these two area, the two models have been developed within the same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

3.4 Signalised Intersections

Signalised junctions have been coded into the model to function under fixed time operation consisted with the phasing structure and times recorded in the IDM files. A review of the signal information provided by Main Roads revealed that phase and cycle times remained broadly consistent between consecutive days, as such these timing were coded into the model for the AM and PM peak periods.

3.5 Trip Matrices

Microsimulation models require accurate trip matrices in order to produce an indicative simulation of existing traffic movements. To develop a detailed set of trip matrices the following data sources were used:

- Turning movement volumes from recent surveys (outlined in Section 2.2); and
- An understanding of routing patterns and trip distributions through the study area network (outlined in Section 2.5).

The information above was combined to generate the trip matrices from the traffic assessment as per the following methodology:

A sub-area cordon was cut in ROM by Main Roads to represent only traffic movements within the study area. This produced a daily trips matrix for the study area network, albeit at a coarse zone and network level. A number of the ROM zones were split in order to match the more detailed definition of the zones within the microsimulation network. Following this, the proportional distribution matrix was determined from the ROM daily trip volume matrix. This distribution pattern was then utilised as the initial estimate of trip distributions for the peak period models.

An iterative process of furnessing was undertaken to factor the row and column totals of the microsimulation demand matrices to match the turning count data for entry and exit points to the Paramics model. This factored the overall matrix size to the observed traffic levels whilst retaining the broad original-destination pattern of the original matrices. This process was undertaken separately from both the AM and PM periods. The resulting matrices then underwent a manual matrix-estimation refinement process based on comparisons against known turning movement volumes. These refined trip sets were then applied as the input demand matrices for the Base models.

3.6 Vehicle Release Profiling

Demand release profiles were developed for each of the key model entry locations (where the necessary data was available). These profiles are used to specify the staged release of vehicles into the models across the hourly periods i.e. vehicles do not necessarily arrive at a constant rate across a one hour peak period. Profiles were developed for 15-minute intervals from observed turning movement counts. Individual profiles were applied to external zones which connect directly to an intersection where a turning movement survey was undertaken (and hence 15-minute data was available). For entry zones where data was not available in 15-minute intervals, the 'average' profile was applied to these releases.

3.7 Model Assignment

The modelled network has no route choice since it is a corridor model. As such, the Paramics assignment method is inconsequential in this instance. Notwithstanding, an all-or-nothing plus perturbation (AON+P) assignment is in use within this model.

3.8 Vehicle Classification

Traffic survey data was interrogated to determine the average recorded proportion of light and heavy vehicles on the network during the AM and PM peak periods. The resulting truck proportions are shown in Table 1 and have been incorporated in the respective model periods.

Table 1 Heavy Vehicle Proportions

Peak Period	Heavy Vehicle Proportion
AM Peak	4.2 %
PM Peak	2.3 %

3.9 Model Plugins

Azalient Ceejazz model plugins have been utilised within the model. These third party plugins operate in conjunction with the core Paramics software and enhance its functionality. The specific plugin modules which have been used on the Wanneroo model network consist of the following:

- Validator: Used to extract results relating to modelled traffic volumes and travel times; and
- Lane Choice: Used to ensure sensible and accurate lane discipline of vehicles on approach to junctions.

4. Model Calibration

4.1 Introduction

Model calibration is the process whereby data that has been used in the model building process is checked against the model output to ensure that the model has been accurately coded and is representing the measured on-site conditions. Turning movement traffic volumes have been used as the calibration measure in this instance. A such, the calibration process involved ensuring traffic volumes output by the model were sufficiently accurate when compared against traffic volumes observed on site.

4.2 Turning Count Calibration

A turning count calibration was undertaken for each of the major intersections within the model study area. The purpose of this calibration was to check that traffic volumes collected from the model were representative of traffic volumes measured on site for each traffic movement at each intersection. The GEH statistic was used to compare observed and modelled traffic volumes.

The GEH statistic is a self scaling indicator developed to sensibly compare observed and modelled flows. Rather than directly comparing flows by measure of either absolute or relative differences, the GEH statistic considers both of these measures within thresholds that are appropriate for traffic flow. For instance, the GEH statistic reflects that while an absolute difference of 100 vehicles/hr can be important in the context of a flow of 200 vehicles/hr, it is much less relevant in a flow of several thousand vehicles/hr.

GEH compares the differences between hourly observed flows and hourly modelled flows by using the following formula:

$$GEH = \sqrt{(V_O - V_A)^2 / (0.5 \times (V_O + V_A))}$$

Where:

V_O = Observed traffic flow (vehicles/hour)

V_A = Assigned (or modelled) hourly traffic flow (vehicles/hour)

The following criteria were used during the turning count calibration process:

- 85% of GEH statistics for individual junction turning-movement total volumes should be less than 5;
- R^2 statistic between 0.9 and 1.0 and slope factors between 0.9 and 1.1, of modelled vs. observed flow plots.

Table 2 provides a summary of the turning movement GEH criteria results. It can be seen that a total of 40 individual movements were assessed within each time period. The turning movements included as part of the calibration assessment include only movements which were directly known from recent survey information i.e. manual counts and selected SCATS detector recordings.

Table 2 demonstrates that during both peak periods, the model provides a close match of modelled and observed traffic flows.

Table 2 Summary of GEH Criteria Results

Time Period	Number of Observations	Observations with GEH < 5	Average GEH	R^2 and Slope	Exceeds Criteria?
AM Peak	40	40 (*100%*)	1.53	0.99, 1.039	Yes
PM Peak	40	40 (*100%*)	1.19	0.99, 0.969	Yes

Figure 4 and Figure 5 show plots of modelled traffic volumes compared with observed traffic volumes for each turning movement. It can be seen from theses charts that there is close fit between observed and modelled traffic volumes across each of the time periods surveyed.

It should be noted that the raw surveyed traffic volumes have been adopted directly for this assessment. That is, there has not been any manual smoothing or manipulation of the surveyed data, as such there exist some minor discrepancies between adjacent sites due to inherent survey errors. Consequently, under this approach it is not possible to match each and every count precisely.

Appendix A provides fully tabulated results of the turning count calibration assessment for each individual turning movement.

Figure 4 AM Peak Traffic Volume Comparison

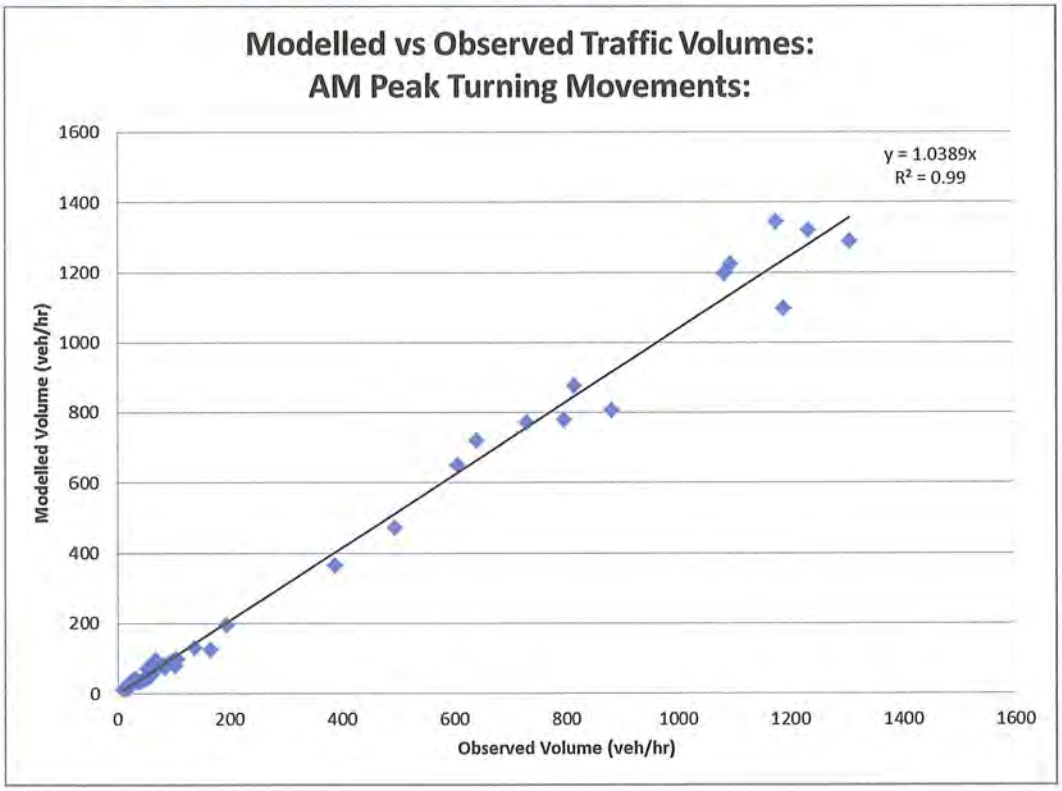
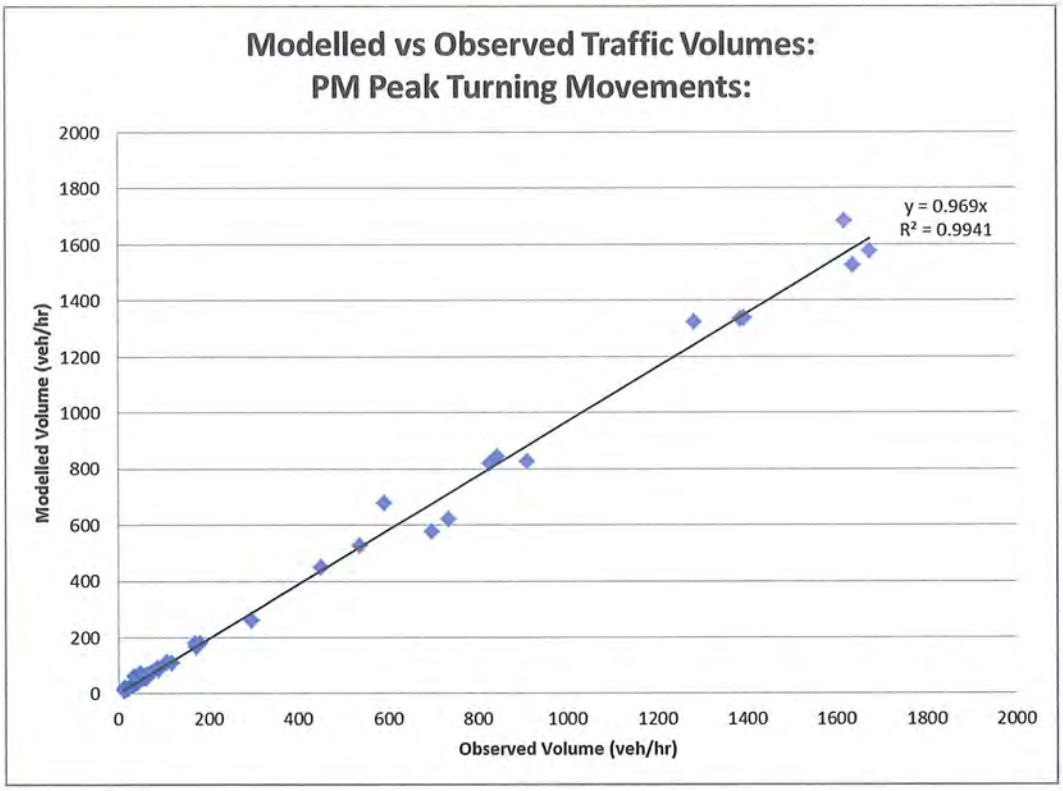


Figure 5 PM Peak Traffic Volume Comparison



5. Model Validation

5.1 Introduction

This section details the results from the validation of the base model. The purpose of model validation is to ensure that statistical results in the model accurately reflect data collected during the survey period, but have not been explicitly used as model inputs during the development stages. The validation measure used in this instance was travel time data.

In addition to the travel time validation, an assessment of model stability has also been presented which shows model output variations across multiple seed value runs.

5.2 Travel Time Validation

As part of the validation process GHD undertook an analysis of journey times for vehicles in the model along Wanneroo Road and compared these against journey time observations recorded on site. Average journey times across five seed runs were collected from the model outputs and analysed. The following criteria was used to assess whether the modelled journey times were representative of conditions on site:

- Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).

Table 3 and Table 4 shows a summary of the travel time validation results for Wanneroo Road for the AM and PM periods respectively. It is clear that the model closely replicates the recorded travel times along this critical corridor for both the AM and PM periods.

Table 3 AM Peak Travel Time Comparison

Location	Observed (seconds)	Modelled (seconds)	Difference (seconds)	Meets Criteria?
Southbound				
Pinjar Road to Dundebar Road	104	100	-4	*Yes*
Dundebar Road to Conlan Road	40	16	-23	*Yes*
Conlan Road to Elliot Road	79	73	-6	*Yes*
Northbound				
Elliot Road to Hastings Street	79	84	6	*Yes*
Hastings Street to Dundebar Road	11	28	18	*Yes*
Dundebar Road to Pinjar Road	83	79	-5	*Yes*

It is noted that the observed travel time between Dundebar Road and Conlan Road is 40 seconds (compared to an average modelled time of 16 seconds). A closer inspection of the individual times representing the 40 second average revealed a range between 10 and 71 seconds, and was dependent upon whether the survey vehicle was required to stop at the Conlan Road traffic signals.

Table 4 PM Peak Travel Time Comparison

Location	Observed (seconds)	Modelled (seconds)	Difference (seconds)	Meets Criteria?
Southbound				
Pinjar Road to Dundebar Road	97	98	1	*Yes*
Dundebar Road to Conlan Road	13	17	3	*Yes*
Conlan Road to Elliot Road	77	72	-4	*Yes*
Northbound				
Elliot Road to Hastings Street	111	96	-15	*Yes*
Hastings Street to Dundebar Road	16	20	4	*Yes*
Dundebar Road to Pinjar Road	111	85	-27	*Yes*

It can be seen from Table 3 and Table 4 that the difference between the observed and modelled journey times is significantly less than the 1-minute threshold for all comparisons (in fact, all are less than 30 seconds).

5.3 Model Stability

The base model has been run with five 'seed' values (as discussed in Section 3.2 of this report) and the results of these model runs have been averaged for the calibration and validation outputs. However, it is important to ensure that the model runs are providing a stable and consistent model platform to take forward to the option testing stage. This requires the assessment of output statistics from each seed run to ensure that the variability of the outputs appears to be within reasonable limits.

In order to assess model stability for this study, two network wide statistics have been extracted and presented comparing each of the five individual seed value runs. The two assessment statistics are as follows:

- Average vehicle speed (veh/hr) of all vehicles currently in the model network; and
- Current number of vehicles being serviced by the network.

Figure 6 and Figure 7 show the stability test outputs for the AM and PM models respectively. These figures display variations between seed vales (as expected), but do not highlight any substantial outlying or rogue results.

Figure 6 AM Peak Model Stability Test Results

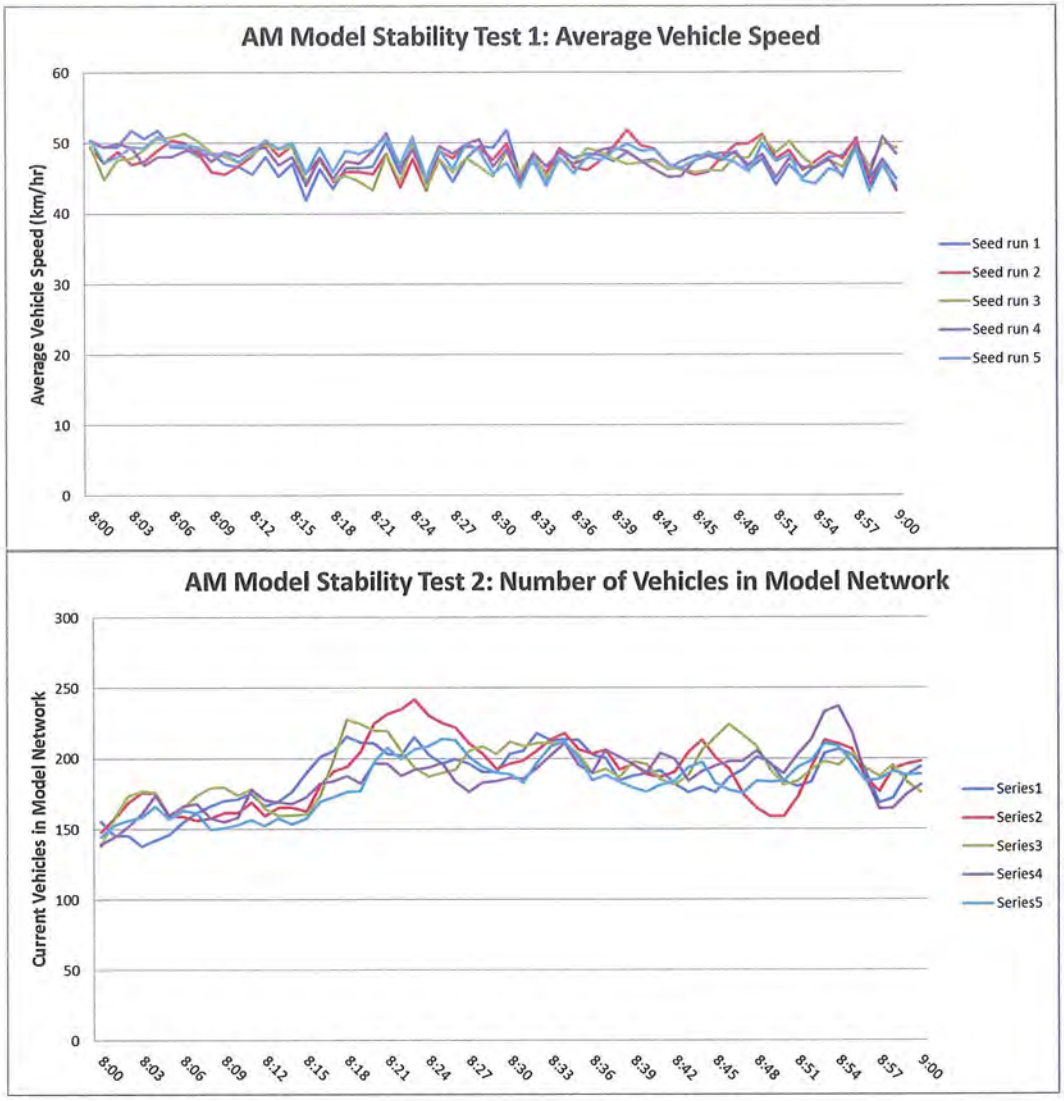
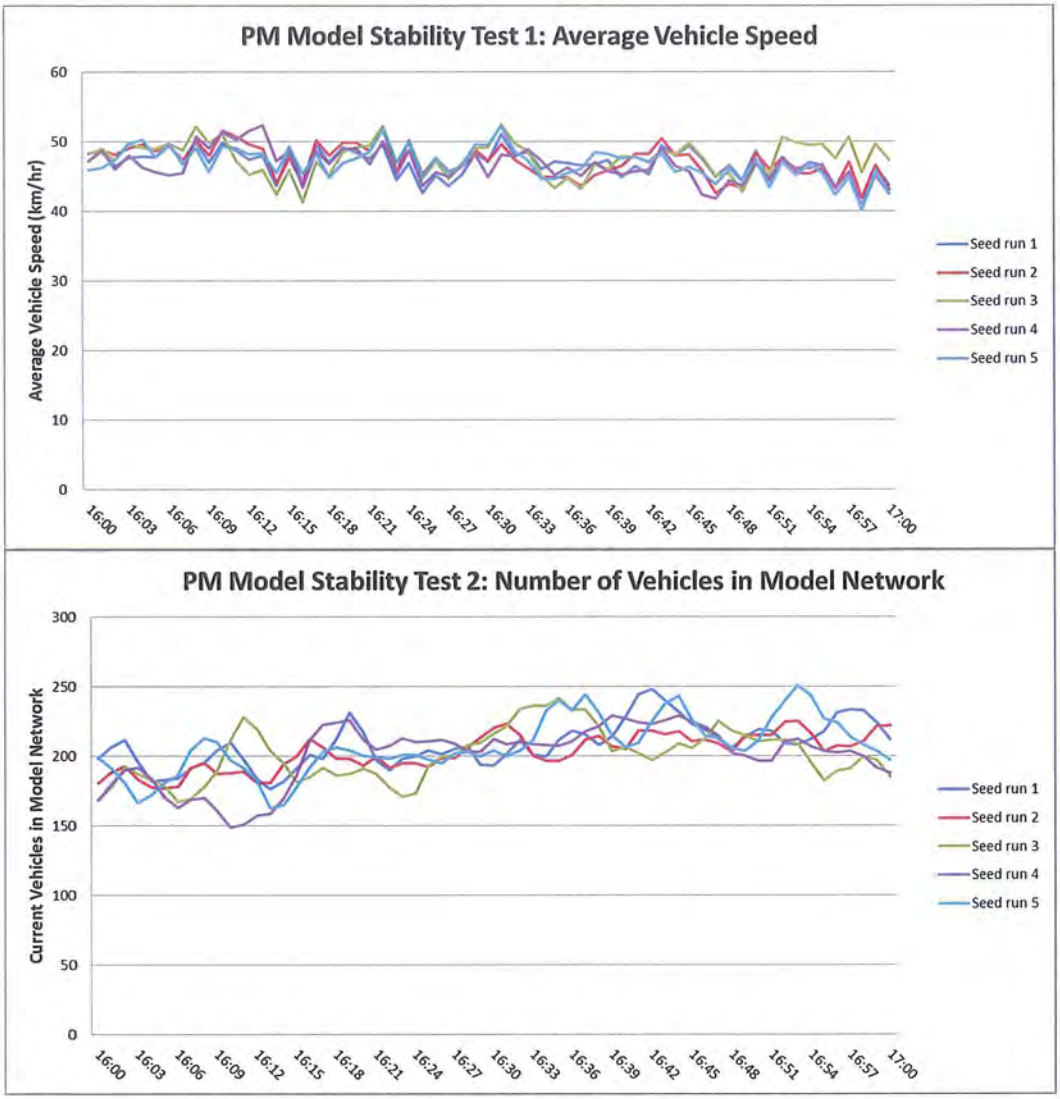


Figure 7 PM Peak Model Stability Test Results



6. Conclusion

6.1 Summary

This document has outlined the development of the microsimulation Base model for the central area of Wanneroo. Paramics (version 6) in conjunction with Azalient plugins has been used to simulate the movement vehicles for the critical AM and PM peak periods of an average weekday.

The report has detailed the calibration process used to ensure that the model is representative of observed on-site turning movement traffic volumes. These have been shown to meet and significantly exceed industry standard guidelines.

In addition, the validation process for travel times has been outlined. All modelled travel time data has been shown to meet the target criteria. Furthermore, both the AM and PM models have been found to exhibit stable results across different seed value runs.

Given the results of the calibration and validation process, the model is now considered a robust representation of the study area during the AM and PM peak time periods. As such, these models are considered suitable to be used as the foundation for future year scenario testing.

6.2 Next Steps

The next step with regards to the traffic modelling assessment consists of using the AM and PM models as detailed in this report to assess the Wanneroo network performance with increased traffic volumes aligning with the following scenarios:

- 2031 horizon with no change to R-coding; and
- 2031 horizon with increased R-coding designations.

The volumes and trip distributions corresponding to the above scenarios will be determined through analysis of the provided ROM trip matrices for the two scenarios. The relative change in volumes between the two scenarios, and the base volumes, will be considered when interpreting these forecast volumes.

Appendices

Appendix A Turning Count Calibration Statistics

AM Peak Turning Movement Comparison

Intersection	Movement	Observed	Modelled	GEH
Wanneroo Road / Elliot Road	S to N	729	772	1.56
Wanneroo Road / Elliot Road	S to E	99	92	0.74
Wanneroo Road / Elliot Road	E to S	137	130	0.64
Wanneroo Road / Elliot Road	E to N	68	96	3.09
Wanneroo Road / Elliot Road	N to E	56	75	2.39
Wanneroo Road / Elliot Road	N to S	1176	1343	4.72
Wanneroo Road / Celestine Road	S to N	797	779	0.63
Wanneroo Road / Celestine Road	S to E	92	87	0.57
Wanneroo Road / Celestine Road	E to S	106	98	0.83
Wanneroo Road / Celestine Road	E to N	28	40	2.06
Wanneroo Road / Celestine Road	N to E	25	30	0.92
Wanneroo Road / Celestine Road	N to S	1232	1320	2.45
Wanneroo Road / Ariti Avenue	S to W	11	12	0.29
Wanneroo Road / Ariti Avenue	S to N	882	805	2.65
Wanneroo Road / Ariti Avenue	N to S	1306	1287	0.52
Wanneroo Road / Ariti Avenue	N to W	21	21	0.09
Wanneroo Road / Ariti Avenue	W to N	21	28	1.34
Wanneroo Road / Ariti Avenue	W to S	50	43	1.09
Wanneroo Road / Hastings Street / Conlan Street	S to W	37	33	0.68
Wanneroo Road / Hastings Street / Conlan Street	S to N	639	720	3.09
Wanneroo Road / Hastings Street / Conlan Street	S to E	103	78	2.63
Wanneroo Road / Hastings Street / Conlan Street	E to S	42	35	1.09
Wanneroo Road / Hastings Street / Conlan Street	E to W	18	14	1.00
Wanneroo Road / Hastings Street / Conlan Street	W to N	10	13	0.88
Wanneroo Road / Hastings Street / Conlan Street	N to E	59	58	0.10
Wanneroo Road / Hastings Street / Conlan Street	N to S	1096	1224	3.75
Wanneroo Road / Hastings Street / Conlan Street	N to W	53	70	2.19
Wanneroo Road / Hastings Street / Conlan Street	W to N	32	41	1.52
Wanneroo Road / Hastings Street / Conlan Street	W to E	65	65	0.00
Wanneroo Road / Hastings Street / Conlan Street	W to S	84	75	1.01
Wanneroo Road / Dundebar Road	S to N	605	650	1.81
Wanneroo Road / Dundebar Road	S to E	167	125	3.49
Wanneroo Road / Dundebar Road	E to N	388	366	1.15
Wanneroo Road / Dundebar Road	N to S	1083	1196	3.36
Wanneroo Road / Pinjar Road	S to N	816	876	2.06
Wanneroo Road / Pinjar Road	S to E	194	196	0.11
Wanneroo Road / Pinjar Road	E to S	494	473	0.94
Wanneroo Road / Pinjar Road	E to N	83	83	0.02
Wanneroo Road / Pinjar Road	N to E	57	50	0.99
Wanneroo Road / Pinjar Road	N to S	1189	1095	2.77

PM Peak Turning Movement Comparison

Intersection	Movement	Observed	Modelled	GEH
Wanneroo Road / Elliot Road	S to N	1619	1682	1.56
Wanneroo Road / Elliot Road	S to E	181	180	0.04
Wanneroo Road / Elliot Road	E to S	117	109	0.75
Wanneroo Road / Elliot Road	E to N	55	61	0.74
Wanneroo Road / Elliot Road	N to E	66	67	0.17
Wanneroo Road / Elliot Road	N to S	843	843	0.01
Wanneroo Road / Celestine Road	S to N	1674	1575	2.46
Wanneroo Road / Celestine Road	S to E	172	166	0.43
Wanneroo Road / Celestine Road	E to S	88	84	0.41
Wanneroo Road / Celestine Road	E to N	12	11	0.29
Wanneroo Road / Celestine Road	N to E	17	15	0.50
Wanneroo Road / Celestine Road	N to S	909	826	2.81
Wanneroo Road / Ariti Avenue	S to W	36	61	3.54
Wanneroo Road / Ariti Avenue	S to N	1637	1525	2.82
Wanneroo Road / Ariti Avenue	N to S	826	817	0.30
Wanneroo Road / Ariti Avenue	N to W	35	30	0.91
Wanneroo Road / Ariti Avenue	W to N	16	23	1.63
Wanneroo Road / Ariti Avenue	W to S	23	19	0.78
Wanneroo Road / Hastings Street / Conlan Street	S to W	36	37	0.17
Wanneroo Road / Hastings Street / Conlan Street	S to N	1283	1325	1.17
Wanneroo Road / Hastings Street / Conlan Street	S to E	170	181	0.85
Wanneroo Road / Hastings Street / Conlan Street	E to S	105	111	0.54
Wanneroo Road / Hastings Street / Conlan Street	E to W	62	66	0.45
Wanneroo Road / Hastings Street / Conlan Street	W to N	87	92	0.49
Wanneroo Road / Hastings Street / Conlan Street	N to E	54	55	0.08
Wanneroo Road / Hastings Street / Conlan Street	N to S	591	677	3.42
Wanneroo Road / Hastings Street / Conlan Street	N to W	49	73	3.03
Wanneroo Road / Hastings Street / Conlan Street	W to N	42	37	0.73
Wanneroo Road / Hastings Street / Conlan Street	W to E	62	61	0.13
Wanneroo Road / Hastings Street / Conlan Street	W to S	61	55	0.79
Wanneroo Road / Dundebar Road	S to N	1386	1334	1.40
Wanneroo Road / Dundebar Road	S to E	107	112	0.52
Wanneroo Road / Dundebar Road	E to N	536	527	0.39
Wanneroo Road / Dundebar Road	N to S	696	577	4.73
Wanneroo Road / Pinjar Road	S to N	1394	1336	1.56
Wanneroo Road / Pinjar Road	S to E	452	448	0.20
Wanneroo Road / Pinjar Road	E to S	296	261	2.08
Wanneroo Road / Pinjar Road	E to N	74	76	0.28
Wanneroo Road / Pinjar Road	N to E	56	58	0.21
Wanneroo Road / Pinjar Road	N to S	733	620	4.34

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Appendix C - 2031 forecast traffic volumes

Intersection	Movement	2031 AM without LHS	2031 AM with LHS	2031 PM without LHS	2031 PM with LHS
Wanneroo Road / Elliot Road	S to N	1050	1185	2296	2589
Wanneroo Road / Elliot Road	S to E	122	139	292	325
Wanneroo Road / Elliot Road	E to S	347	330	230	232
Wanneroo Road / Elliot Road	E to N	262	246	196	192
Wanneroo Road / Elliot Road	N to E	185	217	134	186
Wanneroo Road / Elliot Road	N to S	1830	2049	1217	1328
Wanneroo Road / Celestine Road	S to N	1188	1248	2280	2447
Wanneroo Road / Celestine Road	S to E	121	180	210	335
Wanneroo Road / Celestine Road	E to S	126	168	119	163
Wanneroo Road / Celestine Road	E to N	74	122	24	40
Wanneroo Road / Celestine Road	N to E	54	106	38	50
Wanneroo Road / Celestine Road	N to S	1889	2098	1232	1351
Wanneroo Road / Ariti Avenue	S to W	11	18	59	95
Wanneroo Road / Ariti Avenue	S to N	1252	1360	2243	2412
Wanneroo Road / Ariti Avenue	N to S	1876	2123	1248	1366
Wanneroo Road / Ariti Avenue	N to W	30	52	54	87
Wanneroo Road / Ariti Avenue	W to N	49	76	36	56
Wanneroo Road / Ariti Avenue	W to S	49	77	26	35
Wanneroo Road / Hastings Street / Conlan Street	S to W	31	54	38	44
Wanneroo Road / Hastings Street / Conlan Street	S to N	1168	1241	2015	2102
Wanneroo Road / Hastings Street / Conlan Street	S to E	104	137	224	332
Wanneroo Road / Hastings Street / Conlan Street	E to S	42	62	127	185
Wanneroo Road / Hastings Street / Conlan Street	E to W	26	46	66	139
Wanneroo Road / Hastings Street / Conlan Street	E to N	16	28	189	260
Wanneroo Road / Hastings Street / Conlan Street	N to E	100	137	104	159
Wanneroo Road / Hastings Street / Conlan Street	N to S	1829	2045	1132	1206
Wanneroo Road / Hastings Street / Conlan Street	N to W	100	143	108	165
Wanneroo Road / Hastings Street / Conlan Street	W to N	64	76	68	100
Wanneroo Road / Hastings Street / Conlan Street	W to E	90	166	78	143
Wanneroo Road / Hastings Street / Conlan Street	W to S	81	103	55	67
Wanneroo Road / Dundebar Road	S to N	986	1053	2018	2167
Wanneroo Road / Dundebar Road	S to E	266	294	255	289
Wanneroo Road / Dundebar Road	E to S	361	423	374	443
Wanneroo Road / Dundebar Road	E to N	914	894	1448	1562
Wanneroo Road / Dundebar Road	N to E	1028	1061	528	523
Wanneroo Road / Dundebar Road	N to S	1679	1910	972	1084
Wanneroo Road / Pinjar Road	S to N	1365	1432	2128	2246
Wanneroo Road / Pinjar Road	S to E	754	751	1510	1603
Wanneroo Road / Pinjar Road	E to S	1219	1342	685	764
Wanneroo Road / Pinjar Road	E to N	304	304	384	410
Wanneroo Road / Pinjar Road	N to E	332	297	233	237
Wanneroo Road / Pinjar Road	N to S	1665	1801	944	1024

Appendix D - Modelled intersection configurations – Paramics

Wanneroo Road – Pinjar Road

Existing layout	'without LHS' and 'with LHS'
	

Wanneroo Road – New Intersection

Existing layout	'without LHS' and 'with LHS'
	

Wanneroo Road – Church Street

Existing layout	'without LHS' and 'with LHS'
	

Wanneroo Road – Dundebar Road

Existing layout	'without LHS' and 'with LHS'
	

Wanneroo Road – Hastings Street

Existing layout	'without LHS' and 'with LHS'
	

Wanneroo Road – Ariti Avenue

Existing layout	'without LHS' and 'with LHS'
	

Wanneroo Road – Celestine Street

Existing layout	'without LHS' (no change from existing)	'with LHS'
		

Wanneroo Road – Elliot Road

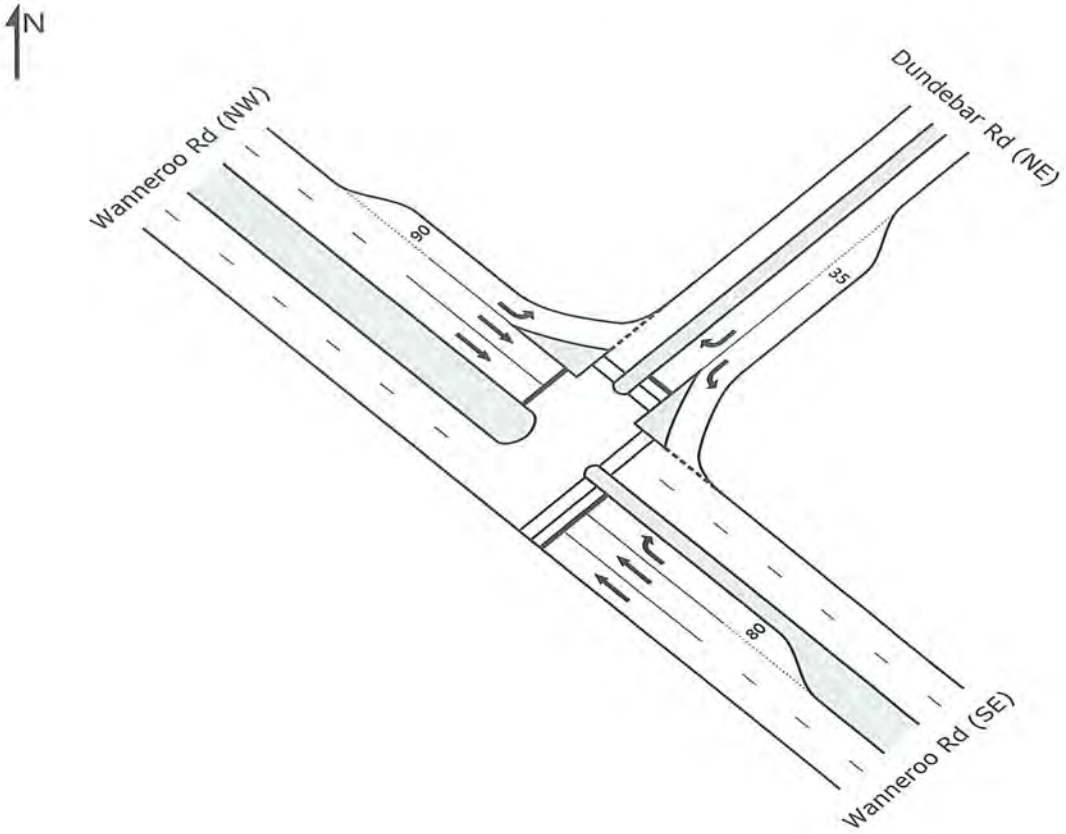
Existing layout	'without LHS' and 'with LHS'
	

Appendix E - Summary of Sidra analysis, 2031 no LHS existing geometry

Sidra Analysis with NO LHS 2031

This technical note provides the Sidra analysis and output for the Existing Intersection Geometry for full development (2031) with No LHS.

Wanneroo Road/Dundebar Road Intersection 2031



Dundebar Rd / Wanneroo Rd 2031 NO LHS am Existing Geometry
Signals - Fixed Time Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Wanneroo Rd (SE)											
22	T	1103	5.0	0.625	31.4	LOS C	29.8	217.4	0.81	0.73	30.7
23	R	149	5.0	1.029	177.3	LOS F	17.8	130.3	1.00	1.30	10.2
Approach		1252	5.0	1.029	48.7	LOS D	29.8	217.4	0.83	0.80	24.8
North East: Dundebar Rd (NE)											
24	L	239	5.0	1.000 [3]	22.5	LOS C	7.9	57.5	0.53	0.72	37.3
26	R	1036	5.0	1.285	595.8	LOS F	280.5	2047.6	1.00	2.20	3.5
Approach		1275	5.0	1.285	488.3	LOS F	280.5	2047.6	0.91	1.92	4.2
North West: Wanneroo Rd (NW)											
27	L	1028	5.0	1.000 [3]	12.7	LOS B	20.1	147.1	0.69	0.81	44.4
28	T	1679	5.0	1.274	572.0	LOS F	220.9	1612.5	1.00	3.12	3.6
Approach		2707	5.0	1.274	359.6	LOS F	220.9	1612.5	0.88	2.24	5.5
All Vehicles		5234	5.0	1.285	316.6	LOS F	280.5	2047.6	0.88	1.82	6.2

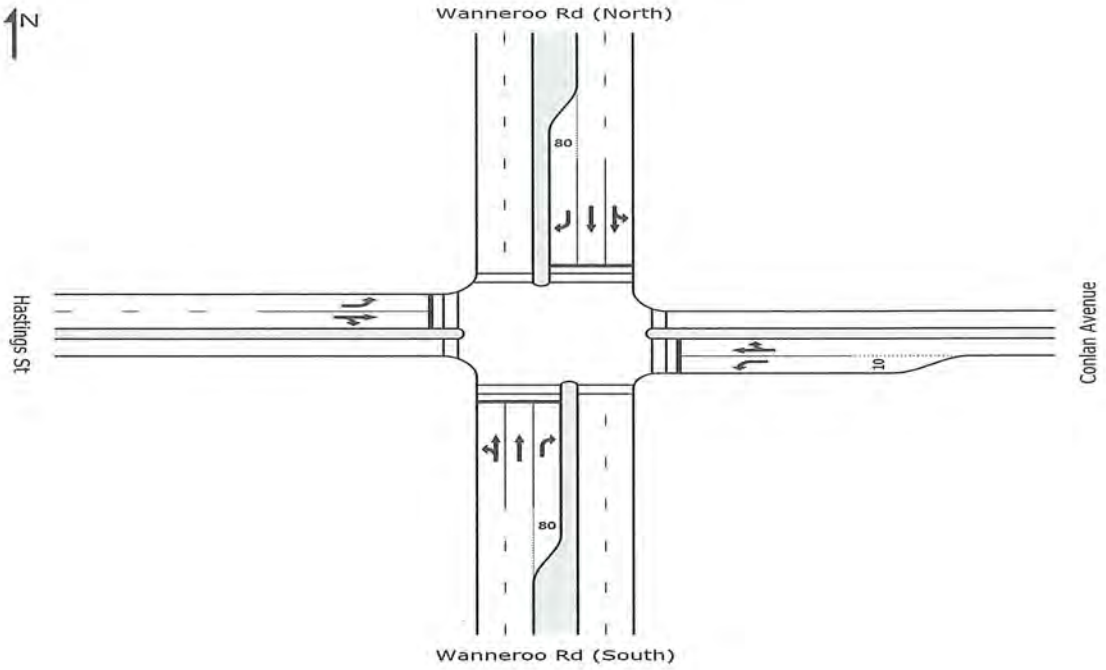
Dundebar Rd / Wanneroo Rd 2031 NO LHS pm Existing Geometry
Signals - Fixed Time Cycle Time = 124 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Wanneroo Rd (SE)											
22	T	2096	5.0	1.499	965.2	LOS F	361.3	2637.2	1.00	4.82	2.2
23	R	177	5.0	1.017	147.6	LOS F	17.8	130.2	1.00	1.33	11.9
Approach		2273	5.0	1.499	901.7	LOS F	361.3	2637.2	1.00	4.54	2.3
North East: Dundebar Rd (NE)											
24	L	374	5.0	0.997	16.5	LOS B	7.9	57.4	0.57	0.74	41.4
26	R	1448	5.0	1.517	1000.7	LOS F	511.5	3733.7	1.00	3.17	2.1
Approach		1822	5.0	1.517	798.7	LOS F	511.5	3733.7	0.91	2.67	2.6
North West: Wanneroo Rd (NW)											
27	L	528	5.0	0.513	9.9	LOS A	6.4	46.6	0.29	0.68	47.3
28	T	972	5.0	1.140	330.0	LOS F	85.7	625.6	1.00	2.43	5.9
Approach		1500	5.0	1.140	217.3	LOS F	85.7	625.6	0.75	1.82	8.6
All Vehicles		5595	5.0	1.517	684.7	LOS F	511.5	3733.7	0.90	3.20	3.0

The above analysis indicates an intersection LoS of F to 2031 with no LHS for the current geometry. Stop rates for some movements are greater than 3 and the degree of saturation is 1.285 to 1.517. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance

Wanneroo Road/Hastings Road Intersection 2031



Wannerroo Hastings 2031 NO LHS Existing Geometry am
Signals - Fixed Time Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
1	L	31	5.0	0.636	37.4	LOS D	31.5	230.2	0.79	0.94	31.0
2	T	1168	5.0	0.636	29.1	LOS C	31.6	230.8	0.79	0.72	31.9
3	R	104	5.0	0.967	117.1	LOS F	9.7	70.8	1.00	1.14	14.2
Approach		1303	5.0	0.967	36.3	LOS D	31.6	230.8	0.81	0.75	29.0
East: Conlan Avenue											
4	L	35	5.0	1.000 [3]	72.9	LOS E	2.2	16.3	0.96	0.71	20.0
5	T	33	5.0	0.192	61.8	LOS E	3.2	23.5	0.92	0.70	21.1
6	R	16	5.0	0.192	70.0	LOS E	3.2	23.5	0.92	0.76	20.9
Approach		84	5.0	1.000	67.9	LOS E	3.2	23.5	0.94	0.72	20.6
North: Wanneroo Rd (North)											
7	L	100	5.0	1.024	149.2	LOS F	122.3	893.0	1.00	1.44	12.0
8	T	1829	5.0	1.024	140.7	LOS F	122.9	897.0	1.00	1.45	12.1
9	R	100	5.0	0.929	103.9	LOS F	8.7	63.2	1.00	1.06	15.6
Approach		2029	5.0	1.024	139.3	LOS F	122.9	897.0	1.00	1.43	12.2
West: Hastings St											
10	L	64	5.0	0.255	71.0	LOS E	4.2	30.8	0.93	0.77	20.3
11	T	90	5.0	0.663	67.3	LOS E	12.1	88.5	1.00	0.83	20.0
12	R	81	5.0	0.663	75.5	LOS E	12.1	88.5	1.00	0.83	19.9
Approach		235	5.0	0.663	71.1	LOS E	12.1	88.5	0.98	0.81	20.0
All Vehicles		3651	5.0	1.024	96.5	LOS F	122.9	897.0	0.93	1.14	16.1

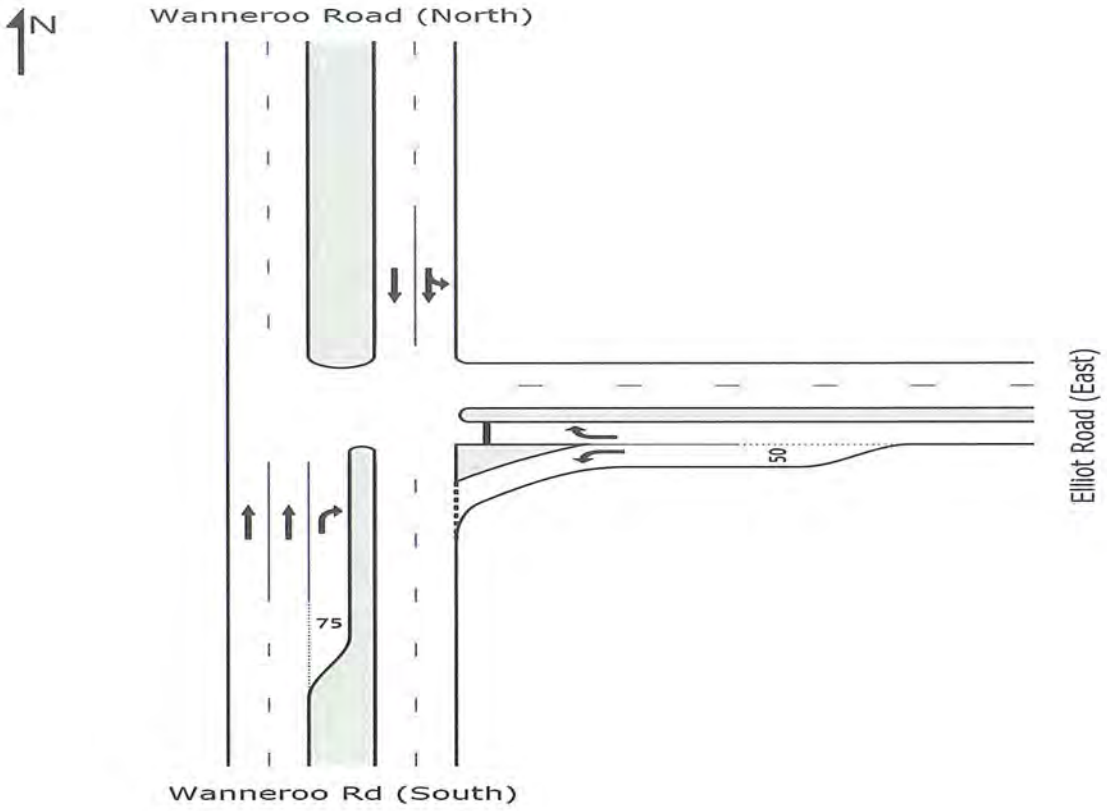
Wannerroo Hastings 2031 NO LHS Existing Geometry pm
Signals - Fixed Time Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Rd (South)											
1	L	38	5.0	1.206	454.2	LOS F	249.4	1820.5	1.00	2.68	4.5
2	T	2112	5.0	1.206	445.8	LOS F	249.4	1820.5	1.00	2.66	4.5
3	R	127	5.0	1.065	230.5	LOS F	17.9	130.6	1.00	1.41	8.2
Approach		2277	5.0	1.206	433.9	LOS F	249.4	1820.5	1.00	2.59	4.6
East: Conlan Avenue											
4	L	36	5.0	1.000 [3]	71.4	LOS E	2.2	16.3	0.97	0.72	20.2
5	T	157	5.0	1.196	443.4	LOS F	76.2	556.1	1.00	2.00	4.5
6	R	189	5.0	1.196	451.6	LOS F	76.2	556.1	1.00	2.00	4.5
Approach		382	5.0	1.196	412.8	LOS F	76.2	556.1	1.00	1.88	4.8
North: Wanneroo Rd (North)											
7	L	104	5.0	0.694	41.2	LOS D	34.8	253.7	0.85	0.92	29.3
8	T	1132	5.0	0.694	32.8	LOS C	35.1	255.9	0.85	0.77	30.1
9	R	108	5.0	0.903	98.5	LOS F	9.1	66.1	1.00	1.01	16.2
Approach		1344	5.0	0.903	38.7	LOS D	35.1	255.9	0.86	0.80	28.1
West: Hastings St											
10	L	68	5.0	0.271	71.2	LOS E	4.5	32.9	0.94	0.77	20.3
11	T	78	5.0	0.514	65.4	LOS E	9.2	66.9	0.98	0.79	20.4
12	R	55	5.0	0.514	73.6	LOS E	9.2	66.9	0.98	0.81	20.3
Approach		201	5.0	0.514	69.6	LOS E	9.2	66.9	0.96	0.79	20.3
All Vehicles		4204	5.0	1.206	288.3	LOS F	249.4	1820.5	0.95	1.87	6.7

The above analysis indicates an intersection LoS of F to 2031 with no LHS for the current geometry. Stop rates for some movements are greater than 2 for some movements and the degree of saturation is 1.024 to 1.206. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

Wanneroo Road/Elliot Road Intersection 2031



Wanneroo Rd / Elliot Rd 2031 NO LHS 2031 am
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Rd (South)											
2	T	1095	5.0	0.291	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	77	5.0	1.283	661.2	LOS F	25.5	186.4	1.00	2.73	3.1
Approach		1172	5.0	1.283	43.4	NA	25.5	186.4	0.07	0.18	27.4
East: Elliot Road (East)											
4	L	70	5.0	1.170	466.8	LOS F	17.0	123.9	1.00	2.28	4.4
6	R	539	5.0	8.045	12757.5	LOS F	609.8	4451.6	1.00	7.97	0.2
Approach		609	5.0	8.045	11340.8	LOS F	609.8	4451.6	1.00	7.32	0.2
North: Wanneroo Road (North)											
7	L	185	5.0	0.536	8.4	LOS A	0.0	0.0	0.00	0.98	49.0
8	T	1830	5.0	0.536	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		2015	5.0	0.536	0.8	NA	0.0	0.0	0.00	0.09	58.8
All Vehicles		3796	5.0	8.045	1833.2	NA	609.8	4451.6	0.18	1.28	1.2

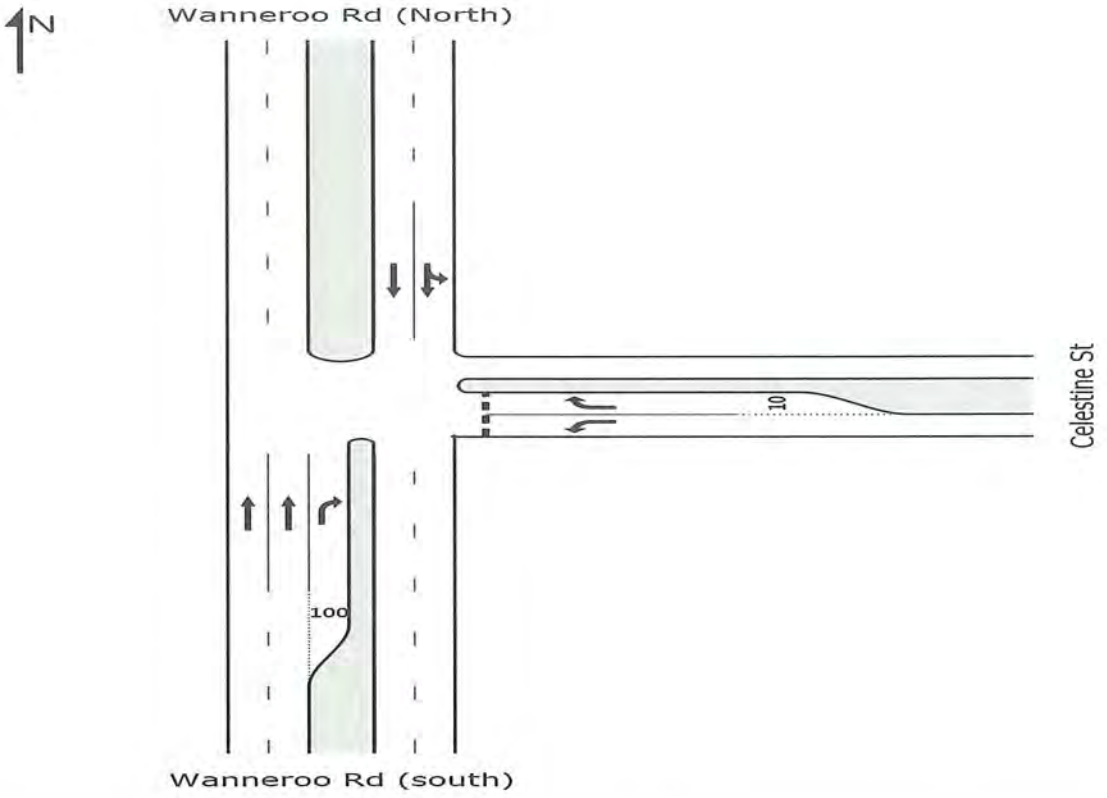
Wanneroo Rd / Elliot Rd 2031 NO LHS 2031 pm
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	2336	5.0	0.619	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	252	5.0	1.044	170.3	LOS F	25.5	186.1	1.00	3.01	10.6
Approach		2588	5.0	1.044	16.6	NA	25.5	186.1	0.10	0.29	41.2
East: Elliot Road (East)											
4	L	195	5.0	1.018	148.7	LOS F	16.8	122.5	1.00	2.42	11.9
6	R	231	5.0	1.458	881.9	LOS F	96.5	704.4	1.00	6.53	2.4
Approach		426	5.0	1.458	545.5	LOS F	96.5	704.4	1.00	4.64	3.8
North: Wanneroo Road (North)											
7	L	134	5.0	0.360	8.4	LOS A	0.0	0.0	0.00	0.97	49.0
8	T	1217	5.0	0.360	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1351	5.0	0.360	0.8	NA	0.0	0.0	0.00	0.10	58.7
All Vehicles		4365	5.0	1.458	63.3	NA	96.5	704.4	0.16	0.66	21.9

The above analysis indicates an intersection LoS of F to 2031 with no LHS for the current geometry. Stop rates for the right turn out of Elliot Road are around 7 and the degree of saturation is up to 8.0451. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

Wanneroo Road/Celestine Road Intersection 2031



Wannerro Rd / Celestine St 2031 NO LHS Existing Geometry AM
Giveway / Yield (Two-Way) To Median

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Rd (south)											
2	T	1223	5.0	0.324	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	86	5.0	1.376	814.3	LOS F	34.0	248.5	1.00	3.16	2.6
Approach		1309	5.0	1.376	53.7	NA	34.0	248.5	0.07	0.21	24.2
East: Celestine St											
4	L	133	5.0	2.223	2294.8	LOS F	97.5	712.0	1.00	5.14	0.9
6	R	67	5.0	1.000 [3]	88.8	LOS F	3.4	24.9	1.00	1.07	17.4
Approach		200	5.0	2.223	1560.2	LOS F	97.5	712.0	1.00	3.79	1.4
North: Wanneroo Rd (North)											
7	L	54	5.0	0.515	8.4	LOS A	0.0	0.0	0.00	1.06	49.0
8	T	1889	5.0	0.515	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1943	5.0	0.515	0.2	NA	0.0	0.0	0.00	0.03	59.6
All Vehicles		3452	5.0	2.223	110.9	NA	97.5	712.0	0.08	0.31	14.8

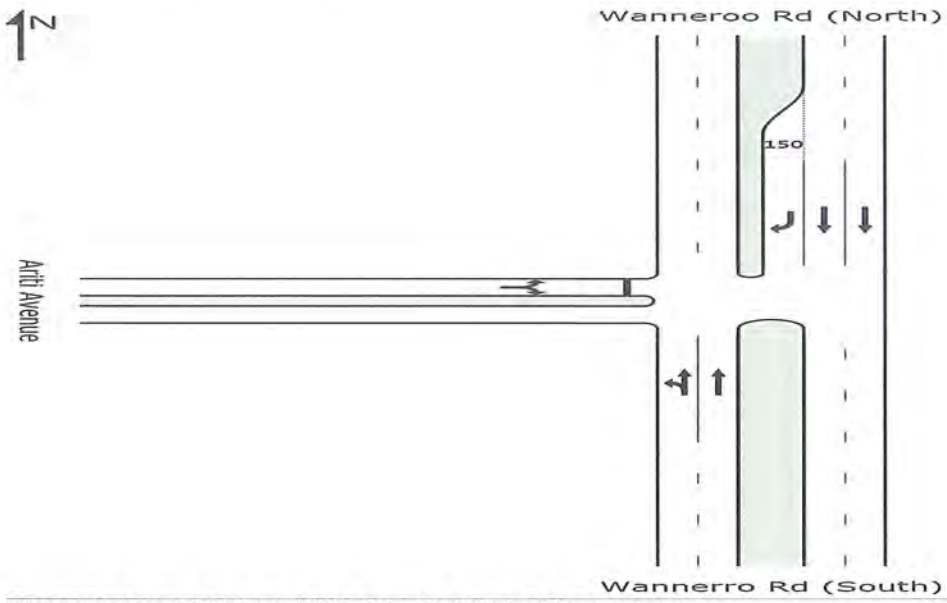
Wannerro Rd / Celestine St 2031 NO LHS Existing Geometry PM
Giveway / Yield (Two-Way) To Median

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (south)											
2	T	2280	5.0	0.604	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	210	5.0	0.750	36.4	LOS E	4.4	31.8	0.94	1.26	30.1
Approach		2490	5.0	0.750	3.1	NA	4.4	31.8	0.08	0.11	55.4
East: Celestine St											
4	L	119	5.0	0.580	35.0	LOS E	2.4	17.6	0.92	1.10	30.6
6	R	24	5.0	0.134	27.6	LOS D	0.4	3.0	0.87	0.96	34.2
Approach		143	5.0	0.580	33.8	LOS D	2.4	17.6	0.91	1.07	31.2
North: Wanneroo Rd (North)											
7	L	38	5.0	0.337	8.4	LOS A	0.0	0.0	0.00	1.06	49.0
8	T	1232	5.0	0.337	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1270	5.0	0.337	0.3	NA	0.0	0.0	0.00	0.03	59.6
All Vehicles		3903	5.0	0.750	3.3	NA	4.4	31.8	0.08	0.12	55.1

The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for the left turn out of Celestine Street Road are around 5 and the degree of saturation is up to 2.223. Queuing is significant and unacceptable in Celestine Street. The analysis indicates that upgrade is required to improve the performance.

Wanneroo Road/Ariti Ave 2031



Wanneroo Road / Ariti Ave 2031 NO LHS Existing Geometry am
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wannerro Rd (South)											
1	L	12	7.4	0.357	8.5	LOS A	0.0	0.0	0.00	1.10	49.0
2	T	1318	7.4	0.357	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1329	7.4	0.357	0.1	NA	0.0	0.0	0.00	0.01	59.9
North: Wanneroo Rd (North)											
8	T	1975	7.4	0.531	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
9	R	32	7.4	0.141	24.4	LOS C	0.5	3.4	0.86	0.95	36.1
Approach		2006	7.4	0.531	0.4	NA	0.5	3.4	0.01	0.02	59.4
West: Ariti Avenue											
10	L	52	7.4	0.599	43.9	LOS E	2.4	18.0	0.93	1.12	28.0
12	R	52	7.4	0.599	43.9	LOS E	2.4	18.0	0.93	1.13	28.0
Approach		103	7.4	0.599	43.9	LOS E	2.4	18.0	0.93	1.12	28.0
All Vehicles		3439	7.4	0.599	1.6	NA	2.4	18.0	0.04	0.05	57.6

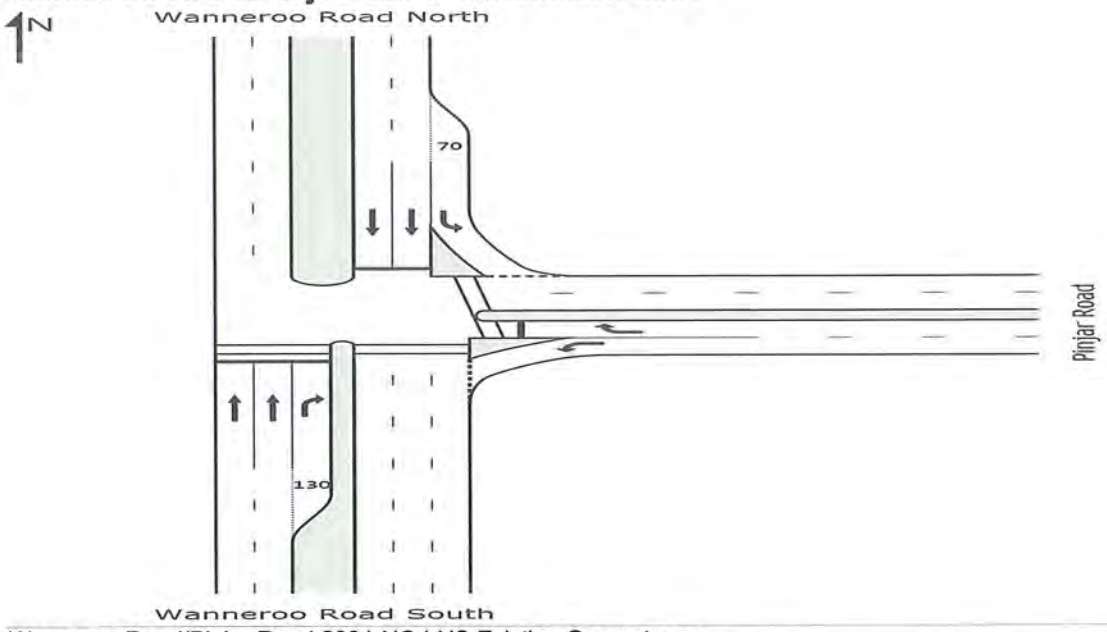
Wanneroo Road / Ariti Ave 2031 NO LHS Existing Geometry am From Median
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wannerro Rd (South)											
1	L	12	7.4	0.357	8.5	LOS A	0.0	0.0	0.00	1.10	49.0
2	T	1318	7.4	0.357	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1329	7.4	0.357	0.1	NA	0.0	0.0	0.00	0.01	59.9
North: Wanneroo Rd (North)											
8	T	1975	7.4	0.531	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
9	R	32	7.4	0.141	24.4	LOS C	0.5	3.4	0.86	0.95	36.1
Approach		2006	7.4	0.531	0.4	NA	0.5	3.4	0.01	0.02	59.4
West: Ariti Avenue											
10	L	52	7.4	1.211	506.3	LOS F	27.6	205.3	1.00	3.09	4.0
12	R	52	7.4	1.211	506.3	LOS F	27.6	205.3	1.00	2.93	4.0
Approach		103	7.4	1.211	506.3	LOS F	27.6	205.3	1.00	3.01	4.0
All Vehicles		3439	7.4	1.211	15.4	NA	27.6	205.3	0.04	0.10	42.2

AM analysis has been undertaken only. The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for the left/right turn out of Ariti Ave are around 3 and the degree of saturation is up to 1.211. Queuing is significant and unacceptable in Ariti Ave. The analysis indicates that upgrade is required to improve the performance.

Wanneroo Road/Pinjar Road Intersection 2031



Wanneroo Road/Pinjar Road 2031 NO LHS Existing Geometry am
Signals - Fixed Time Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road South											
2	T	1713	5.0	0.681	15.5	LOS B	37.3	272.3	0.66	0.61	39.8
3	R	406	5.0	1.000 [3]	70.9	LOS E	30.0	218.7	1.00	0.87	20.4
Approach		2119	5.0	1.000	26.2	LOS C	37.3	272.3	0.72	0.66	33.7
East: Pinjar Road											
4	L	1219	5.0	1.291	584.1	LOS F	310.8	2269.1	1.00	2.38	3.6
6	R	304	5.0	0.687	63.3	LOS E	20.2	147.6	0.97	0.85	22.0
Approach		1523	5.0	1.291	480.1	LOS F	310.8	2269.1	0.99	2.08	4.3
North: Wanneroo Road North											
7	L	332	5.0	0.589	14.8	LOS B	7.8	57.2	0.40	0.70	42.8
8	T	1665	5.0	1.084	239.2	LOS F	134.4	980.9	1.00	1.89	7.8
Approach		1997	5.0	1.084	201.9	LOS F	134.4	980.9	0.90	1.70	9.1
All Vehicles		5639	5.0	1.291	211.0	LOS F	310.8	2269.1	0.86	1.41	8.8

Wanneroo Road/Pinjar Road 2031 NO LHS Existing Geometry pm
Signals - Fixed Time Cycle Time = 125 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road South											
2	T	3086	5.0	1.153	331.3	LOS F	301.1	2198.0	1.00	2.41	5.9
3	R	552	5.0	1.000 [3]	45.6	LOS D	29.1	212.2	1.00	0.89	26.7
Approach		3638	5.0	1.153	287.9	LOS F	301.1	2198.0	1.00	2.18	6.7
East: Pinjar Road											
4	L	685	5.0	0.579	16.9	LOS B	19.4	141.8	0.59	0.78	41.1
6	R	384	5.0	1.164	382.3	LOS F	72.9	532.2	1.00	1.95	5.2
Approach		1069	5.0	1.164	148.2	LOS F	72.9	532.2	0.74	1.20	11.9
North: Wanneroo Road North											
7	L	233	5.0	0.436	15.6	LOS B	5.2	38.2	0.45	0.71	42.2
8	T	944	5.0	0.919	66.7	LOS E	34.5	252.1	1.00	1.13	20.5
Approach		1177	5.0	0.919	56.6	LOS E	34.5	252.1	0.89	1.04	22.8
All Vehicles		5884	5.0	1.164	216.3	LOS F	301.1	2198.0	0.93	1.78	8.6

The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for some movements are in excess of 1 for a number of movements. The degree of saturation is up to 1.291. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

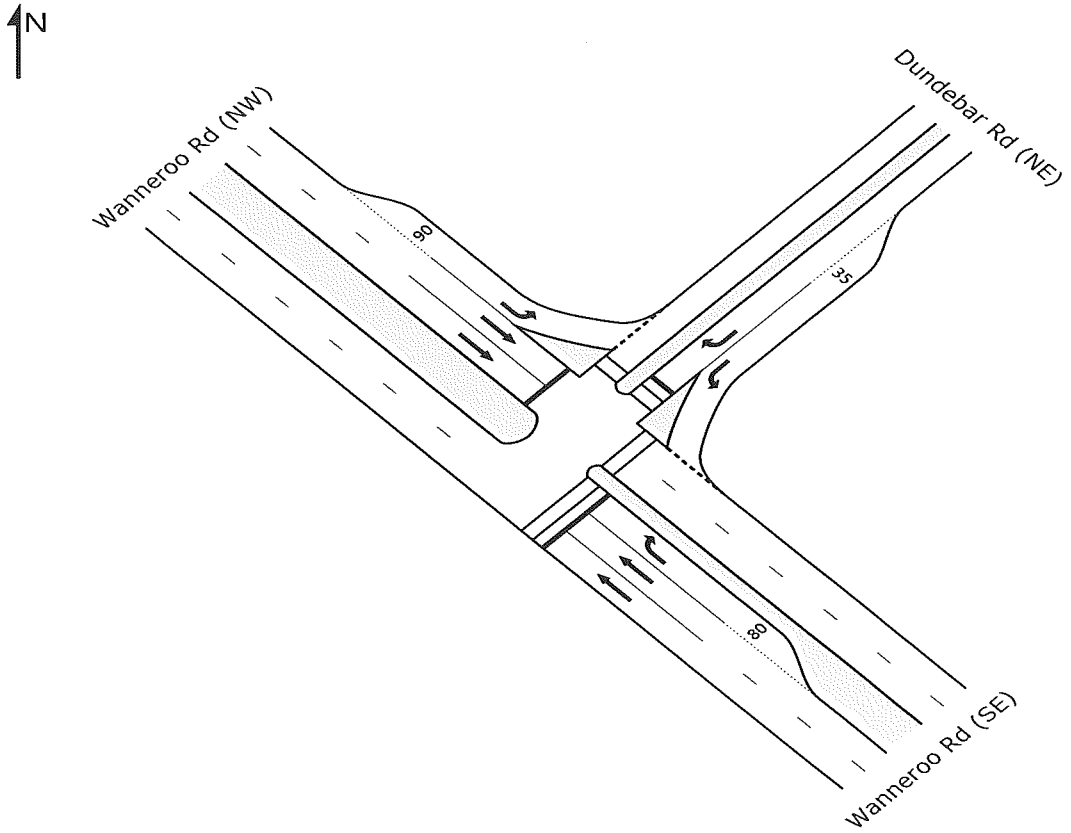
Appendix F - Summary of Sidra analysis, 2031 with LHS proposed geometry

Sidra Analysis with LHS 2031

This technical note provides the Sidra analysis and output for the Proposed Ultimate Intersection Geometry for full development (2031) WITH LHS and a compromise Geometry where the site is constrained to avoid land acquisition.

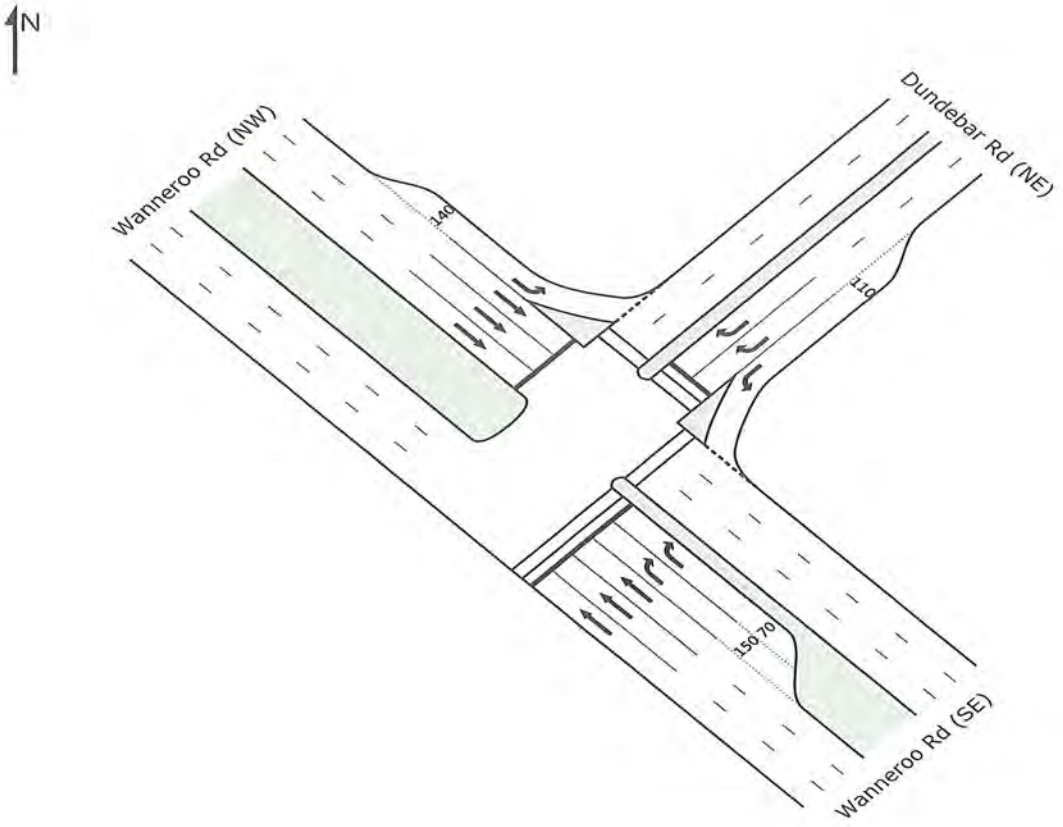
Wanneroo Road/Dundebar Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Dundebar Rd / Wanneroo Rd 2031 WITH LHS am
Signals - Fixed Time Cycle Time = 90 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Wanneroo Rd (SE)											
22	T	1053	4.0	0.339	12.2	LOS B	8.5	61.8	0.60	0.52	43.0
23	R	294	4.0	0.814	57.5	LOS E	7.1	51.8	1.00	0.95	23.4
Approach		1347	4.0	0.814	22.1	LOS C	8.5	61.8	0.69	0.61	36.3
North East: Dundebar Rd (NE)											
24	L	423	4.0	0.514	19.7	LOS B	9.3	67.0	0.62	0.83	39.2
26	R	894	4.0	0.768	40.2	LOS D	18.8	136.3	0.96	0.90	28.6
Approach		1317	4.0	0.768	33.6	LOS C	18.8	136.3	0.85	0.88	31.4
North West: Wanneroo Rd (NW)											
27	L	1061	4.0	0.816	12.0	LOS B	16.5	119.8	0.47	0.78	45.3
28	T	1910	4.0	0.887	40.1	LOS D	32.1	232.3	1.00	1.08	27.3
Approach		2971	4.0	0.887	30.1	LOS C	32.1	232.3	0.81	0.97	31.8
All Vehicles		5635	4.0	0.887	29.0	LOS C	32.1	232.3	0.79	0.86	32.7

Dundebar Rd / Wanneroo Rd 2031 with LHS PM
Signals - Fixed Time Cycle Time = 130 seconds (Practical Cycle Time)

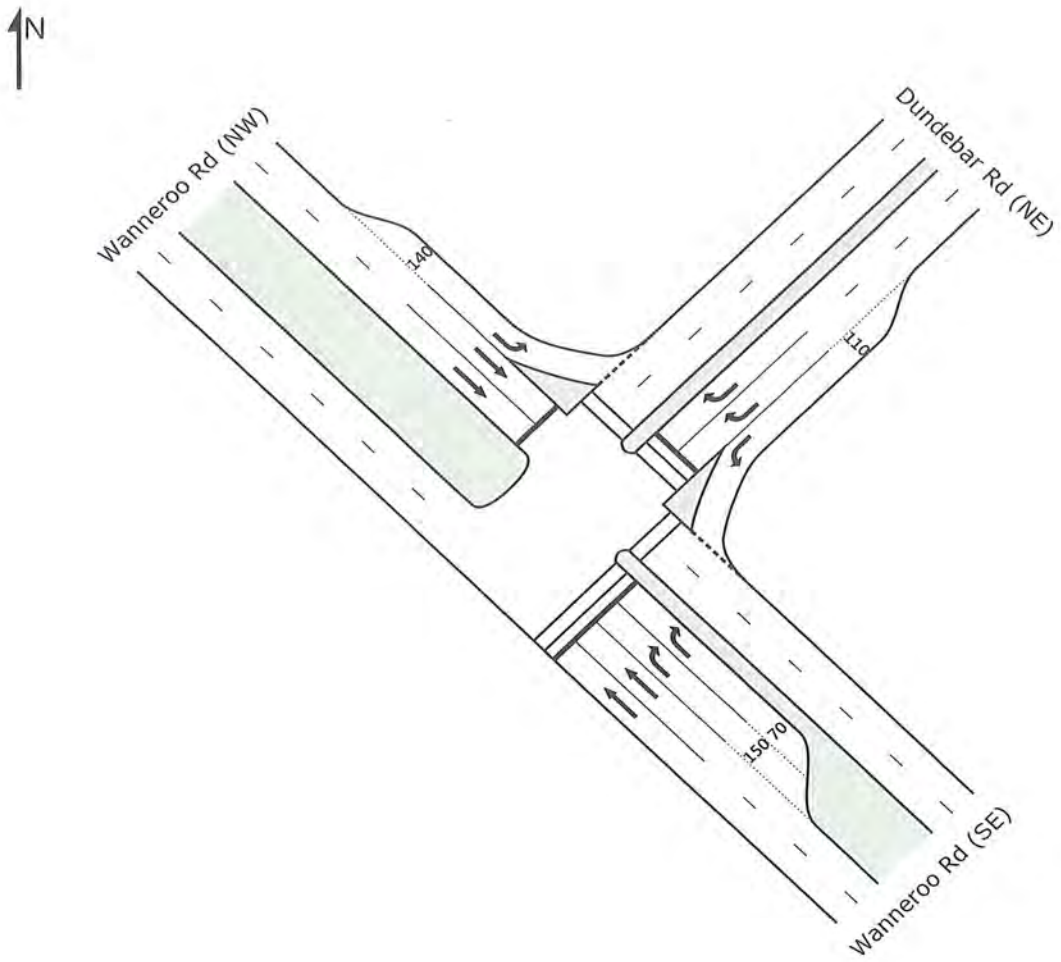
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Wanneroo Rd (SE)											
22	T	2167	4.0	0.898	49.5	LOS D	49.4	357.9	1.00	1.02	24.4
23	R	289	4.0	0.694	70.6	LOS E	9.3	67.0	1.00	0.84	20.5
Approach		2456	4.0	0.898	52.0	LOS D	49.4	357.9	1.00	1.00	23.9
North East: Dundebar Rd (NE)											
24	L	442	4.0	0.505	14.2	LOS B	9.5	68.9	0.42	0.75	43.4
26	R	1561	4.0	0.892	51.1	LOS D	51.4	372.3	0.98	0.97	25.1
Approach		2003	4.0	0.892	43.0	LOS D	51.4	372.3	0.86	0.92	27.7
North West: Wanneroo Rd (NW)											
27	L	522	4.0	0.428	9.4	LOS A	5.9	42.5	0.24	0.66	47.8
28	T	1083	4.0	0.726	47.6	LOS D	21.1	152.5	0.97	0.85	25.0
Approach		1605	4.0	0.726	35.2	LOS D	21.1	152.5	0.73	0.79	29.6
All Vehicles		6064	4.0	0.898	44.6	LOS D	51.4	372.3	0.88	0.92	26.4

The above analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required.

A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise and the operation is forecast to be unacceptable. Additional through lanes on Wanneroo Road are required.

Recommended Geometry (if no land resumption)



Dundebar Rd / Wanneroo Rd 2031 WITH LHS am
Signals - Fixed Time Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Wanneroo Rd (SE)											
22	T	1053	4.0	0.420	12.6	LOS B	17.7	127.8	0.51	0.46	43.0
23	R	294	4.0	0.939	105.3	LOS F	13.0	94.3	1.00	1.08	15.5
Approach		1347	4.0	0.939	32.8	LOS C	17.7	127.8	0.62	0.59	30.9
North East: Dundebar Rd (NE)											
24	L	423	4.0	0.808	48.1	LOS D	21.6	156.4	0.80	1.00	26.1
26	R	894	4.0	0.952	100.2	LOS F	42.2	305.4	1.00	1.06	16.0
Approach		1317	4.0	0.952	83.5	LOS F	42.2	305.4	0.94	1.04	18.3
North West: Wanneroo Rd (NW)											
27	L	1061	4.0	0.869	11.5	LOS B	20.2	146.2	0.40	0.76	45.9
28	T	1910	4.0	0.942	57.0	LOS E	80.7	584.3	1.00	1.06	22.5
Approach		2971	4.0	0.942	40.8	LOS D	80.7	584.3	0.79	0.96	27.6
All Vehicles		5635	4.0	0.952	48.9	LOS D	80.7	584.3	0.78	0.89	25.2

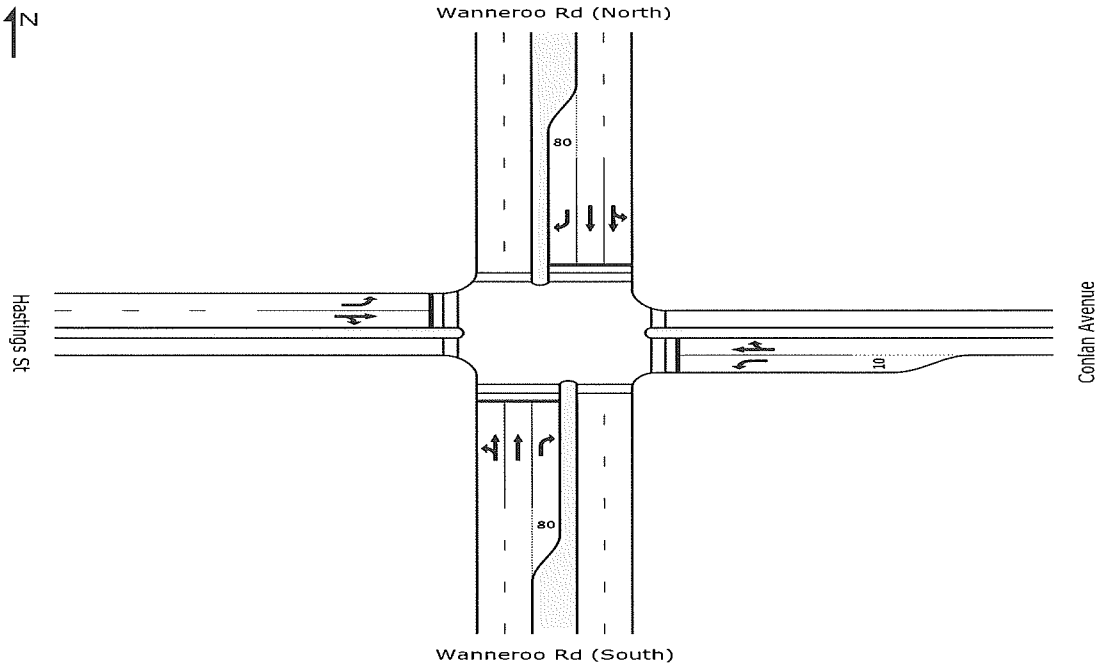
Dundebar Rd / Wanneroo Rd 2031 WITH LHS pm
Signals - Fixed Time Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South East: Wanneroo Rd (SE)											
22	T	2167	4.0	1.089	238.7	LOS F	178.6	1293.1	1.00	1.92	7.8
23	R	289	4.0	0.745	81.8	LOS F	10.8	77.9	1.00	0.86	18.5
Approach		2456	4.0	1.089	220.2	LOS F	178.6	1293.1	1.00	1.79	8.4
North East: Dundebar Rd (NE)											
24	L	443	4.0	0.625	22.2	LOS C	14.6	105.8	0.56	0.83	37.5
26	R	1562	4.0	1.092	262.7	LOS F	129.9	940.8	1.00	1.51	7.3
Approach		2005	4.0	1.092	209.6	LOS F	129.9	940.8	0.90	1.36	8.9
North West: Wanneroo Rd (NW)											
27	L	523	4.0	0.439	9.5	LOS A	6.3	45.4	0.22	0.66	47.7
28	T	1084	4.0	0.759	43.2	LOS D	34.0	246.5	0.94	0.84	26.3
Approach		1607	4.0	0.759	32.3	LOS C	34.0	246.5	0.71	0.78	30.9
All Vehicles		6068	4.0	1.092	166.9	LOS F	178.6	1293.1	0.89	1.38	10.7

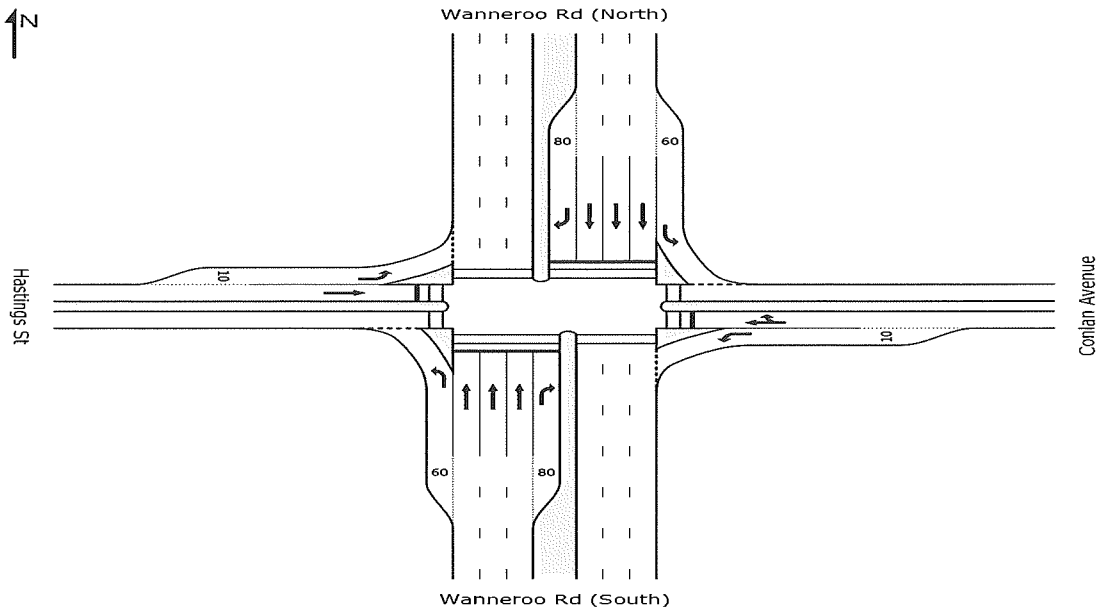
Wanneroo Road/Hastings Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Wannerroo Hastings 2031 With LHS Ultimate Geometry am
Signals - Fixed Time Cycle Time = 134 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
1	L	54	5.0	0.067	9.3	LOS A	0.5	3.7	0.20	0.64	47.9
2	T	1241	5.0	0.481	27.0	LOS C	18.6	135.7	0.75	0.66	33.1
3	R	137	5.0	0.731	74.9	LOS E	9.2	67.3	1.00	0.85	19.7
Approach		1432	5.0	0.731	30.9	LOS C	18.6	135.7	0.75	0.68	31.4
East: Conlan Avenue											
4	L	62	5.0	0.668	27.0	LOS C	2.0	14.3	0.43	0.74	34.7
5	T	46	5.0	0.765	74.5	LOS E	5.2	38.2	1.00	0.86	18.8
6	R	28	5.0	0.765	82.4	LOS F	5.2	38.2	1.00	0.86	18.9
Approach		136	5.0	0.765	54.5	LOS D	5.2	38.2	0.74	0.81	23.8
North: Wanneroo Rd (North)											
7	L	137	5.0	0.214	10.8	LOS B	1.9	13.8	0.28	0.66	46.4
8	T	2045	5.0	0.793	33.1	LOS C	37.6	274.1	0.92	0.84	30.0
9	R	143	5.0	0.763	76.0	LOS E	9.7	71.1	1.00	0.87	19.5
Approach		2325	5.0	0.793	34.4	LOS C	37.6	274.1	0.89	0.83	29.6
West: Hastings St											
10	L	76	5.0	0.533	11.3	LOS B	1.1	8.1	0.30	0.66	45.9
11	T	166	5.0	0.421	49.7	LOS D	9.5	69.1	0.92	0.75	24.4
Approach		242	5.0	0.533	37.7	LOS D	9.5	69.1	0.72	0.72	28.7
All Vehicles		4135	5.0	0.793	34.1	LOS C	37.6	274.1	0.83	0.77	29.9

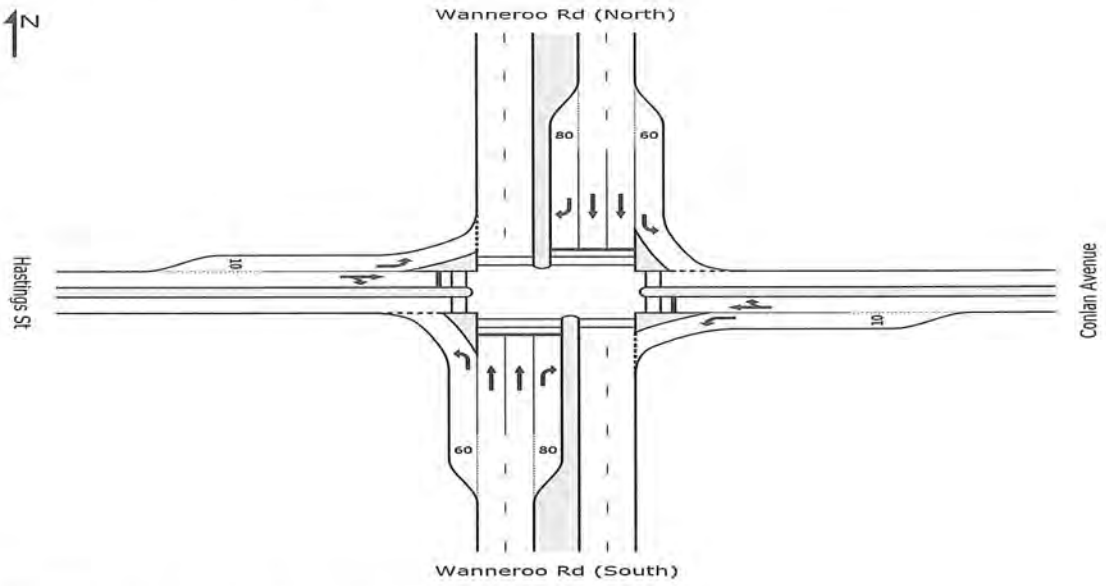
Wannerroo Hastings 2031 With LHS Existing Geometry pm
Signals - Fixed Time Cycle Time = 158 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
1	L	44	5.0	0.073	10.9	LOS B	0.6	4.7	0.25	0.64	46.4
2	T	2275	5.0	1.117	301.1	LOS F	140.5	1025.4	1.00	2.04	6.4
3	R	159	5.0	1.002	150.0	LOS F	17.8	130.3	1.00	1.22	11.8
Approach		2478	5.0	1.117	286.2	LOS F	140.5	1025.4	0.99	1.96	6.7
East: Conlan Avenue											
4	L	111	5.0	1.000 [3]	17.5	LOS B	2.2	16.3	0.58	0.71	40.7
5	T	213	5.0	1.109	294.8	LOS F	83.8	612.0	1.00	1.73	6.5
6	R	260	5.0	1.109	302.7	LOS F	83.8	612.0	1.00	1.73	6.5
Approach		584	5.0	1.109	245.5	LOS F	83.8	612.0	0.92	1.54	7.7
North: Wanneroo Rd (North)											
7	L	159	5.0	0.271	11.4	LOS B	2.6	19.1	0.27	0.66	45.9
8	T	1212	5.0	0.593	43.6	LOS D	25.0	182.6	0.87	0.77	26.3
9	R	159	5.0	1.001	149.2	LOS F	17.8	129.8	1.00	1.21	11.8
Approach		1530	5.0	1.001	51.3	LOS D	25.0	182.6	0.82	0.80	24.3
West: Hastings St											
10	L	54	5.0	1.000 [3]	31.8	LOS C	2.2	16.3	0.61	0.69	32.2
11	T	189	5.0	0.843	76.5	LOS E	20.7	151.4	1.00	0.96	18.5
12	R	67	5.0	0.843	84.4	LOS F	20.7	151.4	1.00	0.96	18.5
Approach		310	5.0	1.000	70.4	LOS E	20.7	151.4	0.93	0.91	20.0
All Vehicles		4902	5.0	1.117	194.4	LOS F	140.5	1025.4	0.92	1.48	9.4

The above analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031 in the am peak hour however pm operation is poor. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required.

A compromise is to retain two lanes in each direction on Wanneroo Road to avoid land resumption however operation will be poor as indicated in the analysis below, this option therefore is not recommended.



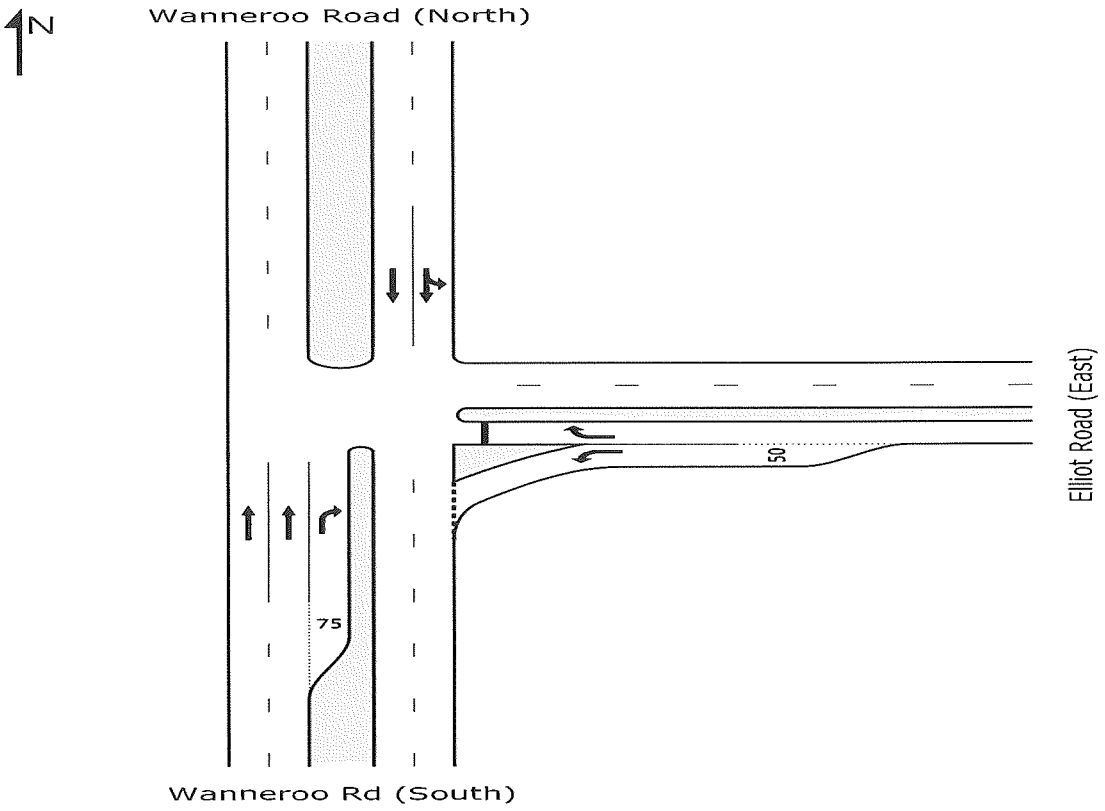
Wannerroo Hastings 2031 With Compromise Geometry pm
Signals - Fixed Time Cycle Time = 159 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
1	L	44	5.0	0.061	9.5	LOS A	0.5	3.5	0.19	0.63	47.8
2	T	2333	5.0	1.352	710.9	LOS F	359.3	2622.8	1.00	3.29	2.9
3	R	101	5.0	1.119	324.5	LOS F	17.9	130.6	1.00	1.53	6.1
Approach		2478	5.0	1.352	682.7	LOS F	359.3	2622.8	0.99	3.17	3.0
East: Conlan Avenue											
4	L	80	5.0	1.000 [3]	21.4	LOS C	2.2	16.3	0.55	0.70	38.0
5	T	244	5.0	1.336	695.5	LOS F	148.6	1084.6	1.00	2.61	3.0
6	R	260	5.0	1.336	703.5	LOS F	148.6	1084.6	1.00	2.61	3.0
Approach		584	5.0	1.336	607.1	LOS F	148.6	1084.6	0.94	2.35	3.4
North: Wanneroo Rd (North)											
7	L	159	5.0	0.235	10.1	LOS B	2.1	15.4	0.23	0.65	47.1
8	T	1270	5.0	0.734	37.1	LOS D	39.6	289.2	0.88	0.80	28.4
9	R	101	5.0	1.120	324.4	LOS F	17.9	130.6	1.00	1.53	6.1
Approach		1530	5.0	1.120	53.3	LOS D	39.6	289.2	0.82	0.83	23.6
West: Hastings St											
10	L	47	5.0	1.000 [3]	39.8	LOS D	2.2	16.3	0.69	0.69	28.9
11	T	196	5.0	1.081	252.8	LOS F	41.6	303.5	1.00	1.70	7.4
12	R	67	5.0	1.081	260.9	LOS F	41.6	303.5	1.00	1.70	7.4
Approach		310	5.0	1.081	222.5	LOS F	41.6	303.5	0.95	1.55	8.4
All Vehicles		4902	5.0	1.352	448.2	LOS F	359.3	2622.8	0.93	2.24	4.5

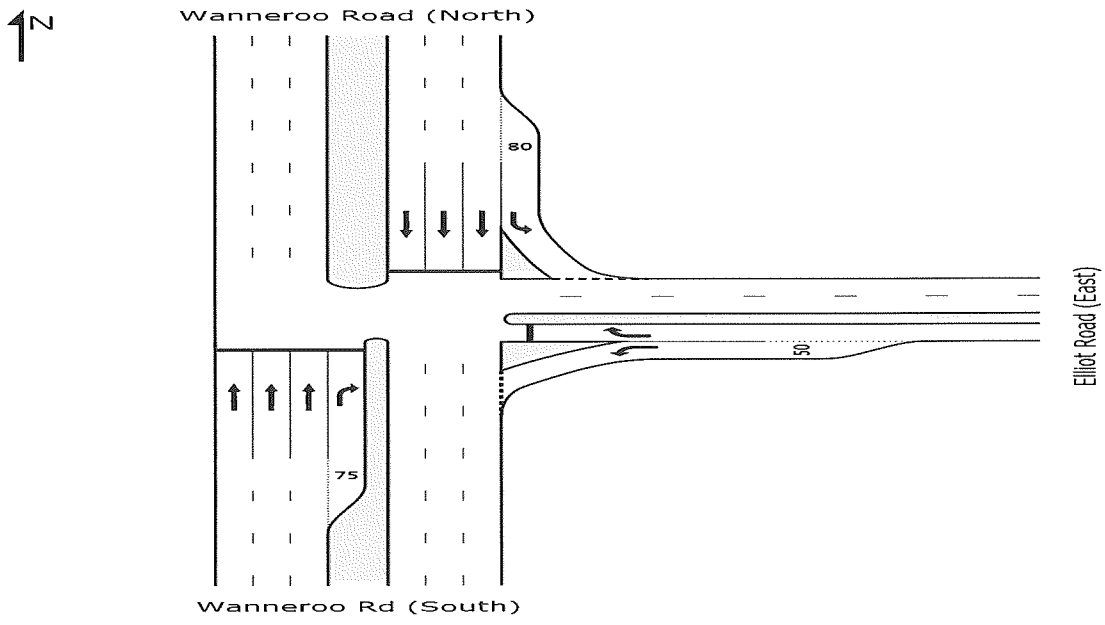
Wanneroo Road/Elliot Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry- Signalised



Wanneroo Rd / Elliot Rd 2031 With LHS 2031 am Ultimate Geometry Signals
Signals - Fixed Time Cycle Time = 101 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	1185	5.0	0.306	6.8	LOS A	7.7	55.9	0.43	0.38	48.9
3	R	139	5.0	0.712	58.8	LOS E	7.1	52.0	1.00	0.86	23.0
Approach		1324	5.0	0.712	12.2	LOS B	7.7	55.9	0.49	0.43	43.7
East: Elliot Road (East)											
4	L	330	5.0	0.817	28.6	LOS C	11.2	81.6	0.60	0.85	33.9
6	R	246	5.0	0.693	50.4	LOS D	11.7	85.7	0.98	0.85	25.3
Approach		576	5.0	0.817	37.9	LOS D	11.7	85.7	0.76	0.85	29.6
North: Wanneroo Road (North)											
7	L	217	5.0	0.196	9.0	LOS A	1.6	11.5	0.23	0.65	48.3
8	T	2049	5.0	0.702	19.9	LOS B	25.4	185.5	0.82	0.74	36.9
Approach		2266	5.0	0.702	18.9	LOS B	25.4	185.5	0.76	0.73	37.7
All Vehicles		4166	5.0	0.817	19.4	LOS B	25.4	185.5	0.68	0.65	37.9

Wanneroo Rd / Elliot Rd 2031 With LHS 2031 pm Ultimate Geometry Signals
Signals - Fixed Time Cycle Time = 100 seconds (Optimum Cycle Time - Minimum Delay)

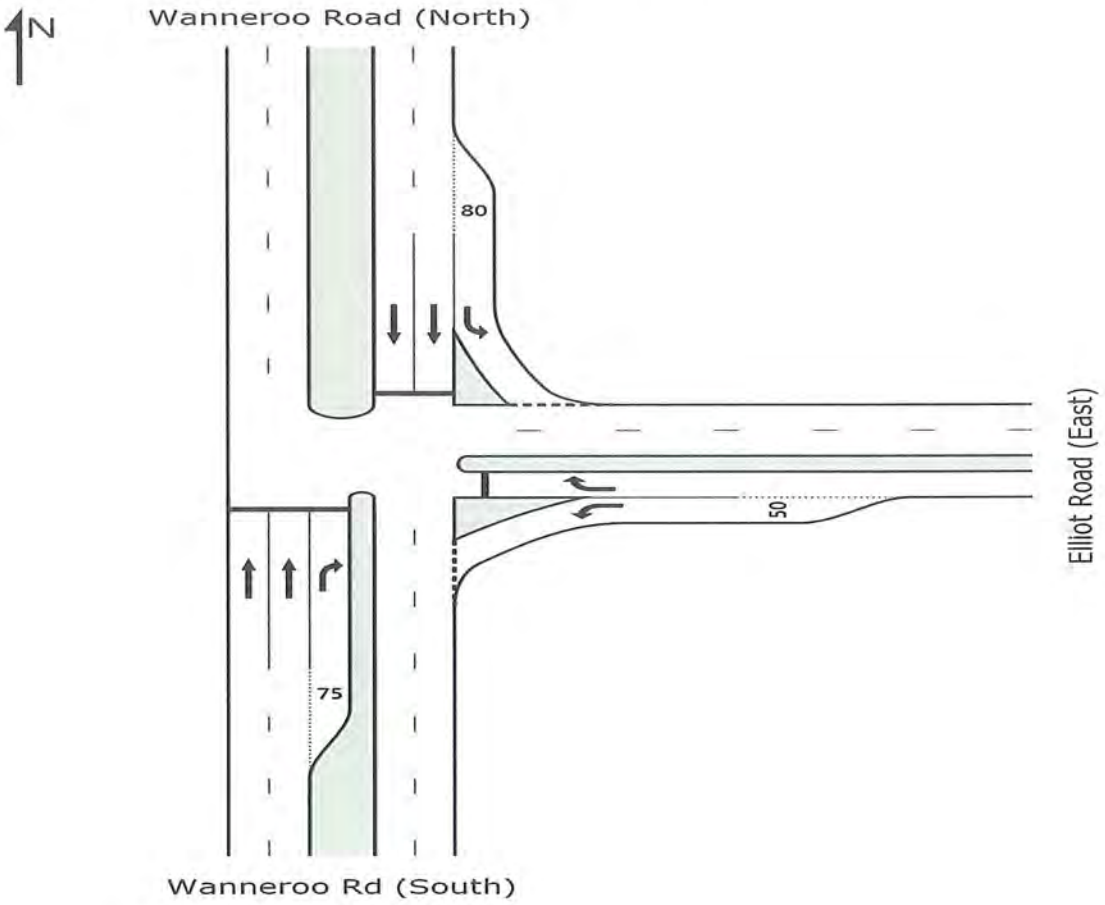
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	2589	5.0	0.617	6.6	LOS A	19.8	144.8	0.52	0.48	48.7
3	R	325	5.0	0.778	39.0	LOS D	13.5	98.8	0.82	0.87	29.1
Approach		2914	5.0	0.778	10.2	LOS B	19.8	144.8	0.55	0.52	45.3
East: Elliot Road (East)											
4	L	232	5.0	0.417	12.5	LOS B	3.5	25.9	0.41	0.70	44.8
6	R	192	5.0	0.765	57.1	LOS E	9.8	71.6	1.00	0.90	23.5
Approach		424	5.0	0.765	32.7	LOS C	9.8	71.6	0.68	0.79	31.8
North: Wanneroo Road (North)											
7	L	186	5.0	0.222	10.2	LOS B	2.0	14.4	0.30	0.67	47.1
8	T	1328	5.0	0.756	35.3	LOS D	20.2	147.8	0.96	0.87	29.1
Approach		1514	5.0	0.756	32.2	LOS C	20.2	147.8	0.88	0.85	30.5
All Vehicles		4852	5.0	0.778	19.0	LOS B	20.2	147.8	0.67	0.65	38.1

The above analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. A LoS of B is forecast and stop rates of less than 1.

A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design particularly in the am peak hour.

Recommended Geometry (if no land resumption)



Wanneroo Rd / Elliot Rd 2031 With LHS 2031 am Ultimate Geometry Signals
Signals - Fixed Time Cycle Time = 102 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (South)											
2	T	1185	5.0	0.438	6.4	LOS A	12.0	87.6	0.45	0.40	49.3
3	R	139	5.0	0.988	103.6	LOS F	10.4	75.8	1.00	1.30	15.6
Approach		1324	5.0	0.988	16.6	LOS B	12.0	87.6	0.51	0.50	40.2
East: Elliot Road (East)											
4	L	306	5.0	1.000 [3]	30.1	LOS C	11.2	81.8	0.83	0.81	33.0
6	R	270	5.0	0.904	68.4	LOS E	16.2	118.0	1.00	1.05	20.9
Approach		576	5.0	1.000	48.1	LOS D	16.2	118.0	0.91	0.92	26.0
North: Wanneroo Road (North)											
7	L	217	5.0	0.194	8.9	LOS A	1.6	11.5	0.22	0.65	48.3
8	T	2049	5.0	0.938	45.5	LOS D	65.1	474.9	1.00	1.14	25.5
Approach		2266	5.0	0.938	42.0	LOS D	65.1	474.9	0.93	1.10	26.8
All Vehicles		4166	5.0	1.000	34.8	LOS C	65.1	474.9	0.79	0.88	29.8

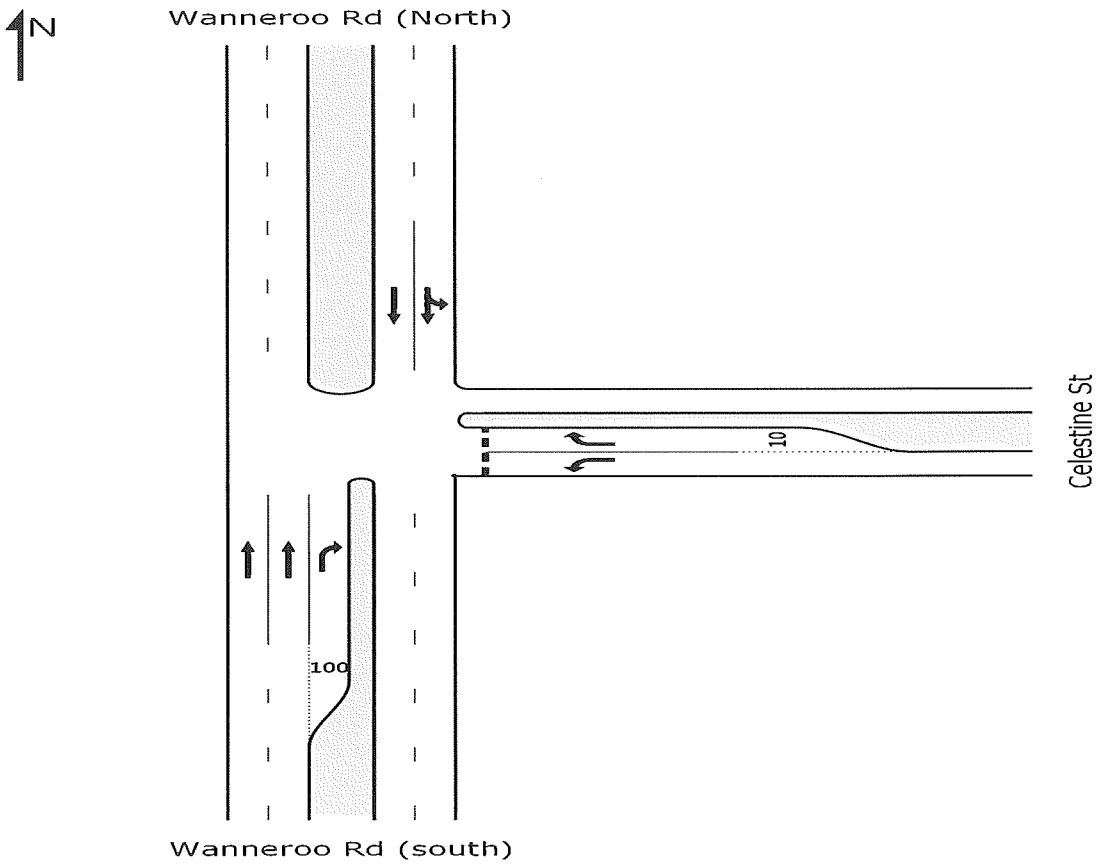
Wanneroo Rd / Elliot Rd 2031 With LHS 2031 pm Ultimate Geometry Signals
Signals - Fixed Time Cycle Time = 101 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Rd (South)											
2	T	2589	5.0	0.899	18.3	LOS B	57.1	416.6	0.83	0.85	37.9
3	R	325	5.0	0.881	53.9	LOS D	16.8	122.4	0.94	0.95	24.2
Approach		2914	5.0	0.899	22.3	LOS C	57.1	416.6	0.84	0.86	35.6
East: Elliot Road (East)											
4	L	232	5.0	0.531	16.6	LOS B	5.0	36.2	0.53	0.73	41.4
6	R	192	5.0	0.901	69.7	LOS E	11.3	82.4	1.00	1.06	20.7
Approach		424	5.0	0.901	40.6	LOS D	11.3	82.4	0.75	0.88	28.5
North: Wanneroo Road (North)											
7	L	186	5.0	0.226	10.9	LOS B	2.3	16.6	0.33	0.68	46.4
8	T	1328	5.0	0.826	31.7	LOS C	31.3	228.5	0.95	0.92	30.6
Approach		1514	5.0	0.826	29.1	LOS C	31.3	228.5	0.88	0.89	31.9
All Vehicles		4852	5.0	0.901	26.0	LOS C	57.1	416.6	0.84	0.87	33.7

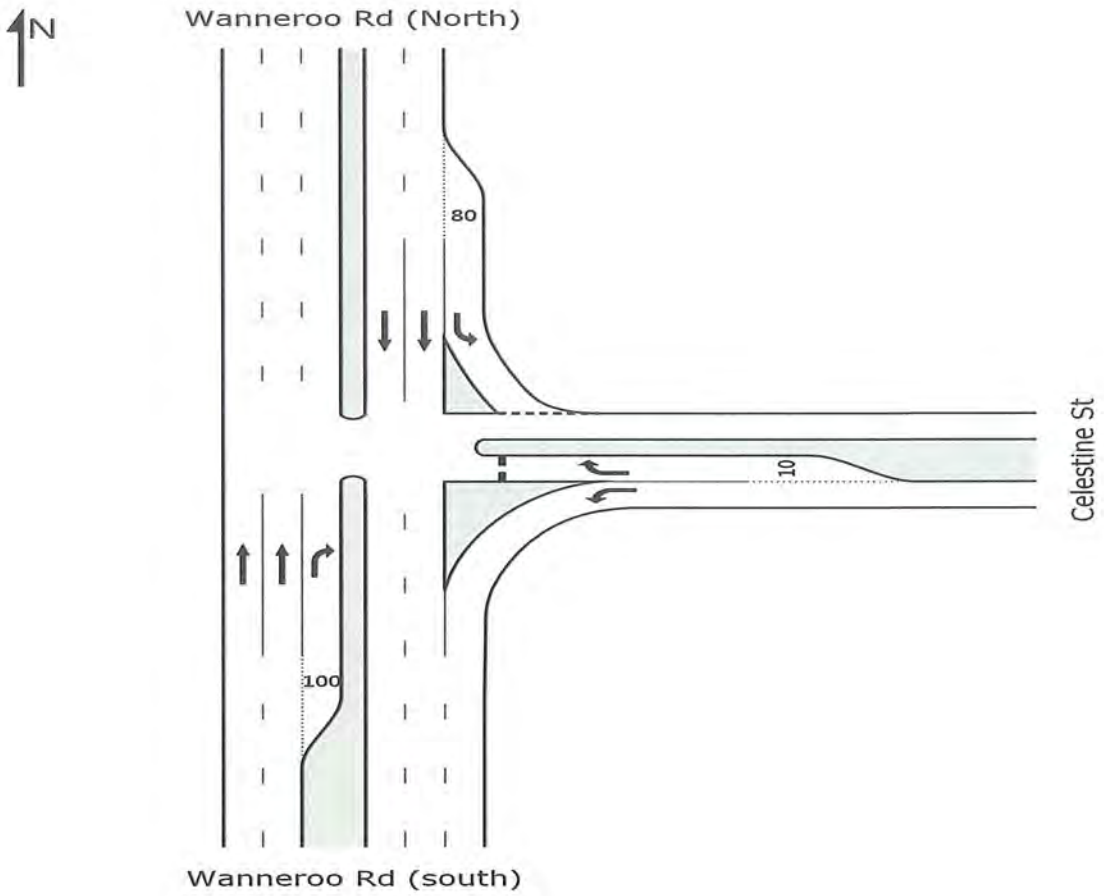
Wanneroo Road/Celestine Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry
A number of options have been tested however a good operational performance has not been achieved. The best operation for an unsignalised intersection is indicated below and includes acceleration lanes for the right and left turns from Celestine Street. Improved performance would be gained by traffic signals however it would not be practical to signalise all side road intersections.



Wannerro Rd / Celestine St 2031 With LHS Upgraded unsignalised Geometry AM To Median Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Rd (south)											
2	T	1344	5.0	0.357	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	84	5.0	1.398	844.5	LOS F	34.0	248.5	1.00	3.20	2.5
Approach		1428	5.0	1.398	49.6	NA	34.0	248.5	0.06	0.19	25.4
East: Celestine St											
4	L	230	5.0	0.128	7.7	X	X	X	X	0.59	49.8
6	R	60	5.0	1.000 [3]	121.4	LOS F	3.4	24.9	1.00	1.22	13.9
Approach		290	5.0	1.000	31.2	LOS D	3.4	24.9	0.21	0.72	32.5
North: Wanneroo Rd (North)											
7	L	106	5.0	0.085	7.9	LOS A	0.3	2.3	0.15	0.56	48.9
8	T	2098	5.0	0.555	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		2204	5.0	0.555	0.4	NA	0.3	2.3	0.01	0.03	59.3
All Vehicles		3922	5.0	1.398	20.6	NA	34.0	248.5	0.04	0.14	38.3

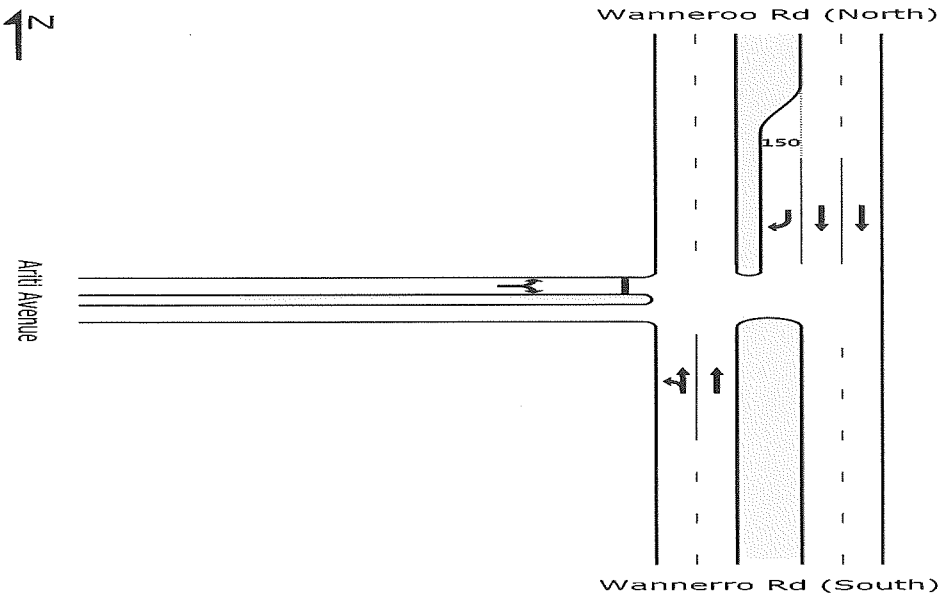
Wannerro Rd / Celestine St 2031 With LHS Upgraded unsignalised Geometry PM To Median Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Rd (south)											
2	T	2522	5.0	0.669	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	260	5.0	1.079	218.0	LOS F	34.0	248.4	1.00	3.55	8.6
Approach		2782	5.0	1.079	20.4	NA	34.0	248.4	0.09	0.33	38.5
East: Celestine St											
4	L	163	5.0	0.091	7.7	X	X	X	X	0.60	49.8
6	R	40	5.0	1.000 [3]	207.1	LOS F	3.4	24.9	1.00	1.26	9.0
Approach		203	5.0	1.000	47.0	LOS E	3.4	24.9	0.20	0.73	26.4
North: Wanneroo Rd (North)											
7	L	50	5.0	0.044	8.7	LOS A	0.2	1.3	0.34	0.60	48.0
8	T	1351	5.0	0.358	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1401	5.0	0.358	0.3	NA	0.2	1.3	0.01	0.02	59.5
All Vehicles		4386	5.0	1.079	15.2	NA	34.0	248.4	0.07	0.25	42.3

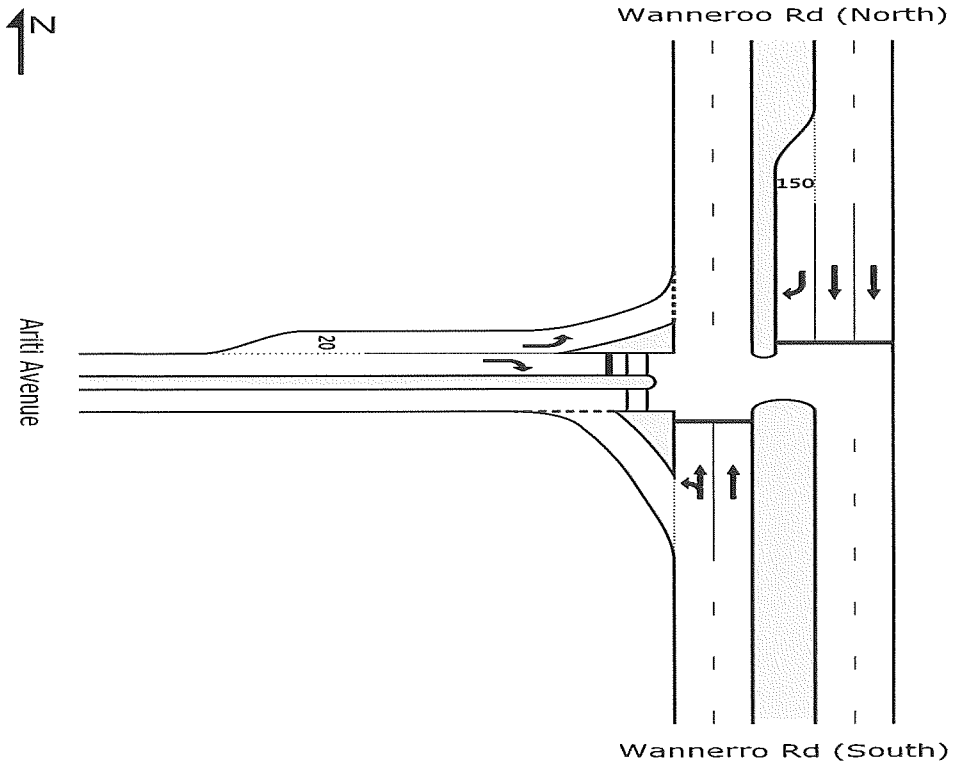
Wanneroo Road/Ariti Ave Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry – Recommended.



Wanneroo Road / Ariti Ave 2031 with LHS Ultimate Geometry am Signals
Signals - Fixed Time Cycle Time = 111 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wannerro Rd (South)											
1	L	18	7.4	0.514	16.6	LOS B	16.2	120.4	0.48	0.95	42.9
2	T	1360	7.4	0.514	7.9	LOS A	16.3	121.0	0.48	0.44	47.5
Approach		1378	7.4	0.514	8.0	LOS A	16.3	121.0	0.48	0.45	47.4
North: Wanneroo Rd (North)											
8	T	2123	7.4	0.688	4.0	LOS A	22.5	167.2	0.44	0.41	52.1
9	R	52	7.4	0.545	68.0	LOS E	3.0	22.2	1.00	0.76	21.0
Approach		2175	7.4	0.688	5.5	LOS A	22.5	167.2	0.45	0.42	50.3
West: Ariti Avenue											
10	L	76	7.4	0.340	11.3	LOS B	1.0	7.8	0.32	0.67	46.1
12	R	77	7.4	0.692	68.6	LOS E	4.5	33.2	1.00	0.83	20.8
Approach		153	7.4	0.692	40.1	LOS D	4.5	33.2	0.66	0.75	28.7
All Vehicles		3706	7.4	0.692	7.9	LOS A	22.5	167.2	0.47	0.44	47.7

Wanneroo Road / Ariti Ave 2031 with LHS Ultimate Geometry pm Signals
Signals - Fixed Time Cycle Time = 142 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

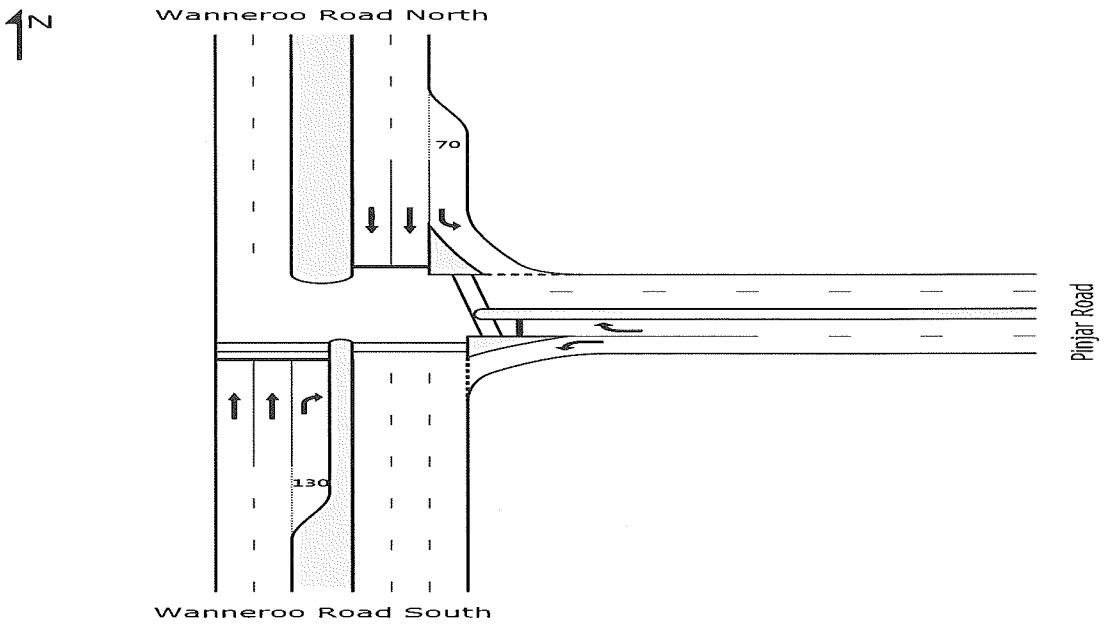
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wannerro Rd (South)											
1	L	95	7.4	0.871	20.6	LOS C	58.4	434.8	0.76	0.96	40.5
2	T	2412	7.4	0.871	12.0	LOS B	58.8	437.9	0.76	0.73	42.6
Approach		2507	7.4	0.871	12.4	LOS B	58.8	437.9	0.76	0.74	42.5
North: Wanneroo Rd (North)											
8	T	1366	7.4	0.420	1.9	LOS A	9.2	68.5	0.22	0.20	55.9
9	R	87	7.4	0.875	92.2	LOS F	6.8	50.6	1.00	0.98	17.0
Approach		1453	7.4	0.875	7.3	LOS A	9.2	68.5	0.26	0.25	49.2
West: Ariti Avenue											
10	L	56	7.4	0.569	32.0	LOS C	2.3	17.5	0.64	0.75	32.2
12	R	35	7.4	0.470	85.3	LOS F	2.5	19.0	1.00	0.73	17.9
Approach		91	7.4	0.569	52.5	LOS D	2.5	19.0	0.78	0.74	24.7
All Vehicles		4051	7.4	0.875	11.4	LOS B	58.8	437.9	0.58	0.56	43.9

The above analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of A/B is forecast and stop rates of less than 1. A signalised intersection is therefore recommended.

Land resumption is not required.

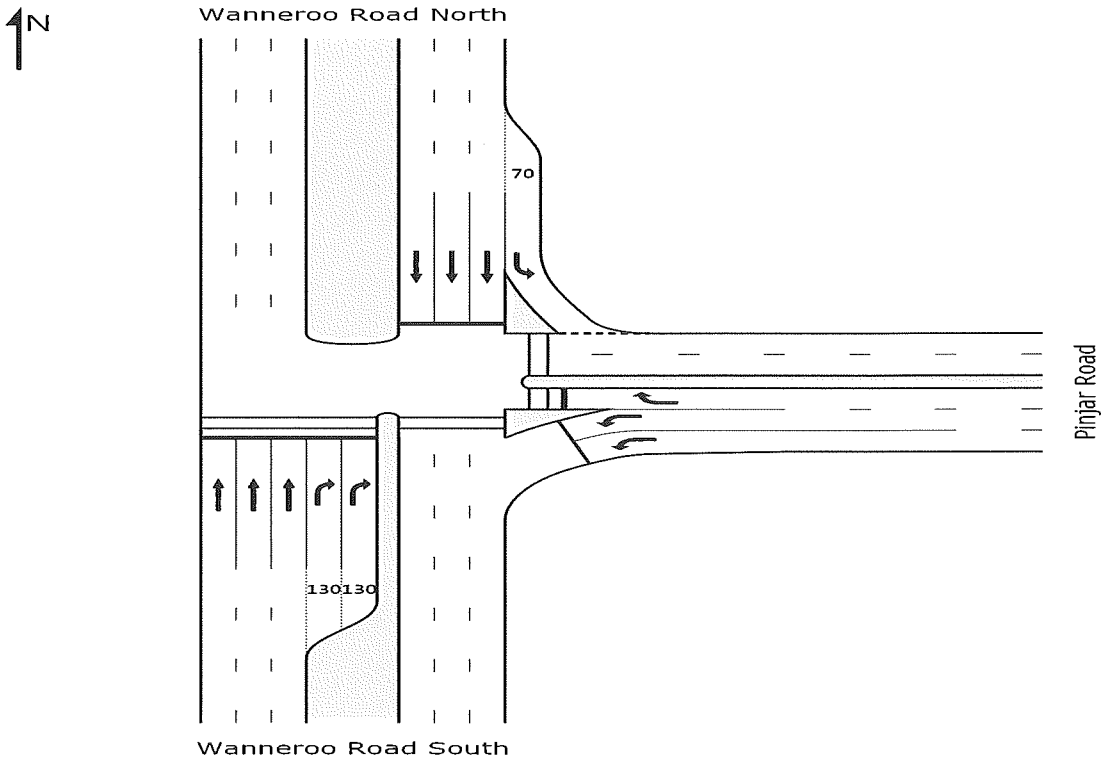
Wanneroo Road/Pinjar Road Intersection 2031

Existing Geometry



Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Wanneroo Road/Pinjar Road 2031 with LHS Ultimate Geometry am
Signals - Fixed Time Cycle Time = 131 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road South											
2	T	1432	5.0	0.368	9.0	LOS A	12.5	91.1	0.45	0.40	46.4
3	R	751	5.0	0.831	64.0	LOS E	24.6	179.9	1.00	0.93	21.9
Approach		2183	5.0	0.831	27.9	LOS C	24.6	179.9	0.64	0.58	33.5
East: Pinjar Road											
4	L	1342	5.0	0.721	33.4	LOS C	32.5	237.5	0.83	0.86	31.5
6	R	304	5.0	0.766	62.2	LOS E	19.0	138.8	1.00	0.88	22.3
Approach		1646	5.0	0.766	38.7	LOS D	32.5	237.5	0.86	0.86	29.3
North: Wanneroo Road North											
7	L	297	5.0	0.466	12.6	LOS B	5.5	39.9	0.37	0.69	44.7
8	T	1801	5.0	0.816	40.7	LOS D	35.4	258.7	0.96	0.90	27.1
Approach		2098	5.0	0.816	36.7	LOS D	35.4	258.7	0.88	0.87	28.7
All Vehicles		5927	5.0	0.831	34.0	LOS C	35.4	258.7	0.79	0.76	30.5

Wanneroo Road/Pinjar Road 2031 with LHS Ultimate Geometry pm
Signals - Fixed Time Cycle Time = 108 seconds (Optimum Cycle Time - Minimum Delay)

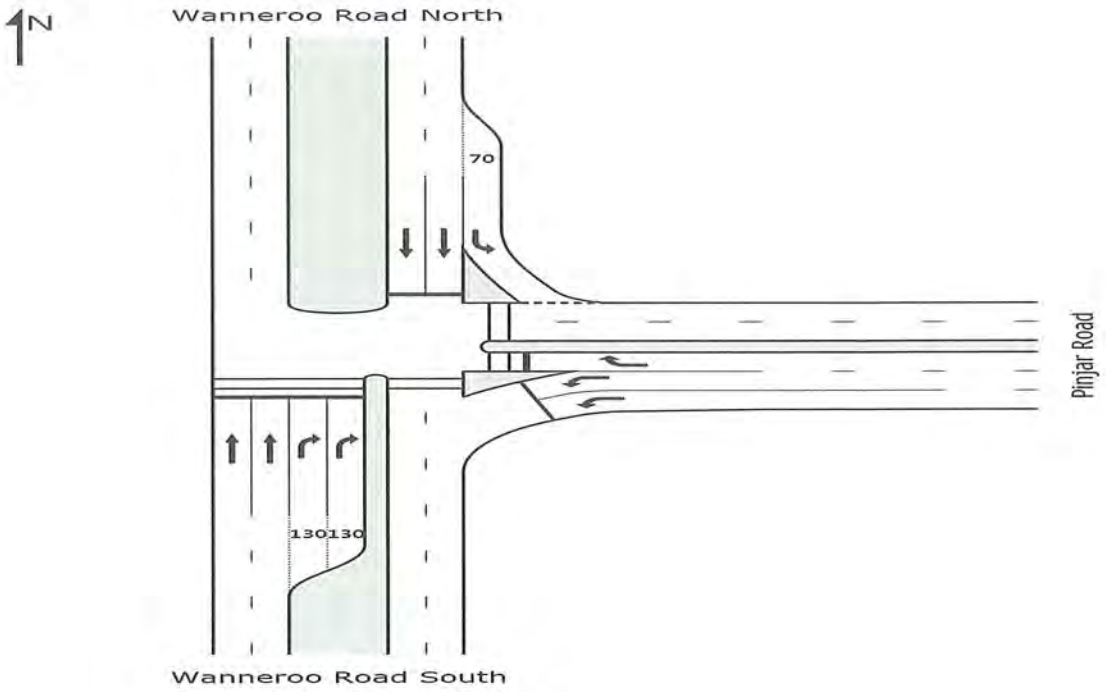
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road South											
2	T	2662	5.0	0.764	15.7	LOS B	33.6	245.2	0.78	0.72	39.4
3	R	1187	5.0	1.000 [3]	41.5	LOS D	29.1	212.2	1.00	0.89	28.2
Approach		3849	5.0	1.000	23.7	LOS C	33.6	245.2	0.85	0.78	35.1
East: Pinjar Road											
4	L	764	5.0	0.303	14.0	LOS B	7.4	54.3	0.40	0.71	43.6
6	R	410	5.0	0.852	56.5	LOS E	23.2	169.7	1.00	0.96	23.6
Approach		1174	5.0	0.852	28.9	LOS C	23.2	169.7	0.61	0.80	33.7
North: Wanneroo Road North											
7	L	237	5.0	0.434	16.8	LOS B	5.3	38.5	0.52	0.72	41.2
8	T	1024	5.0	0.976	90.5	LOS F	26.8	195.5	1.00	1.36	16.7
Approach		1261	5.0	0.976	76.6	LOS E	26.8	195.5	0.91	1.24	18.9
All Vehicles		6284	5.0	1.000	35.3	LOS D	33.6	245.2	0.82	0.87	29.7

The above analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of C/D is forecast and stop rates of less than 1 during the am peak hour but the southbound through movement is 1.36 during the pm peak hour. Significant land resumption is required.

A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design with unacceptable queues and delays and is not therefore recommended.

Compromise Design



Wanneroo Road/Pinjar Road 2031 with LHS Compromise Geometry am
Signals - Fixed Time Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Wanneroo Road South											
2	T	1432	5.0	0.509	8.2	LOS A	20.8	151.9	0.45	0.41	47.3
3	R	751	5.0	0.975	78.6	LOS E	29.1	212.2	1.00	0.91	19.0
Approach		2183	5.0	0.975	32.4	LOS C	29.1	212.2	0.64	0.58	31.3
East: Pinjar Road											
4	L	1342	5.0	0.871	55.9	LOS E	48.0	350.4	0.99	0.94	23.9
6	R	304	5.0	0.972	117.6	LOS F	30.2	220.1	1.00	1.13	14.2
Approach		1646	5.0	0.972	67.3	LOS E	48.0	350.4	0.99	0.98	21.2
North: Wanneroo Road North											
7	L	297	5.0	0.498	13.4	LOS B	6.3	45.7	0.36	0.69	44.0
8	T	1801	5.0	0.973	83.4	LOS F	89.3	652.2	1.00	1.19	17.7
Approach		2098	5.0	0.973	73.5	LOS E	89.3	652.2	0.91	1.12	19.4
All Vehicles		5927	5.0	0.975	56.6	LOS E	89.3	652.2	0.83	0.88	23.2

Wanneroo Road/Pinjar Road 2031 with LHS Compromise Geometry pm
Signals - Fixed Time Cycle Time = 101 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Wanneroo Road South											
2	T	2606	5.0	1.064	178.5	LOS F	165.8	1210.1	1.00	2.02	10.0
3	R	1243	5.0	1.000 [3]	43.9	LOS D	30.9	225.6	1.00	0.89	27.3
Approach		3849	5.0	1.064	135.1	LOS F	165.8	1210.1	1.00	1.66	12.5
East: Pinjar Road											
4	L	764	5.0	0.336	16.8	LOS B	8.6	63.0	0.50	0.74	41.3
6	R	410	5.0	1.004	120.9	LOS F	36.1	263.5	1.00	1.36	14.0
Approach		1174	5.0	1.004	53.2	LOS D	36.1	263.5	0.67	0.96	24.6
North: Wanneroo Road North											
7	L	237	5.0	0.428	18.2	LOS B	5.4	39.7	0.56	0.73	40.2
8	T	1024	5.0	0.996	96.4	LOS F	39.2	286.4	0.98	1.44	16.0
Approach		1261	5.0	0.996	81.7	LOS F	39.2	286.4	0.91	1.31	18.1
All Vehicles		6284	5.0	1.064	109.1	LOS F	165.8	1210.1	0.92	1.46	14.8

Appendix G - Council and Main Roads Response to Draft Measures and GHD Commentary

From: HOLMES Rob (RPO) [rob.holmes@mainroads.wa.gov.au]

Sent: Monday, 26 November 2012 6:40 AM

To: Koroveshi, Jordan

Cc: Zamir, Marzia; BROADHURST Lindsay (MRP); MCKIRDY Justin (URPM)

Subject: TRIM: Local Housing Strategies -Girrawheen-Koondoola Housing Precinct & Wanneroo Housing Precinct

Hi Jordan

I refer to your email dated 5 November 2012 providing copies the following documents:

Draft Report for Wanneroo Housing Precinct Traffic Impact Assessment – September 2012; and .

Draft Report for Girrawheen-Koondoola Housing Precinct Traffic Impact Assessment – September 2012.

Please note that we were not provided a copy of Appendix A, C and D for either draft report so we are unable to provide feedback on the data / information contained within these sections.

I also make reference to our meeting on 5 November 2012 where discussion focused on the changes in R- Coding around the Wanneroo Centre and Girrawheen-Koondoola precincts, resulting from the implementation of Local Planning Policy 3.1, and the effect this will have on road networks.

It is our understanding that the City of Wanneroo is keen to understand future implications of the R-Coding changes with the intention of being able to progressively move toward an appropriate outcome. Main Roads is very supportive of this approach and is keen to remain involved in the process. The following comments are provided in response to your request for comments and are intended to be constructive without being a detailed critique:

General Comments

1. The draft reports appear to be a good start and provide some good information. We consider some of the recommendations debatable and worthy of further consideration and discussion.

2. Network analysis seems to have jumped to 'single solutions' too fast. What network options were considered and tested?

GHD Response

The planned road network as provided was analysed additional road networks are beyond the scope of this project.

3. Wanneroo Rd Metropolitan Region Scheme (MRS) amendment from Wallawa St to Dundebar Rd involves widening the road reservation to be consistent with the existing reserve width north and south of the Wanneroo town site. This widening is intended to

provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Rd within this area.

GHD Response

Noted.

However as indicated a poor LoS is forecast if Wanneroo Road is not widened to include an additional traffic lane.

4. Further to Point 11, ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded / recommended that:

Wanneroo Rd consist of four lanes through Wanneroo town site, with widening for turn lanes,but accepting it will be about 10% overloaded in 2031; and.

Additional north south capacity through the area is required and can be achieved by improvements to Lenore Rd / Franklin Rd and the proposed East Wanneroo North South Route.

These conclusions / recommendations were touched on in the draft report.

GHD Response

The ROM modelling included the North South Route however if Wanneroo Rd becomes congested then it is logical that traffic will divert to this route. This comment will be added to the report.

5. Future development of the land north of the Wanneroo town site in Sinagra will likely necessitate a new connection to Wanneroo Rd. The draft report suggests Road 2, connecting Wanneroo Rd opposite Hart Ct, should be signalised. Main Roads does not support this suggestion due to its proximity to Church St and Dundebar Rd intersections. Planning work associated with the Wanneroo Rd MRS amendment suggests a more appropriate location for a new connection may be within the vicinity of the existing Inghams Enterprises entrance. This location would be preferable to the Road 2 location because it will result in a more efficient arrangement of access along Wanneroo Rd. Nevertheless, at a spacing of approximately 500m from up and downstream signalised intersections, such an outcome would be detrimental to the operation of Wanneroo Rd. Consideration of implementing a parallel road connecting Pinjar Rd and Dundebar Rd may reduce the demand for this new connection and allow the proposed land development to access Wanneroo Rd via existing signalised connections.

GHD Response

As discussed in the report Pinjar Rd/Wanneroo Rd and Dundebar Rd/Wanneroo Rd intersections will be under pressure even without higher densities. It will be important to maintain at least left in/out to Wanneroo Rd from any new access to Wanneroo Road. GHD's analysis assumes a signalised intersection at Road 2 but the concerns of Main Roads regarding the proximity to other signalised intersections are acknowledged. This will be discussed in the report.

6. There are currently plans which promote the signalising of the Wanneroo Rd and Church St intersection even though the intersection is located only 150m from Dundebar Rd (which is signalised). It would be preferable that Church St not be signalised. A reconfiguration of access arrangements within the town precinct may actually produce a better outcome on a number of fronts.

GHD Response

Noted a preferred option may be to signalise Scenic Drive/Wanneroo Road which is located some distance south of the Town Centre. This will be discussed in the report.

The data available suggests there is/will be spare capacity on Scenic Drive.

7. Double right turn into Dundebar Rd, whilst desirable for efficiency, is unlikely to be possible due to land constraints.

GHD Response

A concept would be required to prove or disprove.

8. Removal of pedestrian phases from the Wanneroo Rd, Hastings St and Conlan Ave intersection is interesting but may be undesirable if pedestrian volumes are high. This may be likely given the proximity of the intersection to the centre of the town site.

GHD Response

This was a suggestion however in view of the proximity to the Shopping Centre the crossing facility should be maintained. Other options would be a grade separated crossing, but the feasibility would need to be examined and may not be as convenient for users.

The intention was not to remove all pedestrian movements; rather remove them from one crossing leg only (and to remove the scatter-phase (i.e all-ped phase).

9. Main Roads does not support signalising of the Wanneroo Rd and Ariti Ave intersection. Whilst queuing may be undesirable, the volume of traffic trying to access Wanneroo Rd at this location is insufficient to warrant traffic signals. This traffic can utilise other connections to Wanneroo Rd which have traffic signals to assist right turning traffic.

GHD Response

Noted.

Signalising Scenic Drive/Wanneroo Road would be preferable.

10. Section 6.2.4 (Wanneroo Rd / Celestine Rd intersection 2031) is an excellent example to consider when dealing with side road connections. We agree with the statement in this section that all side road intersections cannot be signalised. Similarly, there needs to be consideration of how to deal with traffic at the Wanneroo Rd and Celestine Rd intersection (or any other specific location). We would promote the idea of a network review to determine how the network could be structured to make best use of locations which are chosen for the higher level of service afforded by signalisation. The

suggestion of acceleration lanes is considered inappropriate in the context of adjacent intersections and vehicle crossovers to properties. The separation between intersections is insufficient, as is available land.

GHD Response

Noted.

The option remains to signalise Elliot Road and retain this intersections as is.

11. Wanneroo Rd and Elliot Rd intersection analysis demonstrates that a reasonable level of service could be achieved for this intersection in 2031. However, it is important to recognise that modelling undertaken by Main Roads for the East Wanneroo North South Route and the East Wanneroo Structure Plan has indicated that ultimate volumes at this intersection could be three times, or more, than that analysed in the study undertaken for Wanneroo Housing Strategy. Accordingly, whilst the suggested intersection configuration may prove to be satisfactory at this time, it is highly probable that significant adjustments will be required in the future. This is likely to take the form of longer turning lanes and expansion of Elliot Rd to four lanes.

GHD Response

Noted.

Will be included in report.

12. As part of our review of the draft report, a suggested possible alternative road network option has been prepared to help illustrate the intent behind our comments (refer attached copy). This alternative road network aims to retain the integrity of Wanneroo Rd and its function of a Primary Regional Road, whilst highlighting the need to promote the use of Lenore Rd / Franklin Rd and Scenic Dr as parallel routes to share the transport demand through this area.

GHD Response

Connection of Shaw Rd to Wanneroo Rd

This intersection is unlikely to operate to a good LoS as a three way, if constructed as a 4 way would likely result in unacceptable congestion. However overall network would need to be tested.

Hastings/Conlan left in/out

Likely to result in significant pressure on Dundebar/Wanneroo Int and other connections to Wanneroo Rd. Impacts would need to be tested.

Scenic Drive/Wanneroo Rd Signals

Should be tested as part of the broader network, but would provide good access to the area west of Wanneroo Road.

Promotion of Lenore Rd and realignment to Hartman Dr (future)

Would seem logical and should be supported.

A broader model would be required to test the overall impacts of the Main Roads proposals.

13. It aims to achieve a more appropriate distribution of signalised connections to Wanneroo Rd at strategic locations, in order to service the development whilst maintaining the traffic safety and efficiency on the regional route and access to adjacent residential and commercial areas.

It is understood that Lenore Rd / Franklin Rd is planned to ultimately become an 'Other Regional Rd' to service the current and future development in the Wanneroo and East Wanneroo areas. It is understood that Scenic Dr is currently a local distributor road however, given the proposed development and the geographically isolated nature of the land use it services, it should perhaps be considered as a district distributor with controlled connections to the regional network.

GHD Response

Agreed.

14. The current signalisation works at Wanneroo Rd and Wallawa St are an anomaly that could become an opportunity. Serious consideration should be given to how Scenic Dr could be connected to Wanneroo Rd at the northern end. Wallawa St provides an opportunity if the link between Scenic Dr and Banyandah Bvd or Kilindi Cr can be created.

GHD Response

Agreed. The opportunity of connecting Scenic Drive to Wanneroo Road vai Wallawa Street should be examined, not part of this project scope.

Thank you for informing Main Roads of these proposals and for the opportunity to comment. It is hoped that the City finds this feedback beneficial. The opportunity to discuss our feedback would also be welcomed should the City desire. If you require any further information please contact Justin McKirdy, Urban Road Planning Manager North, on 9323 4991.

Regards

Lindsay Broadhurst

Manager Road Planning

City of Wanneroo Comments

1. Local roads – Comment re local road impacts.

GHD Response

Will add comments re local roads as per email.

The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.

The WAPC document 'Liveable Neighbourhoods' indicates the anticipated traffic volumes for residential streets:

Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd

Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd

The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.

The following intersection thresholds are indicated by Austroads below which capacity analysis is unnecessary.

Major Road Flow	*Minor Road Flow*
400vph	*250vph*
500vph	*200vph*
650vph	*100vph*

Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.

2. **Traffic apportioning and clarity**

GHD Response

Will add to report as suggested by City.

3. **Upgrade trigger/threshold**

GHD Response

GHD have undertaken a staging analysis (looking at 25% and 50% development horizons). This analysis has been included into the body of the report.

4. **Cost apportioning should be b-a/b**

GHD Response

Noted will add to report.

5. **Involvement of Main Roads. Confirm consultation.**

GHD Response

Will add to report.

6. **Consistency, Wanneroo Rd/Celestine not recommended for signals in Appendix. Remove mention of traffic signals.**

GHD Response

Noted re Wanneroo Rd/Celestine will amend report.

7. **Cost estimates**

Will prepare conceptual design for each location following CoW confirmation of agreed measure.

Six designs allowed for in tender, will price 2 additional options for concepts and cost estimation.

Main Roads Transport Modelling team comments:

- **The greatest strength of Paramics is its dynamic assignment. This works to reroute traffic in response to congestion. However, the two models developed by GHD have little to none sensible route choices available, (acknowledged in sections 3.7). Furthermore SCATS is showing little congestion is occurring around this area (low saturation flow rates). This means traffic assignment becomes redundant. In my opinion, if you are building a model without route choice and with standard (4 leg & 3 leg) signalised intersections, Paramics isn't necessary, you might as well stick with SIDRA.**

GHD Response

It is agreed that the networks being assessed have little logical alternate route choices (and no route choice at all in the case of the Wanneroo study network). However, one of the biggest drawbacks of using SIDRA analyses only is that the interaction and impact of upstream and downstream intersections cannot be efficiently considered. The microsimulation model enables the network to be considered as an integrated system and the interaction between junctions can be evaluated. In the case of the corridor network of the Wanneroo study area, the impact of queuing, vehicle platooning and signal co-ordination was easily considered within microsimulation framework. Additionally, the ability to visual see the simulation model in operation enables a greater understanding (particularly to non-technical persons) of the anticipated network performance.

- **GHD have used fixed time signals rather than vehicle actuated signals. If traffic demand increases dramatically in the 2031 scenarios, the signal phasings may need to be modified.**

GHD Response

During the 2031 scenario testing phase times were modified from the existing times to account for change in volumes, if required. Sidra models were initially run to obtain the starting point for signal operations, and then modified further through inspections of the models in operation.

- **Heavy vehicles have been considered which is good.**
- **The reports are not clear whether or not public transport (bus routes) have been considered.**

GHD Response

Bus routes were not coded into the models, as public transport operations were not critical to the traffic model component of the study.

- **The calibration results are excellent. However this isn't surprising given the models have limited route choice.**

  GHD Response

  Agree, given the study area networks a high level of calibration could be reasonably expected.

- **The travel time validation criteria is stated as "*Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).*" I am not sure where this criteria has come from. Is a reference available?**

  GHD Response

  This travel time validation criteria is from the Design Manual for Roads and Bridges (DMRB) (prublished by Highways Agency, UK) and is also stated within the latest RMS (previously RTA) Traffic Modelling Guidelines (to be officially released shortly).

- **The report is not clear whether the observed journey times where measured once each, or are averaged over multiple runs. Best practice is to measure multiple journey times on site, and then calculate both an average and a confidence interval for each journey (as per the RTA guidelines).**

  GHD Response

  Observed travel times were the result (average) of multiple runs of a floating car travel time survey. The Wanneroo study area consisted 5 recordings for each direction and the Girrawheen study area 2 recordings for each network section (Note, there were 14 sections in total).

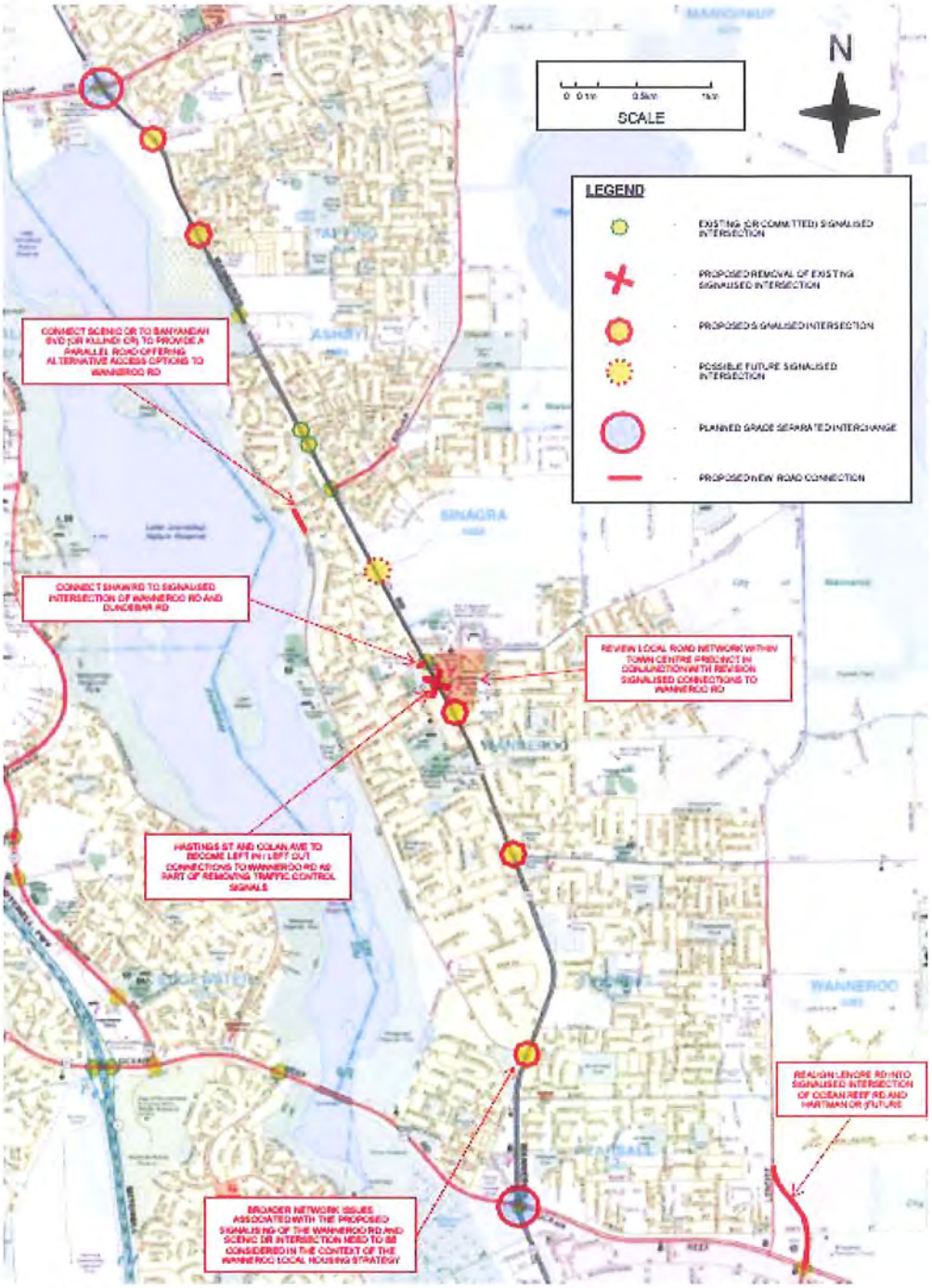
- **GHD have used an Azalient Ceejazz plugin which isn't owned by Main Roads. This means the model runs cannot be run by Main Roads (unless we purchase a plugin of our own)**

  GHD Response

  These plugins enhance the functionality of the core simulation software (and are available from Azalient at a modest cost).

- **Sections 5.3 demonstrates that the model is stable (no gridlocking) which is good.**

A copy of Main Roads preferred signal strategy for Wanneroo Road and road network option is shown overleaf.



WANNEROO HOUSING PRECINCT - POSSIBLE ALTERNATIVE ROAD NETWORK OPTION 1

MAIN ROADS Western Australia
Wanneroo Local Housing Strategy – Possible Alternative Road Network Option 1

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S McDermott S Bennet	Paul Fisher	*Paul Fisher*	Paul Fisher	*Paul Fisher*	*22.1.13*

www.ghd.com

ATTACHMENT 4 – CITY OF WANNEROO AND WATER CORPORATION CORRESPONDENCE

Stawarz, Nicholas

From: Peter Howard [Peter.Howard@watercorporation.com.au]
Sent: Monday, 11 August 2014 11:00 AM
To: Koroveshi, Jordan
Cc: Frank Kroll
Subject: RE: Water & sewer infrastructure upgrades related to infill recoding

Hi Jordan,

To confirm the information from our phone conversation under the 4 points contained in your email I advise as follows:

- *Other infill areas have not required much upgrading as the networks are sufficiently engineered for higher R-Codes;*

Our systems have been designed to serve the densities identified in local planning schemes. As development seldom reaches the densities identified in local authority town planning schemes; and water consumption per person has been declining; and pipe sizes are selected which are "rounded up" from the modelled hydraulic requirement, we estimate we have sufficient capacity in the reticulation systems to accommodate diffuse infill development in most locations across the metro area. This is being demonstrated in older suburbs which have been absorbing brownfield development over the past couple of decades without issue. Point load demands greater than the diffuse 2-5 dwelling type developments may require upgrades but these are development specific and can't be assessed in advance and will vary depending on the location.

- *The most appropriate time to conduct an upgrade would be at subdivision clearance;*

The requirement to upgrade the reticulation assets would be identified at subdivision, development or building application stage. As a lot of infill will be achieved through strata schemes these retic upgrades would be identified through the building process. So the most appropriate time to do the upgrades would be at these application times.

- *If Council chooses to pay for the upgrades, Council would also hire the contractors to do the work and consult with Water Corp at that stage*

Individual developers would need to seek the Corporation's advice on the availability of water or sewer capacity. The Corporation would advise if particular developments may trigger upgrades, and this would be informed via the subdivision clearance, development application and building application processes as applicable, to alert the City to commence the construction process.

The works would be constructed by the City under tender, and handed over to the Corporation. The same process as per Greenfields applies.

The Corporation will fund all works apart from reticulation via its Capital Investment program.

- *Council may incur additional expense if upgrades are conducted prior to being required;*

Council should not do upgrades to the reticulation upgrades identified in the Cardno planning study. The study is a desk top evaluation based on a range of assumptions. The actual upgrades would need to be based on the observed performance of the scheme and the solutions would be quite different to the theoretical conclusions of the study depending upon

the rate of infill development, the location of the infill and the type of development. For example, the Corporation would not normally dig up a 150mm pipe to replace it with a 225mm pipe, but rather run another 150mm pipe down the other side of the road; other options may be to divert flows into another catchment; however these types of solutions would have to be designed in response to the performance issue being observed.

Also, creating capacity in the retic system before it is required is wasteful in a financial sense. Much more cost effective to utilise existing capacity that has been paid for and upgrade only when that capacity has been reached.

The Corporation would take the approach of identifying the expenditure as a required future project with costs to be refined closer to delivery and schedule it for a nominal 15yrs or so in the future. The project could be brought forward or pushed back depending on its need. I don't know whether your Council uses a similar capital works program model to allocate and schedule funds over a long period of time, but if you do it would allow you to keep the expenditure on your horizon and review it periodically.

- *Constraints Mapping*

With regards to the constraints mapping, I am not sure what assumptions have been used to identify these areas. As discussed previously the Cardno study is a theoretical desk top assessment using a range of assumptions. We would identify constraints based on performance issues of the systems. We have not observed any issues in these areas and would not expect any in the short to medium term depending on the type and scale of development. That is, incremental small scale infill development should not require retic upgrades any time soon.

I hope this helps. Please contact me if you need anything else

Peter Howard
Manager Land Planning Section
Development Services Branch
Water Corporation

T: (08) 9420 2769 | **F:** (08) 9420 3193 | **M:** 0403 398 953
629 Newcastle Street, Leederville, WA 6007
PO Box 100, Leederville, WA 6902
www.watercorporation.com.au

From: Koroveshi, Jordan [mailto:Jordan.Koroveshi@wanneroo.wa.gov.au]
Sent: Monday, 28 July 2014 11:18 AM
To: Peter Howard
Subject: FW: Water & sewer infrastructure upgrades related to infill recoding

Hi Peter,

Regarding our phone convo just now, I'd like to confirm what you said:

- Council may incur additional expense if upgrades are conducted prior to being required;
- Other infill areas have not required much upgrading as the networks are sufficiently engineered for higher R-Codes;
- The most appropriate time to conduct an upgrade would be at subdivision clearance;
- If Council chooses to pay for the upgrades, Council would also hire the contractors to do the work and consult with Water Corp at that stage.

Could you please confirm if this is correct?

Also, I've attached a map of the areas that need upgrades. Could you please ask your team whether the critical areas have had any enquiries thus far regarding capacity issues?

Regards,

Jordan Koroveshi
Project Planner
City Growth

City of Wanneroo

T : 08 9405 5523
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23 Dundebar Road, Wanneroo WA 6065
Locked Bag 1, Wanneroo WA 6946

wanneroo.wa.gov.au

From: Searles, Nyssa
Sent: Monday, 21 July 2014 1:42 PM
To:
Cc: Dickson, Mark
Subject: Water & sewer infrastructure upgrades related to infill recoding

Hi Peter,

Phil Thompson has passed on your contact details.

The City of Wanneroo is progressing the recoding of two of our housing precinct areas – Wanneroo and Girrawheen/Koondoola. Infrastructure studies we've had completed have identified a number of water and sewer upgrades that will be required to ensure sufficient infrastructure capacity to maximise infill development. I understand Phil Thompson and Jordan Koroveshi have previously met with you on this project.

We are now at a stage where one of the options available to Council is to fund the non-head works water and sewer infrastructure upgrades. We are investigating four scenarios based on 5, 10, 15 or 20 year funding scenarios.

In this regard, I am keen to discuss with Water Corporation how to progress the water and sewer infrastructure upgrades if Council agrees to fund them. Specifically I have the following questions:

- Does the City of Wanneroo fund the Water Corporation to complete the upgrades?
- If yes, over what timeframe are these upgrades likely to be completed? i.e do they need to be programmed into the Water Corporation's capital works program?
- If no, will the City of Wanneroo and Water Corporation need to develop an agreement to enable the City of Wanneroo to contract out the work to agreed contractors?

Do you have any time to discuss this over the phone? Alternatively I'm happy meet with yourself and other relevant staff at Water Corporation if this is preferred.

Kind regards,

Nyssa Searles
Business Development & Research Officer
City Growth

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Adopted by resolution of the Council of the City of Wanneroo at the Ordinary meeting of the Council held on the 3rd day of February 2015.

.....

MAYOR

.....

CHIEF EXECUTIVE OFFICER

Adopted for final approval by resolution of the City of Wanneroo at the meeting of the Council held on the day of and the Common Seal of the City of Wanneroo was hereunto affixed by the authority of a resolution of the Council in the presence of:

.....

MAYOR

.....

CHIEF EXECUTIVE OFFICER

Recommended/Submitted for final approval

.....

DELEGATED UNDER S.16 OF
PD ACT 2005

DATE .....

Final Approval Granted

.....

MINISTER FOR PLANNING

DATE .....